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Asian health sectors growth in the next decade - optimism despite challenges ahead

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Asian health sectors growth in the next decade - optimism despite challenges ahead

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Editorial: Asian health sector growth in the next decade—Optimism despite challenges ahead

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KEYWORDS

Asia-Pacific, China, Japan, universal health coverage (UHC), health expenditure, developing countries, health care cost, medical care

Editorial on the Research Topic
Asian health sectors growth in the next decade—Optimism despite challenges ahead

The Western Pacific and the Southeast WHO regions of Asia have a variety of economies, from middle-income India, Laos, and Myanmar to high-income OECD countries, such as Japan and South Korea. These regions are home to a sizable population and act as an epicenter of global manufacturing and industrial capacity (1).

While most of Asia was under colonial rule before World War II, it became the fastest-growing economic region of the world in recent decades, manifesting some of the world's longest economic booms, starting from Japan in the 1950s, to South Korea, China, and recently to India and the Tiger Cub Economies, such as Singapore and Malaysia (2). In contrast, these boomed economies later faced setbacks due to various reasons, such as the 1997 Asian financial crisis, which spread to the ASEAN (Association of South East Asian Nations) region (3), the contraction of the GDP in countries such as Indonesia and Sri Lanka, the aftermath of the heavy inflow of foreign aid that was demanded following a tsunami and other disastrous natural calamities (4), the impact of the 2008–2009 global recession and its effects in Asian countries (5), and the recent COVID-19 pandemic. These caused multi-faceted economic effects in Central Asia (6), and other Asian countries.

In addition to these ups and downs, a meager proportion (approximately 4–7%) of total GDP has been invested in the health sector in most Asian countries, in comparison to approximately 12% or more of that in European countries, the United States, and other high-income countries. Increased health awareness leading to increased health demand has, directly and indirectly, pressurized the ruling governments in the region to invest in the health sector, leading to multiple and mixed avenues of different opportunities and challenges for health sector growth.

TABLE 1 Scopes and summary findings of the studies.

References	Title	Country/Region	Type of article	Major findings/conclusions
Scope/Areas/Theme 1: Primary health care (PHC) and health systems development (HSD)				
1. Katoue et al.	Healthcare system development in the middle east and North Africa region: challenges, endeavors, and prospective opportunities	Middle East and North Africa (MENA)	Review	• Explored the experiences, challenges, and future opportunities of various governments' initiatives for health system development (HSD).
2. Poudel et al.	Disempowered mothers have undernourished children: how strong is the intrinsic agency?	Nepal	Original research	• Maternal empowerment, basically an intrinsic agent, strongly affects children's nutritional status, especially child wasting and being underweight.
3. Wenang et al.	Availability and accessibility of primary care for remote, rural, and poor populations in Indonesia	Indonesia	Original research	• Guiding referral and utilization of primary care will be a key success factor for effective and efficient usage of available healthcare infrastructure and achievement of universal health coverage.
4. Jackojevic et al.	Governmental investments in hospital infrastructure among regions and its efficiency in China: an assessment of building construction	China	Original research	• Investment efficiency was higher when switching governmental investment predisposition in the aspect of healthcare infrastructure construction toward less developed regions.
Scope/Areas/Theme 2: (Health) insurance, governance, and UHC				
5. Paneru et al.	Adopting social health insurance in Nepal: A mixed study	Nepal	Original research	• Further explored that social health insurance may not suffice, and so, future perspectives of HI may be taken up with alternate strategies; • Prediction models were presented.
6. Li et al.	Official tenure and governance effectiveness of China's basic pension insurance system: An inverted u-shaped curve	China (31 Provinces)	Original research	• Localized government officials, rather than non-localized ones, showed positive governance efficiency.
7. Chung	Characteristics associated with financial or non-financial barriers to healthcare in a universal health insurance system: A longitudinal analysis of Korea's health panel survey data	South Korea	Original research	• Along with financial barriers to be addressed, current universal health insurance systems need targeted policy instruments to minimize non-financial barriers to healthcare to ensure effective universal health coverage.
8. Tian et al.	Institutional design and incentives for migrant workers to participate in social insurance in China: evidence from a policy experiment in Chengdu city	China	Original research	• Changing the social insurance model of migrant workers from comprehensive social insurance to urban employee insurance reduces the incentives for migrant workers to participate in insurance and harms the overall welfare of migrant workers. • Policy experiment using the difference-in-differences model.
Scope/Areas/Theme 3: Public health screening				
9. Wang et al.	Benefit-to-harm ratio and cost-effectiveness of government-recommended gastric cancer screening in China: a modeling study	China	Original research	• The gastric cancer risk score scale (GCRSS) strategy is effective and cost-effective in reducing the gastric cancer disease burden and the optimal strategy would occur from the age of 40; • Microsimulation model and deterministic and probabilistic sensitivity analyses were carried out.
10. Shah et al.	Cost-effectiveness of portable electrocardiogram for screening cardiovascular diseases at primary health centres in Ahmedabad District, India	India	Original research	• Portable electro-cardiograms to screen cardiac abnormality at the PHC level is highly cost-effective for high-risk adult and symptomatic cases; • Use of a decision-analytic model.

(Continued)

TABLE 1 (Continued)

References	Title	Country/Region	Type of article	Major findings/conclusions
Scope/Areas/Theme 4: Urban and green economies, and sustainability				
11. Chen et al.	Analysis of spatiotemporal characteristics of urban economic resilience and influencing factors in the Guangdong-Hong Kong-Macao Greater Bay Area	China (Guangdong-Hong Kong-Macao Greater Bay Area)	Systematic Review	• Economic resilience increased in the middle and south regions and decreased in the northwest, and economic status and economic response were the main dimensions affecting resilience • A Pressure-State-Response (PSR) model was used in the post-pandemic situation.
12. Shao et al.	How fast are Asian countries progressing toward a Green Economy? Implications for public health	Asia	Original research	• Some countries have reached a high green development level, and the medium-income ones move fast toward a green economy, while some low-income countries get worse.
Scope/Areas/Theme 5: Health care profession, ethics, and leadership				
13. Wang et al.	Sustainability of nursing leadership and its contributing factors in a developing economy: A study in Mongolia	Mongolia	Original research	• Behavior and problem-solving skills positively contribute to nursing leadership. Transformational ability also contributed significantly to nursing leadership.
14. Dong et al.	Satisfaction as a mediator and its interaction with adherence to labor analgesia protocols: A cross-sectional survey of Chinese medical personnel	China	Original research	• Medical personnel working at PHC levels should be considered for comprehensive incentives, including training for them as well as staff to improve the use of labor analgesia.
15. Ozaki et al.	How do institutional conflicts of interest between pharmaceutical companies and the healthcare sector become corrupt? A case study of scholarship donations between the Department of Anesthesiology, Mie University, and Ono Pharmaceutical in Japan	Japan	Perspective article	• Highlighted potential institutional remedies that may alleviate ICOIs and corrupt behavior affecting the healthcare sector.
Scope/Areas/Theme 6: Health tourism and migrant health				
16. Fenming et al.	Investigating revisit intention of medical tourists in China through nutritional knowledge, perceived medical quality, and trust in the physiologist: A recommendation on health tourism policy measures	China	Original research	• Nutritional knowledge, perceived medical quality, and trust in physiologists significantly influence the revisit intention of medical tourists; • Structural equation modeling using Smart PLS.
17. Li et al.	Measuring Patients' Satisfaction toward Health Tourism in Malaysia through hospital environment, nutritional advice, and perceived value: A study on Chinese exchange	Malaysia	Original research	• Hospital environment, nutritional advice, and perceived value significantly influence patients' satisfaction; • Structural equation modeling using Smart PLS.

Of the total 17 manuscripts accepted for this Research Topic, 14 are original research papers, two are reviews, and one is a perspective article. The manuscripts and total numbers are found under the following six themes: Primary Health Care (PHC) and Health Systems Development (HSD) (four manuscripts); (Health) insurance, governance, and universal health coverage (UHC) (four manuscripts); public health screening (two manuscripts); urban and green economics, and sustainability (two manuscripts); health care profession, ethics, and leadership (three manuscripts); and health tourism and migrants' health (two manuscripts). Geographic coverage is as follows: seven and two manuscripts are from China and Nepal, respectively, and one each represents Asia, the Middle East and North Africa (MENA), Mongolia, Malaysia, South Korea, Japan, and Indonesia (Table 1).

The editors observed that shifting infrastructure development to less developed regions, focusing on women's empowerment, and guiding the referral system may enhance access to PHC and thereby advance health and social development (HSD); for which the non-state actors should work in close collaboration with the state. In order to achieve UHC, the health sector in the next decade is expected to grow and move beyond HSD. For this, in addition to financial and non-financial barriers to health insurance, alternative strategies to existing insurance schemes are crucial, including social health insurance (HI), as some Asian and African countries are moving closer to UHC by HI reforms (7, 8); improved governance through localized employees; public health screening with cost-effective tools and strategies, such as portable ECGs and the gastric cancer risk score scale (GCRSS), which can be further

captivated with the Health Technology Assessment (HTA) (9) and may further help in reducing the ongoing catastrophic expenditures of households with noncommunicable diseases (NCDs) (10); and the leadership skills and training of health care professionals. Another area of growth in the health sector is health tourism, for which patient satisfaction and enhancing the trust between the health professionals and the patient are warranted. Since domestic manufacturing is not meeting the ever-rising demand for medical services, which is visible in terms of more significant health and pharmaceutical expenditures (11) on equipment and medicines (12), cross-country health and medical tourism is inevitable. To meet this demand and intra-country unmet healthcare challenges in some countries while also seizing other markets, institutions should consider other informed solutions to solve conflicting interests between the pharma company and the health sector. Furthermore, economic resilience after the COVID-19 pandemic and maintaining the pro-green economies may contribute to the region's health sector growth and to its sustainability, including the ability to face challenges to meet sustainable development goals (13).

Conclusive remarks

The editors believe these valuable and diverse topic contributions might open new horizons of knowledge. Last but not least this is a unique opportunity to open the floor for a public debate on the Asian challenges through the lens of the Global South's health sector growth (12). The main goal of this Research Topic was to describe the progress made in the healthcare arena in Asian Emerging economies. A diverse group of authors coming from academia, industry, governing authorities, and professional associations attempted to provide a thorough overview of the status of the healthcare sector growth in Asian-Pacific economies (14). We hope that this collection of articles can trigger curiosity among aspiring Asian public health authorities, HTA experts, clinical physicians, economists, and public communities alike.

Author contributions

MJ and CA prepared the manuscript draft while MJ, CA, and LW revised it for important intellectual content. All authors fulfill ICMJE conditions for full authorship. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Availability and Accessibility of Primary Care for the Remote, Rural, and Poor Population of Indonesia

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Background: Adopting Universal Health Coverage for implementation of a national health insurance system [Jaminan Kesehatan Nasional (JKN)/Badan Penyelenggara Jaminan Sosial or the Indonesian National Social Health Insurance Scheme (BPJS)] targets the 255 million population of Indonesia. The availability, accessibility, and acceptance of healthcare services are the most important challenges during implementation. Referral behavior and the utilization of primary care structures for underserved (rural/remote regions) populations are key guiding elements. In this study, we provided the first assessment of BPJS implementation and its resulting implications for healthcare delivery based on the entire insurance dataset for the initial period of implementation, specifically focusing on poor and remote populations.

Methods: Demographic, economic, and healthcare infrastructure information was obtained from public resources. Data about the JKN membership structure, performance information, and reimbursement were provided by the BPJS national head office. For analysis, an ANOVA was used to compare reimbursement indexes for primary healthcare (PHC) and advanced healthcare (AHC). The usage of primary care resources was analyzed by comparing clustered provinces and utilization indices differentiating poor [Penerima Bantuan Iur (PBI) membership] and non-poor populations (non-PBI). Factorial and canonical discrimination analyses were applied to identify the determinants of PHC structures.

Results: Remote regions cover 27.8% of districts/municipalities. The distribution of the poor population and PBI members were highly correlated ($r^2 > 0.8$; $p < 0.001$). Three clusters of provinces [remote high-poor ($N = 13$), remote low-poor ($N = 15$), non-remote ($N = 5$)] were identified. A discrimination analysis enabled the >82% correct cluster classification of infrastructure and human resources of health (HRH)-related factors. Standardized HRH (nurses and general practitioners [GP]) availability showed significant differences between clusters ($p < 0.01$), whereas the availability of hospital beds was weakly correlated. The usage of PHC was ∼2-fold of AHC, while non-PBI members utilized AHC 4- to 5-fold more frequently than PBI members. Referral indices ($r^2 = 0.94$; $p < 0.001$) for PBI, non-PBI, and AHC utilization rates ($r^2 = 0.53$; $p < 0.001$) were highly correlated.

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Conclusion: Human resources of health availability were intensively related to the extent of the remote population but not the numbers of the poor population. The access points of PHC were mainly used by the poor population and in remote regions, whereas other population groups (non-PBI and non-Remote) preferred direct access to AHC. Guiding referral and the utilization of primary care will be key success factors for the effective and efficient usage of available healthcare infrastructures and the achievement of universal health coverage in Indonesia. The short-term development of JKN was recommended, with a focus on guiding referral behavior, especially in remote regions and for non-PBI members.

Keywords: healthcare delivery, poor population, primary care, remote population, availability, accessibility, acceptability, universal health coverage

INTRODUCTION

Since the year 2000, many countries have adopted the concept of universal health coverage as a strategic background for their national policies, thus inducing the implementation of reforms, particularly in low- and middle-income countries. The evaluation and quality assurance of healthcare delivery goals (availability, accessibility, affordability, acceptability, and quality of care) are typically defined by three dimensions: covered population (pooled funds–solidarity principle), healthcare infrastructure, and healthcare services covered by healthcare funds (1).

Perhaps one of the most ambitious examples for this is the national health scheme being implemented in Indonesia [*Jaminan Kesehatan Nasional* (JKN)], which made healthcare available to its 255 million population, subsequently becoming the largest single healthcare system worldwide (2). This governmental approach has been intensively changing the expectations of the enrolled population, the required healthcare processes such as referral systems, and treated morbidity patterns. However, very specific challenges have originated from the size, diversity of urban, rural, and remote environments, variable levels of socioeconomic developments within the country, and the growing number of metropolitan areas of Indonesia. Furthermore, an epidemiological transition has produced a double burden of diseases for Indonesia, with the simultaneous increase of non-communicable diseases, such as diabetes, cerebrovascular disease, and ischemic heart disease, while infectious causes, such as tuberculosis, diarrhea, and HIV/AIDS, persist as substantial problems (3). Thus, starting in 2014, the Indonesian National Social Health Insurance Scheme [*Badan Penyelenggara Jaminan Sosial* (BPJS)] (4) aimed to provide healthcare coverage for all Indonesians. For the poor and near-poor population, insurance fees were waved totally or in part (PBI membership). As a result, enrollment in the program increased from 86.4 million (2014) to 111.6 million (2017) members, with the program securing additional funds at the national (92.2 million) or local levels (19.4 million) (5). Thus, BPJS healthcare insurance became mandatory for all Indonesian people as of 2019 (6). Since then, patients have no longer been requested to handle reimbursement issues, as the financial flow has been directly preceded between healthcare providers and BPJS/the government. Furthermore, healthcare infrastructure in Indonesia for primary care is mainly based on puskesmas (outpatients) and primary care hospitals (class A), whereas advanced care is mostly provided in level B/C (secondary/tertiary) hospitals and at the national level (class D hospitals). The reimbursement system differentiated between the Fasilitas Kesehatan Tingkat Pertama (FKTP) for primary healthcare (PHC) and the Fasilitas Kesehatan Rujukan Tingkat Lanjut (FKRTL) for advanced healthcare (AHC) and referral services.

During the BPJS roll-out, different participant groups did not enroll simultaneously. Furthermore, the initial proportion of the PBI members that did not receive subsidiaries was higher than their respective proportion within the population of the country (7, 8). This suggested the potential consequences for healthcare process development and referral strategies similar to other countries (9, 10). Ford et al. (11) emphasized that socioeconomically disadvantaged people living in rural areas face various barriers that limit their access to primary care. However, experiences and solutions of healthcare insurance implementation cannot be easily transferred between various countries (12).

Primary care is recognized as the most important form of healthcare for maintaining population health because it is relatively inexpensive, can be more easily delivered than specialty and inpatient care, and, if properly distributed, it is most effective in preventing disease progression on a wide scale. Recent advances in the field of health geography have greatly improved the understanding of the role played by the geographic distribution of health services in population health maintenance. However, most of this knowledge has been accrued for hospital and specialty services in rural areas (13). Previous evaluations for Indonesia suggested that the inequity of healthcare usage currently occurs, where poor populations and those living in remote areas would benefit less due to their limited geographical access to primary health care in particular. For instance, allocating physicians to remote islands or in mountainous or forest locations subsequently resulting in a shortage of essential health workers have been recognized as a major challenge (14, 15). Financial protection through social health insurance can be provided, but access among poor and rural/remote populations

has remained an issue. Therefore, in Indonesia, PHC provision is important for the assessment of the establishment of a structured improvement process as part of the healthcare insurance roll-out.

This study was the first assessment of BPJS implementation and its resulting implications for healthcare delivery based on the entire insurance dataset for the initial period of implementation. The analysis included all 34 provinces and focused on the differences between rural/remote and urban and between poor and non-poor populations (16, 17). Based on the demographic, reimbursement, and membership data, the usage of healthcare resources with a specific focus on underserved populations (remote regions and poor populations, according to governmental definition) was analyzed. Since preliminary observations suggested inefficient referral structures the utilization of primary care structures compared to advanced care in comparison between various insurance groups was an additional focus. Furthermore, the relationships between the current availability of healthcare resources and their usage were evaluated. The bridging aim was to support strategic decisions for the development of healthcare resources and delivery processes as a differentiated approach for the provinces of Indonesia.

METHODS

Study Design

Data Acquisition

Demographic data, economic parameters, and healthcare infrastructure information were obtained from the public resources of the national statistical agency (18). Data about the JKN membership structure, performance information, and reimbursement (differentiated for PHC and AHC) were provided by the BPJS national head office. Data for the entire year of 2018 were used for the analysis. These data were provided as a random selection from a family membership-based JKN registration (∼73.4 member families). For each sample data, an individual sampling weight was calculated and used in SPSS calculations (a detailed description of the data extraction is provided as **Supplementary File 1**). If applicable, data were normalized for population density (per 1,000) and human resource distribution (per unit). A list and the corresponding descriptions of all the used parameters are available as **Supplementary Table 1**. Ethical approval was obtained from the Muhammaniyah University (No. 202/EC-KEPK FKIK UMY/Vlll/2020) and the Indonesian National Healthcare Insurance BPJS (No. 5060/I.2/0419) for the entire project. Informed consent was not applicable in this type of investigation.

Study Setting

Members of the JKN national health insurance were divided into two major groups:

- poor people supported due to low income (PBI memberships);
- members not supported regarding insurance fees (non-PBI memberships).

Healthcare provision was distinguished into two different groups: PHC for primary healthcare (*puskemas*, independent general practitioners [GP], and class A hospitals) and AHC for advanced care in class B/C/D hospitals. Furthermore, reimbursement by BPJS consists of primary care capitation fees per insured member assigned to the healthcare provider (PHC capitation), procedure/diagnosis-related fees for primary care (PHC non-capitation), and reimbursements for advanced care according to respective efforts (AHC). Due to the lack of detailed data for healthcare procedures in a capitation-based system, the reimbursement parameters were used as indices for healthcare usage in different provider environments.

Definition of Underserved Regions

Indonesia has remote regions (*tertinggal* = underdeveloped, *terdepan/terjauh* = remote, and *terluar* = frontier/outer) consisting of 143 districts/municipalities at 27 provinces (from 34 provinces) defined based on governmental rules (19). This annotation was used for the analysis of the rural and remote populations (further referred to as Remote regions). According to this governmental nomenclature, information regarding the demographic characteristics of each province were available, such as the number of people in the (poor) population in these regions.

All statistical analyses were performed using IBM SPSS Statistics Version 26.

Multivariate Analysis

Analytical Strategy

First, the reduction of high numbers of variables describing available healthcare resources was required. For the analysis of underserved populations and primary care-related healthcare delivery variables were combined using factorial analysis. Subsequently, for the differentiation of provinces with similar structures regarding poor and remote populations, cluster analysis was performed. Combining these descriptive approaches, the relationships between healthcare resources, delivery processes, and clustered provinces were evaluated. Finally, the usage of healthcare resources was analyzed by comparing clustered provinces, JKN membership groups, and primary vs. advanced care utilization indices.

Gross domestic product and parameters describing infrastructure and human resources in the provinces were considered as independent variables. In contrast, variables related to healthcare services (reimbursement data) were treated as dependent during multivariate analyses. For comparability between provinces, variables were calculated based on population size and standardized whenever possible.

Cluster Analysis

A cluster analysis was performed to identify groups of provinces for which developmental strategies of healthcare resources and delivery processes can be formulated. Demographic and economic characteristics were postulated as determinants of healthcare usage, particularly for vulnerable groups. The vulnerability was assumed for the poor population and groups living in remote regions. To group the provinces according to the low and high prevalence of vulnerable groups, clustering based on various parameters describing the mentioned vulnerability was applied (parameter 5–20 in **Supplementary Table 1**). According to the targeted differentiation between these groups,

clustering was performed using partitioning approaches. The selection of the clustering method was driven by the need to minimize heterogeneity within a reasonable number of groups for further analyses. The stability of cluster annotation was ensured using two different clustering approaches (k-means and ward-methods). Cluster quality was accepted if both methods provided >90% coherence. To further test the contribution of the included variables for cluster segmentation, a discriminant analysis was applied. A univariate ANOVA and Eigenwert provided information about the quality of the discrimination functions.

Multivariate Factorial Analysis

Due to a large number of potential variables (parameters 42–206 in **Supplementary Table 1**) influencing healthcare utilization, we were required to reduce the observed complexity and aggregate the mentioned variables, if possible, into a limited number of factors that can be used for further analysis. Therefore, a multivariate factorial analysis was performed as a principal component analysis (PCA). The parameters were combined in a stepwise approach to finding out if a sufficient set of variables could describe available healthcare resources. Since some of the independent variables were, in part, interlinked with potential collinearity, an initial Pearson correlation was performed. As a result, a sufficient number of significant correlations was identified, suggesting eligibility for factorial analysis that was also approved by the Kaiser-Meyer-Olkin criterion (KMO, accepted if >0.5). The significance was also approved by a Bartlett test for sphericity.

ANOVA

The univariate group comparison was performed by an ANOVA method. For the multivariate analysis, *post-hoc* tests were done using the Scheffé procedure and Bonferroni correction. This was used for the analysis of the healthcare delivery parameters (reimbursement data: parameters 207–282 in **Supplementary Table 1**).

Healthcare Usage Rates

Non-capitation-based JKN reimbursement data enabled the differentiation of these groups, subsequently providing a robust data structure for the analysis of the utilization behavior of different JKN groups. To ensure the comparability of these data between the provinces, various indices were defined as the PHC utilization rate (# of non-capitation/# of capitation), JKN service rates [all non-capitation (PHC + AHC) services/# of the insured population], AHC utilization rate (AHC/# of the insured population), and referral index of primary to advanced care (AHC/non-capitation PHC). These parameters did not completely have the same background within the BPJS dataset. However, they were fully comparable between the provinces and the population groups. Therefore, they were used as indicators for the proposed delivery processes.

For the indicator for actual primary care service intensity, a PHC utilization index (= PHC Non-Capitation Service/PHC Capitation Service) was provided. The mentioned referral index of primary to advanced care was expressed by non-capitation AHC/PHC services. If appropriate, Student's *t*-tests were used for the comparison of these two groups. A canonical correlation analysis was done to address the distribution of the variances of the target parameters.

RESULTS

Membership Development and Remote Regions

Enrollment into BPJS membership differed between various population groups. The percentage of PBI members declined from 71.4% in 2014 to 61.2% in 2017. On the other hand, non-PBI participants rose from 25 to 36% (**Supplementary Table 2**).

Of all the districts/municipalities, 27.8% belonged to remote regions. The overall HRH availability in primary care in the remote regions was approximately 170,700 healthcare workers, representing 14.4% of the total national HRH (16.4% nurses/midwives; 10.2% GP; 8.8% all physicians). The distribution of the overall poor population and JKN participants co-financed by the government (PBI groups) were highly correlated ($r^2 > 0.8$; $p < 0.001$). In differentiating the remote and non-remote population, the correlation was slightly less for each subgroup but still highly significant ($r^2 > 0.6$; $p < 0.001$).

Demographic variables describing the poor and remote populations for each province showed high correlations (**Supplementary Table 3A**). Insufficient KMO/Bartlett tests also supported the application of the variables "percentage of remote population" and "percentage of total poor in total remote population" as appropriate population descriptors for these two aspects. Therefore, both variables were used for the further analysis of the regional distribution of rural/remote regions.

Human resources of health were investigated by looking at the local distribution of professional groups (standardized variables) between remote and other regions. Infrastructural variables for the entire provinces (remote and non-remote regions) showed relevant discrimination or correlative impact (data not shown), while further analysis focused on resources available in remote regions. As expected, the HRH availability in *puskemas* was weak but significantly correlated with GDP per capita ($r^2 = 0.16$; $p < 0.05$). In contrast, the densities of GP and all physicians were not different.

Factorial Analysis of the Independent Variables for Healthcare Infrastructure and Population Structure

Since the availability of healthcare infrastructure is determined by various infrastructural and human resource variables, a reduction of the number of these variables for further analysis was required. A factorial analysis was used to identify the aggregated factors that can describe this availability. Professional groups (numbers of available healthcare workers) were combined into three HRH groups (GP, medical specialists, nurses/midwives), and overall HRH capacity that were normalized in each province for population (= absolute numbers/1.000 population) and also related to the number of primary care units (= absolute numbers/puskesmas or class A hospital). Seven variables representing healthcare infrastructure (*puskesmas* and hospital beds) and available HRH

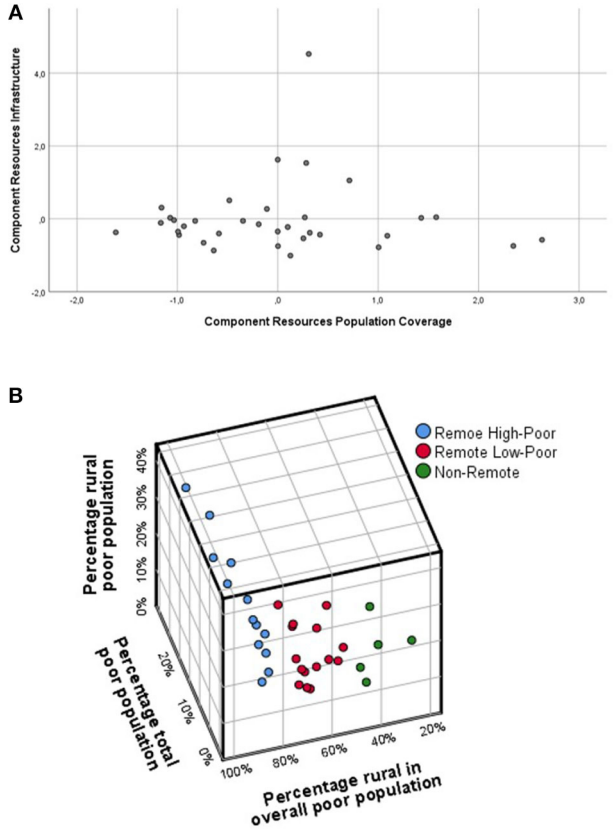

FIGURE 1 | (A) Principal component analysis (PCA) for the HRH and infrastructure availability in the provinces. The factorial load for the obtained factors, "population coverage" and "infrastructure," is shown. DKI Jakarta is included but not considered for subsequent analysis due to its very different characteristics. **(B)** Grouping of provinces according to demographic and economic vulnerability using a ward three-cluster solution; for the avoidance of scaling effects and reduction of parameter variances, they have been further standardized according to $Pstand = \frac{Pprov - mean\ (Pallprov)}{STD\ (Pallprov)}$. Pstand, standardized parameter per capita in each province; Pprov, parameter in the single province; Pallprov, mean and SD for the parameter of all provinces.

were correlated (**Supplementary Table 3B**) and included in the factorial analysis. Two factors explaining >79% of the variance were identified, namely, "population coverage" and "healthcare infrastructure" (**Figure 1A**). Both factors were used for all subsequent evaluations as descriptions of healthcare resources.

Clustering of Provinces Regarding Healthcare Infrastructure

To discriminate and group the provinces regarding their demographic characteristics, which were expected to be relevant as determinants for healthcare coverage, a canonical cluster analysis was performed based on the previously discussed population descriptors and infrastructure variables. Different clustering approaches highlighted that the province of Jakarta (DKI) was characterized by various specialties, such as lack of a remote population and different GDP and healthcare structure, mostly resulting in a single-province cluster. Therefore, this province was separated into various analytical approaches. Based on the remaining 33 provinces, the obtained three-cluster solutions (ward procedure) provided the best results (**Figure 1B**):

- Remote High Poor: the remote region with a high percentage of people in the poor population ($N = 13$).
- Remote Low Poor: the remote region with a low percentage of people in the poor population ($N = 15$).
- Non-Remote: the non-remote region with a low percentage of people in the poor population ($N = 5$).

The subsequent discriminant analysis (**Supplementary Tables 4A–C**) confirmed that the three input variables significantly (Wilks'-Lambda: $p < 0.001$) discriminated the obtained three clusters that were used for further evaluation (**Supplementary Table 5**).

In a similar approach, HRH were investigated regarding their distribution between the obtained clusters of provinces. If infrastructure (human resource density, hospital beds, # of *puskesmas*) was included as a characterizing variable for these clusters, high discriminative power was obtained. The canonical discrimination enabled an >82% correct classification by the two obtained discrimination functions, pointing to the fact that healthcare infrastructure differed between provinces with different demographic characteristics. ($p < 0.005$; **Figure 2A**) Misclassification was solely attributed to the differences between the two clusters with remote regions (**Supplementary Figure 1**). The standardized densities or population-based availabilities (per 100,000) of nurses/midwives and overall HRH per *puskesmas* showed significant differences between the clusters ($p < 0.01$), with the lowest values being found in the remote high-poor cluster and the highest densities in the non-remote cluster. Interestingly, if only overall HRH available in remote regions was used for discrimination: differences between the clusters were not significant (data not shown).

Availability of Resources in Remote and Poor Regions

In the next step, we analyzed whether the province clusters of the provinces could be discriminated based on HRH and infrastructure availability. The population-based availabilities (per 100,000) of HRH in remote regions was very highly correlated between GP, nursing, and all HRH ($r^2 > 0.94$; $p < 0.001$). Based on these variables, the discrimination of province clusters was weak (**Figure 2B**), which was mainly supported by the univariate correlation of the proportions of remote regions and the percentages of people in the poor population with HRH variables in these regions (**Figures 2C,D**). However, by looking at the absolute numbers of the remote population, their comparison with the HRH in remote regions provided a slightly different picture. Large SDs were seen in all groups. Therefore, significant differences were not always found. In general, both GP and nurse/midwife availability were significantly less in remote regions compared to all the provinces ($p < 0.005$), but differences between provinces with high and low impacts of the poor population were not found (**Table 1**). However, if *puskesmas* as outpatient PHC structures were analyzed regarding their HRH

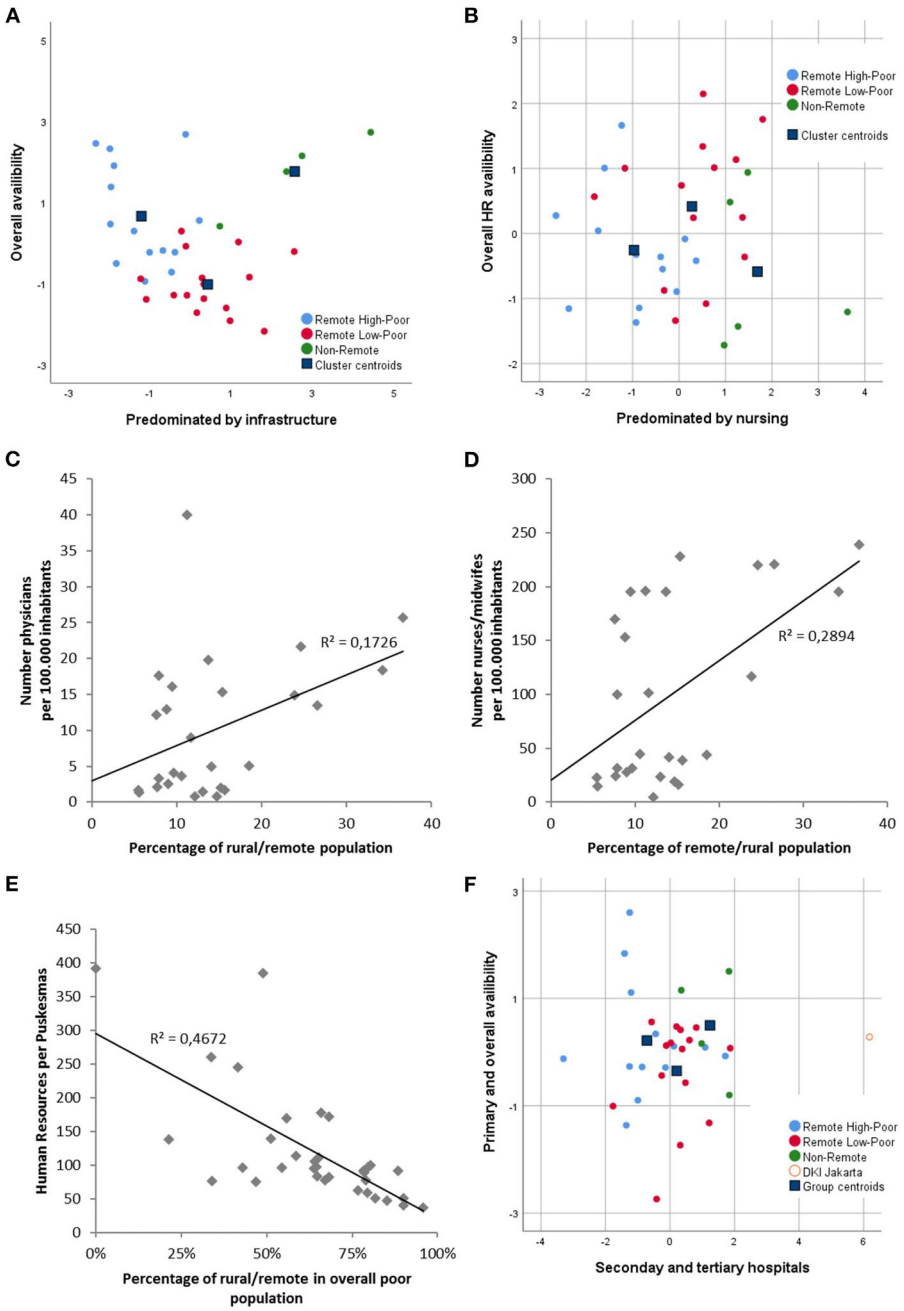

FIGURE 2 | Relationship between healthcare resources and province clusters. Canonical discrimination functions are obtained by infrastructure resource variables for **(A)** the overall healthcare infrastructure and **(B)** HRH. Weak correlations between the percentage of remote populations in provinces and the number of available **(C)** physicians and **(D)** nurses/midwives in remote regions. **(E)** Average HRH per *puskesmas* is related to the percentage of the remote population in the overall poor population. **(F)** Weak differentiation of canonical discrimination functions using hospital bed availability.

availability and compared with the percentage of the remote population, a significant inverse correlation was found. The percentage of the remote population ($p < 0.001$), the percentage of the remote poor population related to the total population ($p < 0.05$), and the percentage of the remote population in the overall poor population ($p < 0.001$) were significantly correlated with HRH per *puskesmas* (physicians, nurses/midwives, and overall) (**Figures 2C–E**). Furthermore, low HRH were identified in the remote high-poor cluster (68.9 ± 23.1), intermediate in the remote low-poor cluster (132.4 ± 78.1), and high in the non-remote cluster (163.3 ± 84.9) (**Table 1**).

The availability of hospital beds per population was also investigated, including the different classes of hospitals with their related healthcare delivery functions. Although large differences

TABLE 1 | Human resources for healthcare (HRH) in entire provinces and remote regions, given as HRH per 100,000 population and HRH density (covered population per HRH) for general practitioners (GP) and nurses/midwives.

Demographic cluster		HRH per 100,000 population				HRH density			
		GP		Nurses & Midwifes		GP		Nurses & Midwifes	
		Remote regions	Province	Remote regions	Province	Remote regions	Province	Remote regions	Province
Remote High Poor	Mean	11.2**	16.7	201.3*	296.4	29015.6	6588.6	1721.6	359.8*
	±	±	±	±	±	±	±	±	±
	SD	7. 5	5.3	128.8	74.6	46334.9	2147.8	3239.1	100
	N	13	13	13	13	13	13	13	13
Remote Low Poor	Mean	7.6**	25	127.7**	298.5	35934	4665.7	1686.5	364.2*
	±	±	±	±	±	±	±	±	±
	SD	8.39	10.5	149.2	92.1	28530.5	1.903.4	1.115.9	105.7
	N	12	15	12	15	12	15	12	15
Non-Remote	Mean	83.9	25.9	917.8	207	12359.2	6653.7	640.7	653.2
	±	±	±	±	±	±	±	±	±
	SD	112.8	19.3	1182.4	107.8	16614.4	5357.2	825.4	412.5
	N	2	5	2	5	2	5	2	5

*Since the clusters "remote high poor" and "remote low poor" were not considered different, significance was given for their comparison to the cluster "non-remote" (*p < 0.01; **p < 0.005).*

were observed between the provinces (0.77–2.33 beds per 1,000 population), this was only very weakly related to the percentages of the remote and poor population (**Figure 2F**). If class A and B hospitals were considered as separate primary care access points, the slight correlation was completely lost (data not shown).

Usage of Healthcare Structures

The usage of PHC structures is of utmost importance for the effectiveness and efficiency of the Indonesian healthcare system. Therefore, the subsequent analyses focused on PHC in relation to AHC usage and their determinants regarding infrastructure availability and demographic characteristics. Overall, the usage of primary care (PHC) was ∼2-fold of advanced care usage (AHC) representing 28.2% and 14.4% of JKN members. PHC capitation reimbursement was considered as principal coverage by JKN, while PHC non-capitation services were taken as indicators for actual primary care service. If included in discrimination analysis, the resulting canonic functions (**Figures 3A,B**) showed significant differences in primary care service between the population clusters, mainly determined by discrimination coefficients related to indices referring to non-PBI participants and the PBI referral index. Interestingly, for the remote high-poor cluster, the highest primary care PHC utilization indices were observed, whereas the non-remote cluster had the lowest index values. For PBI members, this index was significantly higher ($p < 0.001$) than for non-PBI participants (**Figures 3A,B**). In contrast, if advanced care AHC utilization rates were analyzed, an inverse behavior was observed. Non-PBI members and the non-remote cluster showed significantly higher usage compared with PBI members and other population clusters ($p < 0.001$). This was also supported by the AHC/PHC referral index representing relations between primary and advanced care utilization (**Figure 3B**). These differences could be found in the univariate and multivariate comparisons (**Supplementary Table 6**). Non-PBI members utilized advanced care 4- to 5-fold more frequently than PBI members. Referral indices ($r^2 = 0.94$; $p < 0.001$) for PBI and non-PBI groups and AHC Utilization Rates ($r^2 = 0.53$; $p < 0.001$) were highly correlated, whereas PHC utilization indices showed only low correlations between the insurance groups (data not shown). As noticed, the infrastructure for DKI Jakarta differed from all other provinces to a large extent throughout the healthcare usage parameters.

Looking at infrastructural factors influencing usage and referral behavior, it was observed that the availability of HRH at primary care was correlated with the referral and utilization indices reflecting advanced care services. In contrast, the numbers of covered population per *puskemas* were significantly related to utilization indices and utilization rates but not with referral indices (**Table 2A**). Primary and advanced care utilization were inversely related to each other, demonstrating that primary care was less used in regions where *puskesmas* covered larger groups of the population. Interestingly, the differences between PBI and Non-PBI groups and between the population clusters regarding these correlations were not found in the multivariate approach (**Supplementary Figure 2**). For an overall evaluation of the utilization variance explained by infrastructure and HRH availability, the two obtained factors, "population coverage" and "infrastructure" (see above), were combined in a canonical correlation analysis. This showed that more than 60% of the utilization variances could be explained by province characteristics. However, this was mainly attributed to the advanced care indices (AHC utilization rate, referral index). The canonical correlation coefficients were 0.9 for obtained set 1 and 0.67 for set 2 (Wilks' test: $p < 0.001$ and $p < 0.005$), respectively (**Table 2B**).

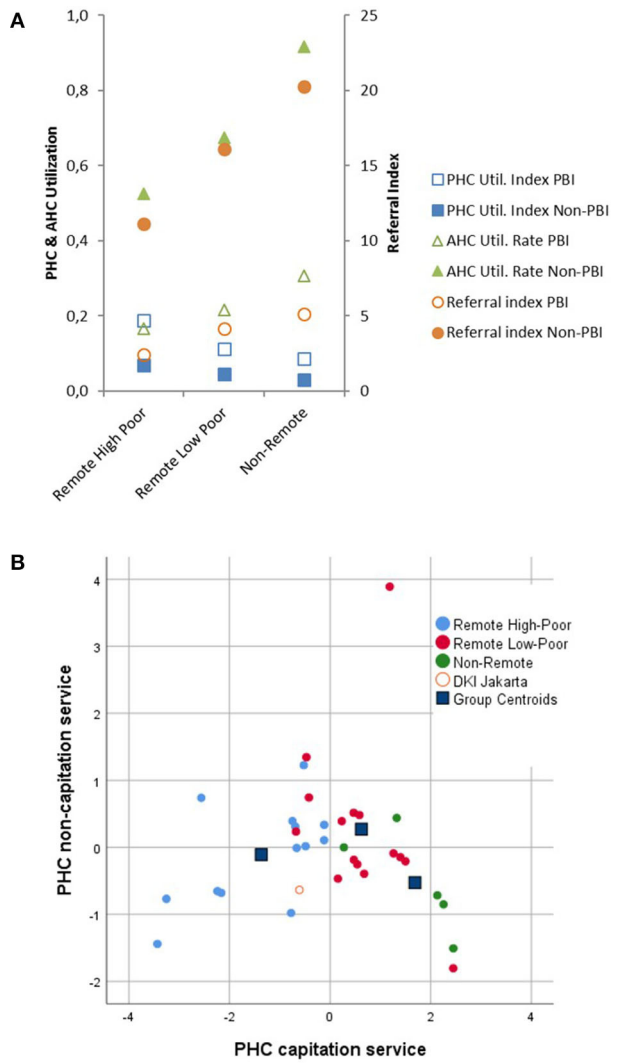

FIGURE 3 | Healthcare services for PBI (□) and Non-PBI insurance (■) members. **(A)** PHC Utilization Index (primary care) (■), AHC Utilization Rate (advanced care) (▲) and AHC/PHC Referral Index (●). **(B)** Canonic discrimination functions obtained by capitation and non-capitation PHC primary services.

TABLE 2A | Pearson correlation between factors related to *puskesmas* and service indices (+ $p < 0.05$; *$p < 0.005$; **$p < 0.001$).

(A)	Number of HRH per Puskesmas (Standardized)	Covered Population per Puskesmas (Standardized)
PHC Utilization Index PBI	−0.202	−0.433+
PHC Utilization Index Non-PBI	−0.263	−0.436+
Referral index PBI	0.572**	0.227
Referral index Non-PBI	0.545*	0.226
AHC Utilization Rate PBI	0.714**	0.388+
AHC Utilization Rate Non-PBI	0.475*	0.637**

TABLE 2B | Standardized numbers were used for the canonic correlation analysis demonstrating multivariate correlation (Wilks' test, $p < 0.01$).

(B)	Standardized canonical correlation coefficients	
	Canonical function 1	Canonical function 2
Set 1 variables		
PHC Utilization Index PBI	0.152	−0.311
PHC Utilization Index Non-PBI	−0.216	0.007
Referral index PBI	0.205	10.954§
Referral index Non-PBI	−0.678§	−10.456§
AHC Utilization Rate PBI	−0.622§	−10.390§
AHC Utilization Rate Non-PBI	−0.070	10.395§
Set 2 variables		
Factor Infrastructure	−0.981§	−0.196
Factor Population Coverage	−0.196	0.981§

§*Relevant canonical correlation coefficients >0.5 are highlighted.*

The referral Indexes, but not both the utilization indices and rates, were highly correlated with GDP per capita in the PBI ($r^2 = 0.55$; $p < 0.001$) and non-PBI ($r^2 = 0.64$; $p < 0.001$) insurance groups. The age structure of the JKN members was independent of most service indices and only slightly correlated with the AHC utilization index in the non-PBI group (**Supplementary Figure 3**).

DISCUSSION

To meet the many challenges inherent in actually delivering affordable healthcare to all Indonesians, the country needs to strengthen its capacity for rigorous evaluation and policy learning at the national and local levels. This would also enable the use of deeper technical evidence to guide the implementation of ambitious plans. Given the diverse range of forms of geography and economic statuses across the country, regular comprehensive assessments of disparities in morbidity, mortality, and disability patterns and their causes are needed. The healthcare system must be able to respond to changing demands due to epidemiological shifts and reduce financial barriers as a result of JKN (20–22). This analysis provided the first evaluation for the new Indonesian health insurance system regarding the availability and accessibility of healthcare resources and delivery processes, with a specific focus on the poor and rural/remote population and PHC utilization. It was based on the entire BPJS dataset. Furthermore, this study initiated the provision of analytical evidence for recommendations regarding the healthcare development strategies at the national and provincial levels.

The provinces of the country can be separated into three different clusters, which were well characterized by the extent of the population in rural/remote regions and the percentage of the poor population. This clustering likely enabled healthcare

politics to develop strategies for delivery processes that are generally applicable throughout the country. The obtained clusters showed high discriminative power for differentiation regarding demographic/HRH and healthcare infrastructure data.

Access to PHC is known as an important component of healthcare provision and referral management. It has also been described as a key factor for acceptability and accessibility (23). Therefore, this analysis of healthcare infrastructure focused on resources that are of special importance for primary care, including GP and nurses/midwives for HRH and *puskesmas*/hospital beds (especially for classes A and B) for infrastructure. If these factors were combined in multivariate approaches, resource availability for primary care can be made distinct between the province clusters. This cluster discrimination was rather predominated by infrastructure availability (*puskesmas* and hospital beds). In contrast, HRH availability was intensively related to the extent of the remote population in the provinces but not the numbers of the poor population. The first conclusion that can be drawn from this observation is that the development of HRH for primary care availability should intensively focus on remote regions. This could be supported by telemedicine approaches (24).

Primary care usage, as expressed by PHC non-capitation index and obtained primary care discrimination functions, was found to be much higher in the remote clusters. In contrast, access to AHC was higher in the non-PBI and non-remote populations. This suggested that primary care access points are mainly used by the poor population and people living in rural/remote regions, whereas other population groups prefer direct access to advanced care structures. Similar effects on AHC preference during healthcare insurance implementation (25) and the importance of rural healthcare accessibility (26) were observed in India, China (27), and the US (28). The uneven subscription into the BPJS programs between the poor and non-poor populations likely potentiated these effects, since PBI members were more predominant in remote regions. However, it was unexpected that the preference of AHC was evident in all Indonesian provinces and that the usage rates differed to a large extent, specifically by 4- to 5-fold. Thus, these differences in healthcare usage between PBI and non-PBI members throughout the delivery chain and all provinces need to be explained and targeted.

The present analysis revealed that HRH availability in primary care seems to be a determinant of referral and utilization indices toward advanced care services. Since the numbers of covered population per *puskemas* were significantly related to utilization indices and utilization rates, but not to referral indices, and considering the discussed importance of remote regions rather than the extent of the poor population, a special focus and priority toward the improvement of primary care infrastructures (in combination with corresponding HRH development) in these regions are strongly supported by the results of this analysis.

It can be hypothesized that anticipated or real differences in the provided quality of care, impaired trust in primary care, and insufficient primary care delivery processes play a role in the behavior of BPJS members. However, BPJS data were not suitable for the evaluation of determinants for PHC acceptance. Indonesia still has other problems that affect the implementation of JKN, such as the historically determined culture of poor people seeking healthcare differing from that of average urban people (29, 30). Overall, HRH availability and sufficient qualification will likely remain a challenge in the upcoming years due to persistent limitations in infrastructure related to economic opportunities (31, 32). Therefore, BPJS development should start implementing a structured review process that, for example, targets the adaptation of benefit packages and a reimbursement system for improved coverage of the entire population. Furthermore, in remote regions, competency-driven utilization appeared to be more dominant than referrals determined by the requirements of effective and efficient healthcare delivery chains. Thus, the insufficient availability and accessibility of medical specialists in remote regions was assumed to be an important driving conflict for utilization behavior and PHC acceptance (29).

Some limitations of the present analysis need to be addressed. The specific structure of the BPJS membership, such as family memberships, and the reimbursement system did not allow the direct analysis of delivery processes. However, the very large numbers of insured members, provided services, and broadly standardized insurance schemes enabled the implementation of various indicators, sufficiently describing the healthcare delivery chain. Similarly, models for the analysis of healthcare access in rural areas based on the analysis of healthcare delivery outcomes have been used in other settings and could identify several potential cofactors (33). Similar approaches were suggested for primary care change management targeting underserved rural populations, such as in the UK (34). Furthermore, the completeness of data must be critically considered. Due to the fact that, for several districts, not all data were fully available, the authors used the provincial level for the analysis, for which sufficient data quality was likely to avoid systematic bias. As for most insurance data sources, it cannot be ruled out that the coding for healthcare delivery and diagnoses from the providers contained mistakes. However, parallel to the insurance roll-out BPJS implemented, a data quality program could likely reduce the related bias to a very low level. As an analytical approach, a stepwise regression analysis would have been another option. However, a cluster analysis was used due to the requirement of a clear distinction between provinces regarding their concluded plans of action.

Summarizing the results of this investigation, the authors primarily recommend intensively focus on the guidance of patient referral as a JKN development policy. The primary usage of first access points (primary care facilities) and a guided referral to advanced care as a second step in the healthcare delivery chain appear to likely have high and short-term impacts on the effectiveness and efficiency of the healthcare system, especially in serving the rural population. Guiding the referral and utilization of primary care by setting the right incentives will be the most challenging task for the healthcare politicians of Indonesia in the near future, who want to ensure the effective and efficient use of BPJS (35). This seems to be especially important in non-remote regions and for non-PBI members. Not surprisingly, and with longer perspectives, the development of PHC infrastructures is required in remote high-poor regions. In contrast, the HRH availability appeared to need priority in

remote regions, in combination with telemedicine approaches, for PHC availability and referral guidance. These challenges will require the continuous control and implementation of the corresponding reporting and analytical pathways (36). Thus, these analyses should be based on high-quality pragmatic designs and focus on later-stage implementation outcomes (37). A suggested way of reporting is the usage of validated indicators that describe referral processes and their cofactors (38). In particular, the indicators developed in this study appear to fulfill these requests. The paramount importance of maintaining support for PHC and referral centers in remote regions was fully supported by the provided evidence of this analysis. However, further investigation of acceptance barriers will be required to fully understand the reasons for such and to provide evidence for strategic healthcare development.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions; insurance data are protected by legal issues from public availability. Requests to access these datasets should be directed to andi.afdal@bpjs-kesehatan.go.id.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Muhammadiyah University (No. 202/EC-KEPK FKIK UMY/Vlll/2020) and the Indonesian National Healthcare Insurance BPJS (No. 5060/I.2/0419). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

SW: concept, data analysis, writing, and discussion. JS: concept and results in interpretation. AA: data provision and data quality. SG: data analysis and methodological discussion. ID: concept and data interpretation. JH: concept, data analysis, and writing. AG: concept and data provision. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.721886/full#supplementary-material

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Governmental Investments in Hospital Infrastructure Among Regions and Its Efficiency in China: An Assessment of Building Construction

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Hospital infrastructure has been addressed as the prerequisite of healthcare delivery which intensively affects medical quality. Over the past decade, China has proposed a series of investment plans for hospital infrastructure in order to promote healthcare development in underdeveloped regions. Focusing on the construction of hospital buildings as the key component of hospital infrastructure, this study aims to examine whether the investment efficiency is lower where a government prioritizes equity and to explore what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures from the perspectives of both investment equity and efficiency. Relevant data from 330 governmental-invested hospital building construction projects in Sichuan province, China, from 2009 to 2018 were collected. Concentration index was used to evaluate the equity in the distribution of the investments. Tobit model was employed to explore the relationship between regional economic development and investment efficiency measured by an integrated approach of principal component analysis and data envelopment analysis. The results demonstrated a slight concentration of governmental investments in economically developed regions, while a negative association with regional economic development was identified with investment efficiency. Our study illustrated the investment efficiency was higher where a government prioritized equity and provided empirical evidences on switching governmental investment predisposition in the aspect of healthcare infrastructure construction toward less developed regions in China from the perspectives of both investment allocation equity and efficiency, which would further assist in the formulation of region-specific policies and strategies for underdeveloped regions.

Keywords: hospital infrastructure, government investment, equity, efficiency, China

INTRODUCTION

Healthcare facility infrastructure, including physical, technical, and organizational components or assets, has been emphasized as the prerequisite for the delivery of healthcare services (1). The deficiency of physical infrastructure, such as buildings, beds, medical equipment, logistics equipment or other fixed assets, could pose a huge obstacle for healthcare facilities to expand their medical services as well as improving healthcare quality (2, 3). However, the distribution of healthcare facility infrastructure typically demonstrated large discrepancies among different regions especially within developing countries which were often constrained by limited investments in healthcare sectors (4), thus ultimately leading to inequities in the distribution of medical facilities (5–7).

Governmental investment, as a method of resource reallocation, has been highlighted as an effective way to reduce discrepancies among different regions thus improving social equity (8). The governmental investment in healthcare facilities infrastructure in less developed regions has been believed to be an essential strategy for minimizing healthcare inequity (9). In addition to equity issues, efficiency should also be taken into consideration throughout the decision-making procedures of governmental investments (10). In the healthcare sector, investment efficiency has been defined as the production of the maximum health gains as the result of a given amount of healthcare input (11).

However, through the ages, multiple countries have simply insisted that the governmental investment in health facilities infrastructure should be more focused on less developed regions from the perspective of equity (12–14). The absence of investment efficiency in investment decision procedure makes us consider that is efficiency lower where a government prioritizes equity? The generally accepted assumption of the production function has indicated that an increased input would result in a reduced marginal output (15). Thus, based on such assumption, it could be theoretically predicted that both higher investment efficiency and better social equity would be probably achieved via predisposed resource allocation toward underdeveloped areas. However, the evidence on this assumption from health care is far from clear, not to mention the conduction of relevant evaluations on governmental investments in terms of healthcare facilities infrastructure among various regions from the perspectives of both investment equity and efficiency.

Therefore, to bridge the gap in existing literatures, this study was designed to answer the following two research questions. First, to examine whether the investment efficiency is lower where a government prioritizes equity. Second, to explore what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures in China from the perspectives of both investment equity and efficiency. Relevant data on 330 governmental-invested hospital building construction projects in Sichuan province, China, from 2009 to 2018, were collected. We firstly used the concentration index to describe the current distribution equity of governmental investments. Then the tobit regression was adopted to address the first research question by exploring the relationship between regional economic development and investment efficiency which was measured by PCA-DEA model. Finally, we combined the two analysis results to shed light on what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures in China from the perspectives of both investment equity and efficiency, i.e., the second research question.

Rather than the whole hospital physical infrastructure, our study specifically focused on the construction of healthcare facilities. Hospital building construction was selected as our study focus for two reasons. First, particular attention should be paid on healthcare facility construction which serves as the fundamental component of hospital infrastructure as well as the prerequisite for all the other components, Second, it should be noted that hospital building construction is the most essential phase reflective of the actual implementation of governmental investment plans for hospital infrastructure promotion in China. Previous studies have investigated the operational status of healthcare facilities via evaluating multiple more specific aspects related to healthcare facility infrastructure such as communication devices, waste disposal and water supplier devices (1, 5–7). However, as in China all these types of devices would be generally purchased as part of hospitals' own finance budgets without receiving any compensation from governmental investments, thus, we merely adopted hospital construction status in this study as the key indicator for obtaining a more comprehensive understanding about governmental investments in the aspect of healthcare infrastructure.

This study was expected to contribute to the relevant literature and health policy planning. First, focusing on the hospital infrastructure, this is, to our best knowledge, the first study to examine whether the investment efficiency is lower where a government prioritizes equity. Second, the development of healthcare infrastructure had been tightly constrained by limited governmental budgets, especially for developing countries like China. Our study was expected to provide evidence-based implications of what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures in China from the perspectives of both investment equity and efficiency. Findings from such study would facilitate the development of hospital infrastructure in the context of limited governmental budgets.

An overview of governmental investments in hospital building construction in China was briefly described in Text A.1 (**Supplementary Material**).

LITERATURE REVIEW

Efficiency and Equity

The balance between equity and efficiency remains a concern among health economists (16, 17). Despite of Adam Smith's belief that competitive markets will make society more equitable and efficient, health care does not often satisfy the requirements for competitive markets (18). Thus, whether equity and efficiency of governmental investment in health care can be achieved simultaneously need empirical studies.

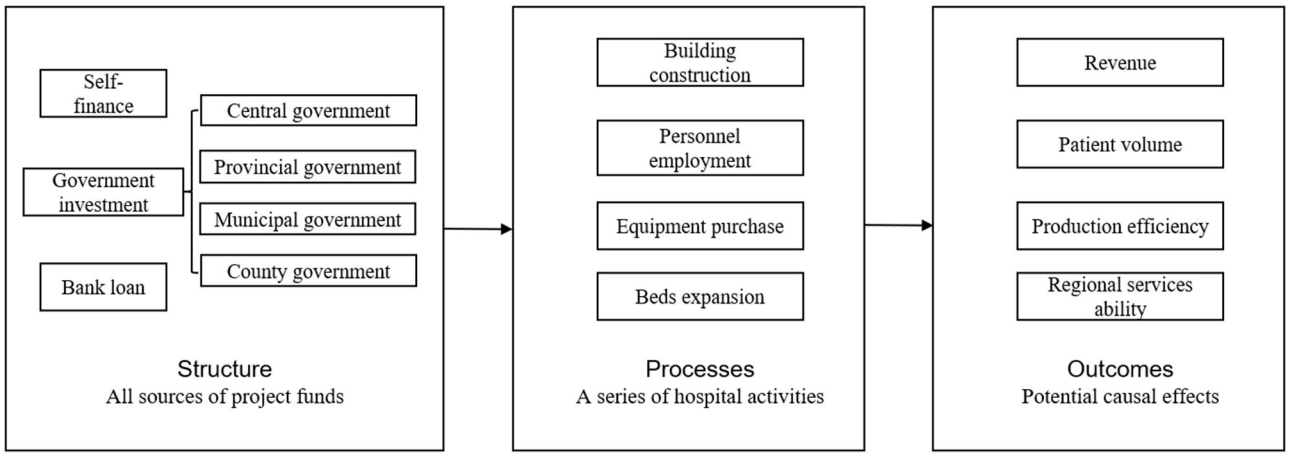

FIGURE 1 | Study framework.

While growing studies have focused on the equity and efficiency of health system (19–22), however, very limited studies have sought to evaluate the governmental investment in health care from the perspective of both equity and efficiency. Liu and He (23) assessed the equity and efficiency of financing for total health expenditure in China; Sun and Luo (24) evaluated the equity and efficiency of health resources allocation in China; Li et al. (25) evaluated the equity and efficiency of healthcare resource allocation of Chinese medicine in mainland China. Caroline et al. (26) proposed the priority setting of health interventions in Ghana based on a novel equity-efficiency tradeoff framework. However, all these previous studies failed to the answer the question: whether the efficiency is lower where a government prioritizes equity?

As for healthcare infrastructure in China, at present, no previous study has evaluated the equity and efficiency of governmental investment in hospital infrastructure. Most studies mainly assessed the locations of existing healthcare facilities from the perspective of distribution equity, based on which consensus has been reached that strengthening healthcare investment in less developed regions at governmental level should be addressed as the key strategy to achieving enhanced distribution equity among different regions (27–33).

Efficiency Measure

Hollingsworth reviewed 188 published papers on efficiency measurement in health care and concluded that data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are mostly used methods to measure efficiency in health area (34). DEA and SFA belong to a class of methodologies for measuring efficiency called "frontier analysis" which compares a firm's (e.g., hospital) use of actual inputs and outputs to efficient combinations of multiple inputs and/or outputs (35). The two methods use different approaches to calculating the "frontier" of efficient combinations used for comparison. Compared with SFA, a parametric model, the main advantage of DEA remains its non-parametric estimation, which relax the assumption required by unbiased efficiency estimation [see chapter 2 of (36) for technical details].

In practice, the selection of inputs and outputs in DEA or SFA depends on the research purpose. Victor and Kim reviewed 57 studies using DEA in health care (37). They found that input indicators were usually selected from capacity dimension (e.g., number of beds), labor dimension (number of physicians), and expenses dimension (e.g., total supplies cost); output indicators were usually selected from activity dimension (e.g., number of inpatient and outpatient visits) and quality dimension (e.g., mortality rate).

MATERIALS AND METHODS

Framework

The framework of our study has been developed based on the logic models proposed by previous studies (38, 39), which was adopted for evaluating hospital construction projects as the predominant aspect of hospital infrastructure. The logic model has been widely used to visually depict the hypothesized relationships among project resources, project activities, and the results the project are expected to achieve (40, 41). In the healthcare sector, Donabedian (42) proposed a logic model as a potent tool for evaluating the quality of healthcare which contained the structures, process and outcomes of healthcare delivery. The terminologies adopted in our study were obtained from his model as our study has the similarity with the previous study in terms of evaluating the productive procedures of healthcare delivery.

As shown in **Figure 1**, we divided the hospital building construction project into three stages, namely structure, processes and outcomes. Structure as the initial phase denotes all the resources required for the project, thus including all the funding resources obtained. The second phase contains a series of hospital activities after receiving project funds, thus were called processes. The hospital activities were summarized as four aspects including building construction, personnel employment,

TABLE 1 | Definition of input and output variables.

Variable	Definition
Processes (Inputs in DEA)	
Planned building area	Building area planned according to the investment plan
Total number of hospital beds	Actual functional status of beds in a hospital
Total value of equipment above 10,000 Yuan	Summing up the values of any equipment whose value is above 10,000 Yuan, including medical equipment and hospital logistics equipment
Number of healthcare workers	Including physicians, pharmacists, nurses, and medical technicians
Proportion of staff with senior professional titles	Proportion of staff with senior professional titles among all staffs in a hospital
Outcomes (Outputs in DEA)	
Outpatient revenue per 10,000 population	Annual outpatient revenue dividing by the population of the county in which the hospital is located
Inpatient revenue per 10,000 population	Annual inpatient revenue dividing by the population of the county in which the hospital is located
Outpatient and emergency department patient volume per 10,000 population	Annual outpatient and emergency department patient volume dividing by the population of the county in which the hospital is located
Number of inpatient discharges per 10,000 population	Number of annual inpatient discharges dividing by the population of the county in which the hospital is located
Number of inpatient surgical procedures per 10,000 population	Number of annual inpatient surgical procedures dividing by the population of the county in which the hospital is located
Bed days per physician per day	Total bed days per day for a hospital divided by the number of physicians
Bed turnover rate	Average number of patients cared for a bed during 1 year
Office visits per physician per day	A doctor's visit per day
Admission ratio within municipality	A ratio of actual frequency of admissions (Total frequency of admissions within a municipality) to theoretical frequency of admissions. The theoretical frequency of admissions is calculated as follows: $\frac{\text{Frequency of admissions within the province}}{\text{Population of the province}}$ * Population of a municipality

equipment purchase, and hospital beds expansion. Combined with the results of expert consultation and relevant literatures (37, 43–46), five variables were selected as indicators reflective of these four aspects, as shown in **Table 1**.

As for the outcomes part, we assumed that the hospital activities as mentioned above would lead to outcomes in four aspects, namely revenue, patient amount, productive efficiency, and regional service capacity. On one hand, the increased amount of hospital beds (47), personnel (48), and equipment (49) would improve the revenues and patient volumes into hospitals. In addition, the expansion of hospitals could increase their revenues and patient volumes by gaining a greater competitive advantage in the hospital market (50). On the other hand, according to the SCP paradigm drawn from industrial organization theory (51), changes in hospital market structure would lead to changes in market performance. Specifically, governmental investment in hospital building construction, as a policy shock to the hospital market, would change the structure of the market and could eventually increase hospital production efficiency (52) as well as regional service capacity (53) within the market through hospital competition. Following a review listing the typical outputs selected in the previous studies (37), we chose outpatient and inpatient revenue to reflect hospital revenue; we selected outpatient and emergency department patient volume, number of inpatient discharges, and number of inpatient surgical procedures to represent patient volume. After consultation with experts in Health Commission of Sichuan Province, we employed bed days per physician per day, bed turnover rate, and office visits per physician per day to reflect production efficiency; and we used admission ratio within municipality to represent regional services ability. Therefore, nine variables were selected as indicators reflective of four aspects of the outcomes, as shown in **Table 1**[1].

We used concentration index to describe the distribution equity of the governmental investment. Despite that governmental investment in hospital building construction projects came from four governmental sources, we only included central and provincial governmental investments as the main resources based on two considerations. First, the data quality of municipal and county investment was too poor to be adopted for analysis[2]. Second, the amount of the investment from municipal or county governments between different regions was not comparable[3]. Based on the processes and outcomes parts in our framework, we further used data envelopment analysis (DEA) along with principal component analysis (PCA) to compute the project efficiency. The project efficiency is very similar with the governmental investment efficiency in our study, and was defined as the maximum population health benefit after the completion of the hospital building construction project given the condition of certain inputs (processes variables in the framework) of supporting health resources. Thus, to avoid confusion, we employed investment efficiency to refer to project efficiency throughout the paper. The tobit regression was then adopted to address the first research question by exploring

[1]Given the disparity in population density, we adjusted some variables in outcomes part by county population size. However, none of the variables in processes part was adjusted since the absolute value can directly measure the changes in the competitiveness of the hospital brought about by building construction projects, while the adjusted relative value more closely reflects the contribution of the changes of the hospital to the whole hospital market, thus the former is more in line with our investment efficiency definition.

[2]According to the leader of Health Commission of Sichuan Province and related literatures (54), there is a common situation where investment funds from municipal and county governments are apparently received by hospitals but actually not, leading to the imprecise of the data.

[3]As mentioned above, municipal or county governments can independently decide the amount of investment. Thus, the amount is affected by numerous factors such as level of regional economic development, thought of government leaders and so on, resulting in the heterogeneity and incomparability. Inclusion of the amount of investment from municipal or county government cannot reflect the regional orientation of governmental investments.

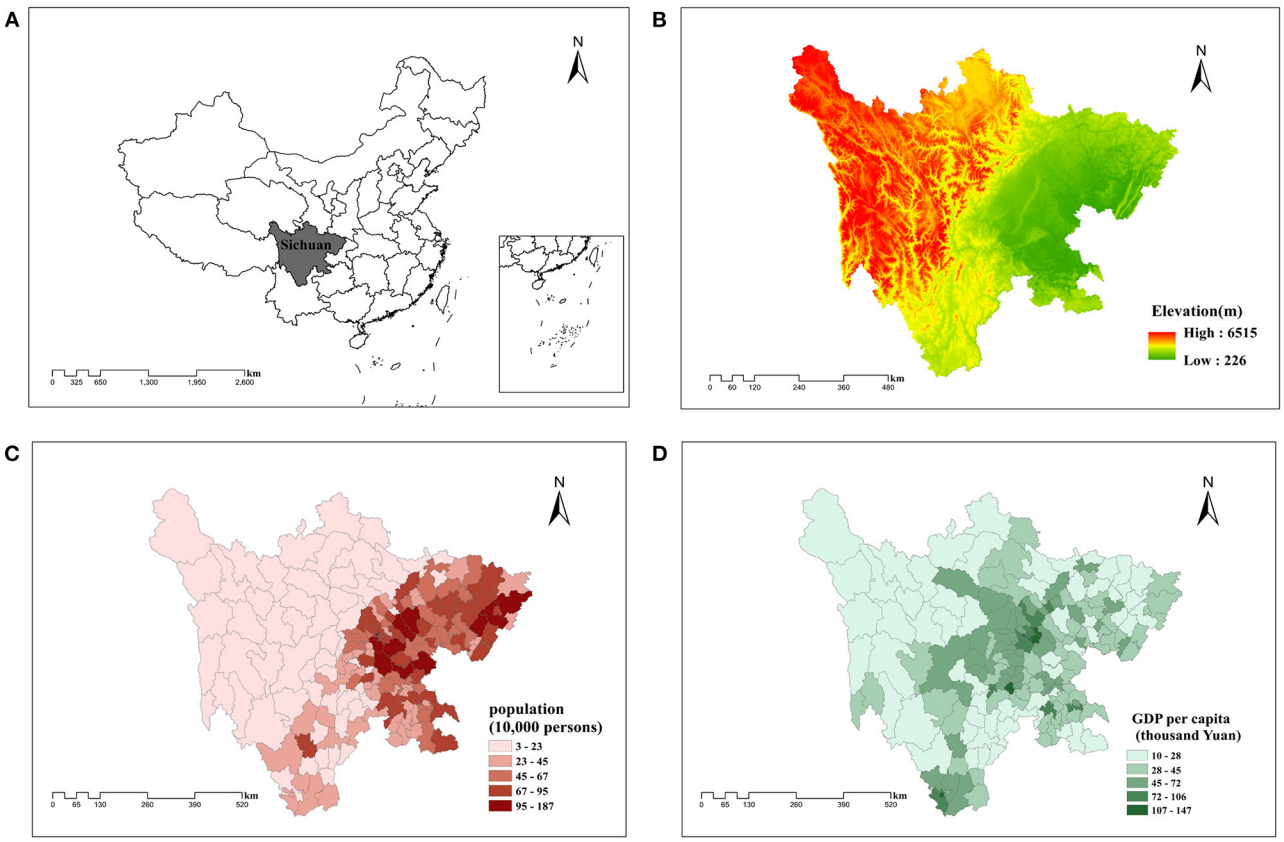

FIGURE 2 | (A) Geographic position, **(B)** topography, **(C)** demography, and **(D)** economic development in Sichuan Province, China. The data for geographic position and topography are from AutoNavi. Copyright 2021 by Amap.com. The data for demography and economic development are from The Statistical Yearbook of Sichuan Province, by Sichuan Provincial Bureau of Statistics, 2019 (http://tjj.sc.gov.cn/tjnj/cs/2019/zk/indexch.htm). Copyright 2021 by China Statistics Press.

the relationship between regional economic development and investment efficiency which was measured by PCA-DEA model. Finally, we combined the two analysis results to shed light on what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures from the perspectives of both investment equity and efficiency, i.e., the second research question.

Study Area

Using Sichuan Province as the study area, this study was designed to reflect the overall situation of healthcare infrastructure construction in China to a certain extent. Sichuan Province is a southwestern province in China (**Figure 2A**), where the land area and GDP per capita ranked fifth and nineteen, respectively, among 31 provinces of Mainland China, with a population of 83.41 million reported in 2018 (55). As indicated by **Figures 2B–D**, eastern Sichuan is characterized by plains, dense population, and high-level economic development, while western Sichuan is in the opposite situation (49). Such geographical characteristics and economic development status in Sichuan province made this region an ideal study area for simulating the nationwide situation. Similarly with Sichuan Province, approximately 41% of the entire population in China reside in the eastern China which has experienced rapid economic development with its topography characterized by plains and hills. In contrast, the western China has a much lower economic development pace which is sparsely populated and covered by mountains and plateaus.

Study Period

As the construction of hospital buildings is a time-consuming process, a time slot was set between the initiation of project and the production of related activities and outcomes in order to evaluate the overall investment efficiency. Based on the consultation with Health Commission of Sichuan Province, we finally set 2 years as the time slot[4]. As the result, investment data from 2009 to 2016 was adopted for assessing the investment equity while other relevant data was collected from 2009 to 2018 for evaluating the overall investment efficiency from 2009 to 2016.

Data Sources

The Department of Statistics of Health Commission of Sichuan Province (http://wsjkw.sc.gov.cn/scwsjkw/zsdw1/2019/3/

[4]According to our data, all hospitals completed the projects within two years.

22/9eb15f774d5549ff9a99c979fa8a0e2b.shtml) provided the information about all governmental-invested hospital building construction projects which was retrieved from its information management system. The data from 2009 to 2016 contained the names and locations of governmental-invested hospitals, the planned building areas, as well as the amount of investment from all funding sources.

Relevant hospital-level data from 2009 to 2018 were administrative data extracted from the hospital annual report and also provided by Health Commission of Sichuan Province, which included each governmental-invested hospital's basic and delivery information. The hospital's basic information included the total number of hospital beds, total value of equipment above 10,000 Yuan, number of healthcare workers, hospital level (primary, secondary, tertiary, and un-graded), whether general, hospital building area, and proportion of staff with senior professional titles. The hospital's delivery information included outpatient revenue, inpatient revenue, outpatient and emergency department patient volume, number of inpatient discharges, number of inpatient surgical procedures, bed days per physician per day, bed turnover rate, and office visits per physician per day.

The county-level data from 2009 to 2018 were extracted from the statistical yearbook of Sichuan Province, including each county's information about its population, urbanization rate, and GDP per capita.

We used the unique hospital code and county code to match the hospital-level data and county-level data to governmental-invested hospital building construction projects, separately. Our sample contained 330 governmental-invested hospital building construction projects which was further adopted for the concentration index computation, among which three projects related to new hospital building construction projects were excluded due to its huge heterogeneity among all kinds of hospital construction projects. Nine projects with missing values were also excluded. After the exclusion step, 318 projects were finally used to explore the relationship between economic development and investment efficiency. All kinds of currencies were adjusted for inflation rates, and measured in 2016 RMB.

Empirical Strategy

Evaluating the Distribution of Government Investment

We used the concentration index (CI) to describe equity in the geographic distribution of government investment in hospital building construction. All of 330 projects from 2009 to 2016 were included in this analysis.

The concentration index, which has been widely used to describe equity (56–58), evaluates the distribution of health resources against economic status (59). The concentration index is defined as twice the area between the concentration curve (cumulative proportion of health resources projected onto the corresponding cumulative proportion of wealth) and diagonal, ranging from -1 to $+1$. The index value equaling zero implies no socioeconomic inequality, a positive value indicates a concentration of health resources in high economic development regions while a negative value represents a concentration of health resources in low economic development regions.

The amount of investment from government used for CI calculation included both central and provincial governments investment. We pooled all the amount in a county in 1 year, and then divided by the county's population, based on which we calculated the concentration index.

Exploring the Relationship Between Regional Economic Development and Efficiency

We first conducted data envelopment analysis along with principal component analysis (PCA-DEA model) in order to compute the investment efficiency. Then, we used tobit model to explore the relationship between regional economic development and investment efficiency.

Data envelopment analysis (DEA) is a non-parametric method for efficiency measure (34). DEA allows for simultaneous consideration of multiple inputs and outputs, which is suitable for measuring the efficiency of complex systems as required in our study. We used BCC model (a kind of DEA model) proposed by Charnes et al. (60) to estimate the investment efficiency. The BCC model is defined as follows:

$$S.T.\begin{cases} \mathrm{Max}\theta_{\mathrm{k}=} \sum_{r=1}^{s} u_{rk} y_{rk} \\ \sum_{i=1}^{m} v_{ik} x_{ik} = 1 \\ \sum_{r=1}^{s} u_{rk} y_{rj} - \sum_{i=1}^{m} v_{ik} x_{ij} \leq 0; j = 1, \ldots, n \\ u_{rk} \geq 0, r = 1, \ldots, s \\ v_{ik} \geq 0, r = 1, \ldots, m \end{cases} \quad (1)$$

where θ_k is the efficiency of building construction project of hospital k. u_{rk}, v_{ik} represents the coefficients of rth output and ith input, respectively. The estimated efficiency ranges from 0 to 1, with higher values indicating higher efficiency.

The variables in the processes and outcomes parts in the framework were set as inputs and outputs in the BCC model, respectively. Apart from the planned building area indicator, the values of inputs and outputs were in forms of the difference between the value in the project beginning year and that of 2 years later. Thus, we collected relevant data from 2009 to 2018 to estimate the efficiency of the projects from 2009 to 2016. Despite the uniqueness embedded in our study, most of the inputs and outputs are consistent with literatures (37, 43–46).

Due to the excessive number of outputs in our study, we used principal component analysis (PCA) to reduce the number of variables in advance. In the integrated approach of PCA and DEA (PCA-DEA model), principal component analysis (PCA) was applied to replace the original s outputs with a smaller group of principal components. Using principal components instead of the original data does not affect the properties of the DEA model (61). Following Kaiser and Morrison (62, 63), the components selection criteria were described as follows. First, eigenvalue of the component should be more than 1. Second, selected components should account for 80 percent of total variance.

Finally, tobit regression model was applied to explore the relationship between regional economic development and the investment efficiency. Censored efficiency scores (0–1) is not suitable for OLS method, so it is preferable to regress using tobit model. Following Cheng and Zere (45, 64), we transformed the technical efficiency scores into inefficiency scores for convenient

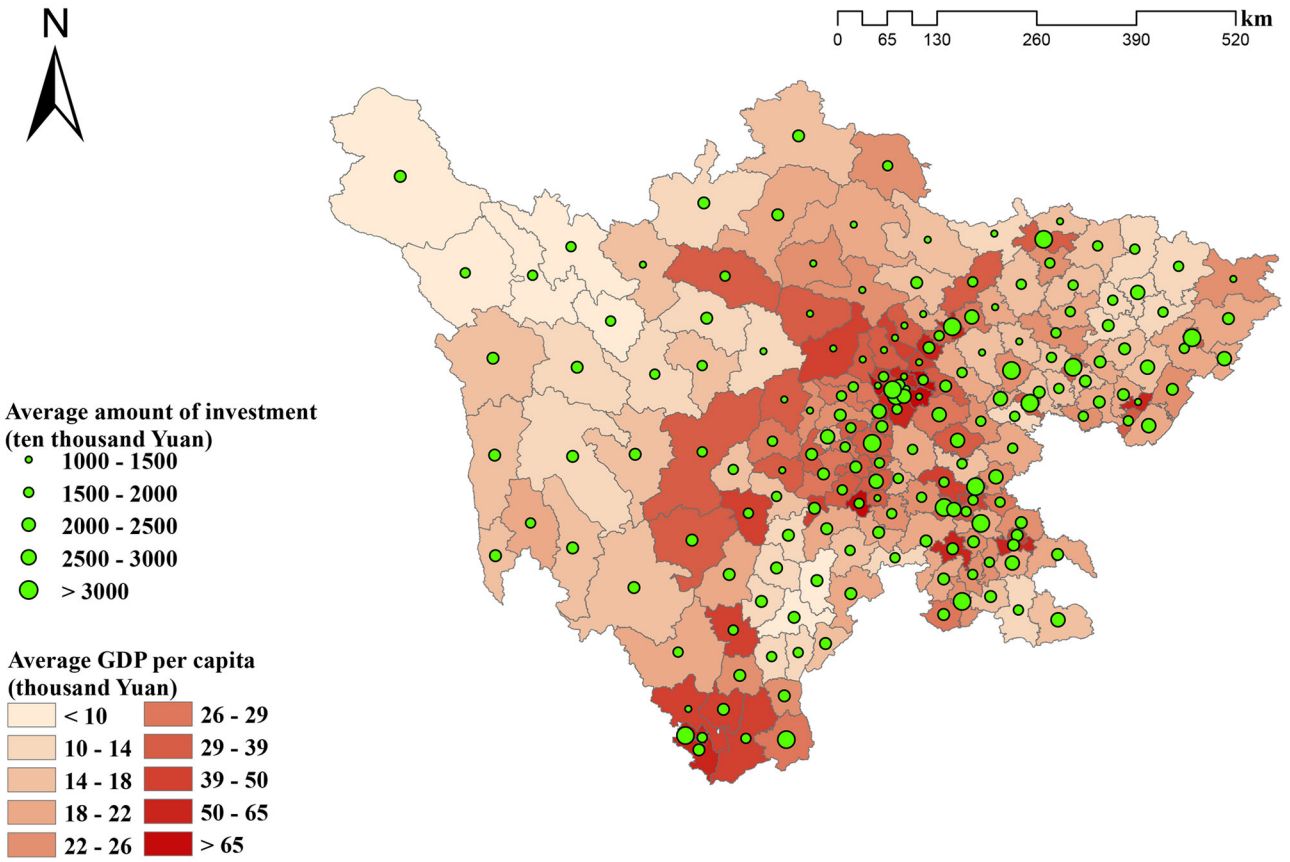

FIGURE 3 | The distribution of average amount of provincial and central governments investment among counties from 2009 to 2016.

computation. After transformation, the censoring point in tobit model was at zero. This transformation of the dependent variable also reversed the signs of the coefficient in the regression. The transformation formula is as follows:

$$Inefficiency\ score = \left(\frac{1}{Technical\ efficiency\ score}\right) - 1 \quad (2)$$

The tobit model was set as follows:

$$Inefficiency_{i,t} = \beta 0 + \beta \mathrm{Log}(GDP\ per\ capita_{i,t}) + \gamma' H_{i,t} + \zeta' County_{i,t} + \varepsilon_{i,t} \quad (3)$$

$H_{i,t}$ is a vector of hospital basic characteristics, including hospital level (primary, secondary, tertiary, and un-graded), whether general, hospital building area, amount of investment from provincial and central government, total number of hospital beds, total value of equipment above 10,000 Yuan, number of healthcare workers, and proportion of staff with senior professional titles. $County_{i,t}$ is a vector of variables related to county's characteristics, including population and urbanization rate. $\varepsilon_{i,t}$ is the error term. Given that the original condition of hospitals such as level, size, et al. should be controlled for in the regression model, the $H_{i,t}$ and $County_{i,t}$ variables are included with the values in the project beginning year. The robust standard errors were used to correct heteroskedasticity (65).

β is the coefficients of interest. A positive value means that GDP per capita is negatively associated with investment efficiency.

It is worth noting that for continuous variables, we employed the median to describe the data. For normally distributed data, median is consistent with mean (66); for skewed data median is the better summary measure (67). Thus, win-win for median. In this study, all analyses are conducted using R 3.6.3, SPSS 23.0, and DEAP 2.1. $P < 0.05$ is used to determine statistical significance.

RESULTS

Equity in the Distribution of Government Investment in Hospital Building Construction

Figure 3 depicts the distribution of averaged amount of provincial and central governmental investments among counties from 2009 to 2016. In terms of governmental investments on hospital building construction projects,

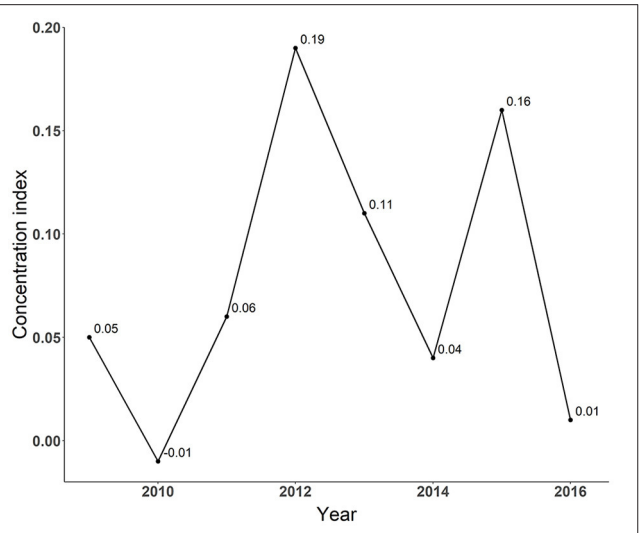

FIGURE 4 | Concentration index of government investment in hospital building construction.

significant discrepancies were found among different regions, showing that regions with higher averaged amounts of the investment per county mainly clustered in the economically developed eastern region. An opposite situation was identified in the western region. **Figure 3** qualitatively implies that the governmental investment varied among regions with different levels of economic development, which ultimately led to investment inequity.

Concentration index was further employed to quantitatively. assess the degree of inequity. **Figure 4** reports the results of concentration index. The values ranged from −0.01 to 0.19, all of which were positive except for the negative value in 2010. As a positive concentration index value indicates a concentration of health resources in high economic development regions, the results demonstrated a slight concentration of governmental investment in regions with highly developed economic status, with more than half of its positive values <0.1 (ranging from 0.01 to 0.06).

The Relationship Between Regional Economic Development and Efficiency of Hospital Building Construction Project

Table 2 shows the descriptive statistics of inputs and outputs in DEA model. The medians of planned building area demonstrated an inverted U-shaped from 2009 to 2016, indicating that the scale of hospital building construction has regained attention in recent years. Apart from bed days per physician per day and admission ratio within municipality, the values of inputs and outputs were found to be significantly positive in most years. The median of total number of hospital beds, for example, ranged from 31 to 70 across years.

Prior to the adoption of DEA, we conducted principal component analysis (PCA) to reduce the number of outputs. KMO test and Bartlett Spherical Detection were firstly used to detect whether the outputs listed in **Table 2** were suitable for PCA. The statistics of KMO test was 0.952 and the *P* value of Bartlett Spherical Detection was <0.001 (**Supplementary Table A1**), which validated the rationale of Principal Component Analysis for these variables (68, 69). **Table 3** shows the principal components from PCA. Five principal components with eigenvalues >1 were selected, which accounted for 82.6% of the total variance. Principal component scores instead of original outputs were used in DEA model.

Following DEA, we employed tobit model to explore the relationship between regional economic development and investment efficiency. **Table 4** demonstrates the descriptive statistics of regression variables. Of note, we reported the efficiency score in **Table 4** but inefficiency score was employed as outcome variable in tobit regression. The medians of efficiency in most years reached up to 1 (censored point), implying the necessity of tobit model. The median of the GDP per capita ranged from 14,756 Yuan to 27,490 Yuan during 2009 to 2016, with the interquartile ranging from 7,301 to 13,818. The majority (67.9%) of the governmental-invested hospitals were found to be secondary hospitals, followed by primary (25.5%), un-grade (4.1%) and tertiary (2.5%) hospitals. Among them, the general hospitals accounted for 63.5% of the analyzed sample. The medians of the amount of investment from provincial and central governments demonstrated an inversed U-shaped trend ranging from 2,437 ten thousand Yuan to 3,920 ten thousand Yuan, which implied that the scale of governmental investment in single hospital building construction projects regained increased attention. The descriptive statistics of other independent variables are not reported in the text due to the space limitation but can be found in **Table 4**.

Table 5 shows the regression results. The coefficient of tobit model regression on inefficiency scores for nature log transformation of GDP per capita was 0.044 and significant at 5% level. The results suggested that higher GDP per capita associates with lower investment efficiency. We also reported the results from OLS regression whose dependent variable was not transformed by Equation 2 to check the sensitivity of our estimator. As indicated by the results, the OLS regression also identified a negative relation between GDP per capita and investment efficiency ($\beta = -0.016$, $p < 0.05$).

In terms of the other co-variables, the coefficient of population was 0.004 and significant at 5% level, which implied the similar association with efficiency like GDP per capita. Compared with primary hospitals, secondary and tertiary hospitals tend to have lower project efficiencies, with the significant coefficients reported as 0.077 and 0.072, respectively. However, un-grade hospitals had no significant difference compared with primary hospitals. The relationship between the amount of investment from provincial and central government and investment efficiency was found to be negative and even significant at 0.1% level. There were no significant differences associated with other covariates.

Robust Test

In robust test, we modeled GDP per capita as categorical variable with 5 quantiles. **Table 6** reports the results of robust test. The

TABLE 2 | Descriptive statistics of inputs and outputs.

Variables	2009	2010	2011	2012	2013	2014	2015	2016
Inputs (Processes in framework)								
Planned building area	12,787 (5,250)	10,545 (6716.25)	9,100 (4139.50)	9,500 (12,720)	9,000 (5,717)	8,710 (14,228)	12,000 (16,050)	13,500 (7,559)
Total number of hospital beds	49.50 (86.25)	40 (94.75)	53 (93.50)	48 (192)	52 (117.50)	31 (73)	70 (184)	32.5 (78.50)
Total value of equipment above 10,000 Yuan	340 (642.25)	327 (719)	175 (998.50)	2,765 (4,980)	764 (3,040)	1697.50 (4247.25)	1,015 (3,035)	121.50 (753.25)
Number of healthcare workers	42.50 (67)	21 (60.50)	34 (71)	83 (157)	74 (78)	79 (143)	51 (125)	38 (55.75)
Proportion of staff with senior professional titles	−24.25 (54.39)	−0.38 (81.85)	−78.70 (48.42)	19.89 (44.07)	55.86 (75.23)	41.24 (120.68)	41.40 (92.85)	56.94 (95.42)
Outputs (Outcomes in framework)								
Outpatient revenue per 10,000 population	87.61 (93.84)	136.86 (148.04)	91.73 (326.58)	547.01 (875.30)	189.32 (352.16)	294.74 (366.61)	247.78 (599.78)	151.87 (233.87)
Inpatient revenue per 10,000 population	235.24 (229.84)	322.51 (363.84)	428.79 (771.95)	966.45 (1698.37)	360.28 (662.17)	619.84 (847.08)	733.89 (1032.80)	329.04 (342.30)
Outpatient and emergency department patient volume per 10,000 population	214.60 (478.89)	514.65 (821.24)	466.17 (1383.71)	910.70 (1732.88)	725.16 (1101.92)	1053.72 (1398.80)	546.20 (1365.15)	667.70 (987.46)
Number of inpatient discharges per 10,000 population	29.27 (54.11)	50.48 (64.81)	49.09 (114.00)	74.40 (122.94)	28.28 (51.87)	50.66 (78.67)	53.03 (88.35)	32.64 (53.49)
Number of inpatient surgical procedures per 10,000 population	4.10 (11.45)	5.45 (13.36)	1.90 (20.96)	25.41 (52.19)	10.34 (22.43)	15.73 (25.96)	19.41 (35.66)	5.46 (25.68)
Bed days per physician per day	−0.09 (0.43)	−0.20 (0.46)	−0.42 (0.77)	−0.37 (0.56)	−0.42 (0.51)	−0.40 (0.51)	−0.35 (0.45)	−0.51 (0.37)
Bed turnover rate	−2.72 (14.04)	−0.01 (11.12)	1.01 (4.77)	1.36 (4.85)	−0.20 (8.12)	0.96 (7.10)	0.87 (6.47)	0.46 (7.56)
Office visits per physician per day	0.00 (0.96)	0.56 (1.41)	0.19 (0.85)	0.10 (1.03)	−0.23 (1.32)	−0.13 (0.92)	−0.03 (1.17)	0.03 (1.12)
Admission ratio within municipality	0.81 (12.23)	−1.74 (12.96)	−0.31 (4.68)	−0.74 (5.91)	−1.02 (8.98)	−3.43 (8.06)	1.67 (6.88)	−2.55 (3.77)
N	56	56	51	33	27	30	37	28

Median (interquartile range) is shown in the table.
The units of equipment value and revenue is 10,000 Yuan and 1,000 Yuan respectively; the unit of planned building area is square meter.
Except planned building area, the values of inputs and outputs are in forms of the difference between the value of project beginning year and that of 2 years later.

TABLE 3 | Principal components from principal component analysis.

Principal components	Eigenvalues	Output variables
PC 1	3.20	Outpatient revenue per 10,000 population, Inpatient revenue per 10,000 population, Outpatient and emergency department patient volume per 10,000 population
PC 2	2.56	Number of inpatient discharges per 10,000 population, Number of inpatient surgical procedures per 10,000 population
PC 3	2.07	Bed days per physician per day, Office visits per physician per day
PC 4	1.55	Bed turnover rate
PC 5	1.07	Admission ratio within municipality

transformation of key independent predictor from continuous variable to categorical variable did not have a significant effect on the effect size of GDP per capita, while a higher quantile of GDP quantile was found to be associated with lower investment efficiency. However, we found a statistically significant difference merely embedded between the lowest and highest quantile of GDP per capita, which could be attributed to both the poor variation in the dependent variable and the lower power of test due to the transformation.

DISCUSSION

In this study, we focused on hospital building construction projects as the most reflective aspect of infrastructure construction in China. Our study aims to examine whether the investment efficiency is lower where a government prioritizes equity and to explore what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures from the perspectives of both investment equity and efficiency. The concentration index was used to describe the distribution equity of governmental investments while tobit regression was adopted for the first research question

TABLE 4 | Descriptive statistics of regression variables.

Variables	2009	2010	2011	2012	2013	2014	2015	2016
Dependent variable								
Efficiency scores	1 (0.04)	0.99 (0.07)	0.97 (0.09)	1 (0.01)	1 (0.00)	1 (0.00)	1 (0.05)	0.99 (0.05)
Explanatory variables								
GDP per capita	14755.56 (7300.77)	17169.75 (13939.49)	25584.43 (18856.14)	35460.51 (29622.80)	29472.73 (17990.80)	37447.84 (19896.80)	32102.58 (19120.52)	27,490 (13817.75)
Population	5.80 (5.57)	3.46 (5.99)	5.94 (5.60)	6.54 (5.09)	5.95 (3.39)	6.21 (2.98)	6.07 (4.09)	4.57 (4.68)
Urbanization rate	16.32 (7.70)	16.48 (19.02)	25.74 (28.59)	42.86 (40.48)	28.13 (34.87)	41.16 (25.36)	41.76 (31.81)	37.99 (14.02)
Hospital level *n (%)*								
Primary	1 (1.79)	2 (3.57)	4 (7.84)	1 (3.03)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Secondary	54 (96.43)	49 (87.50)	28 (54.90)	11 (33.33)	17 (62.96)	13 (43.33)	22 (59.46)	22 (78.57)
Tertiary	0 (0.00)	1 (1.79)	12 (23.53)	20 (60.61)	10 (37.04)	17 (56.67)	15 (40.54)	6 (21.43)
Un-grade	1 (1.79)	4 (7.14)	7 (13.73)	1 (3.03)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Whether general *n* (%)								
No	12 (21.43)	14 (25.00)	27 (52.94)	9 (27.27)	9 (33.33)	11 (36.67)	20 (54.05)	14 (50.00)
Yes	44 (78.57)	42 (75.00)	24 (47.06)	24 (72.73)	18 (66.67)	19 (63.33)	17 (45.95)	14 (50.00)
Hospital building area	16,138 (18070.50)	10031.50 (16559.75)	12,695 (19701)	58,687 (62670)	28,697 (50563.50)	33402.50 (76,599)	30,509 (53,776)	14718.50 (14063.50)
Amount of investment from provincial and central governments	2436.60 (60.16)	2506.79 (174.89)	2103.80 (752.94)	2160.51 (1674.40)	1996.58 (262.71)	2068.57 (2068.57)	1992.15 (962.96)	3,920 (1197.50)
Total number of hospital beds	216 (151.25)	130 (237.75)	310 (358.50)	830 (733)	400 (816.50)	600 (1002.50)	430 (370)	236 (442.50)
Total value of equipment above 10000 Yuan	1188.50 (1366.50)	669 (1,302)	780 (2960.50)	6,014 (13,684)	4,935 (10,390)	6794.50 (16,203.25)	3,760 (8,827)	2172.50 (3,497)
Number of healthcare workers	217.50 (144)	139 (224.75)	148 (304)	770 (739)	418 (778)	624.5 (1034.50)	402 (510)	255 (345.25)
Proportion of staff with senior professional titles	7.67 (3.07)	7.83 (3.46)	7.67 (1.98)	6.81 (2.16)	6.86 (2.29)	7.09 (2.43)	7.20 (1.68)	6.88 (1.78)
N	56	56	51	33	27	30	37	28

n (%): number (percentage).

Unless otherwise indicated, data are expressed as median (interquartile range) in the table.

The unit of population is 100,000; the unit of building area is square meter; the units of equipment value and amount of investment from provincial and central governments are 10,000 Yuan.

The values of independent variables are captured in the year of project beginning.

by exploring the relationship between regional economic development and investment efficiency measured by the PCA-DEA model. Our analysis revealed slight inequity in the distribution of hospital building construction investment in Sichuan province and identified a negative relationship between county's GDP per capita and efficiency. These findings implies that the investment efficiency is higher where a government prioritizes equity since higher investment efficiency and better social equity would be achieved via predisposed resource allocation toward underdeveloped areas. Besides, our findings also illustrate that Chinese government should change the current governmental investment strategy that favors the developed regions and we provided evidence-based suggestions for regional predisposition of governmental investment toward less developed regions in terms of enhancing both equity and efficiency.

Regarding regional distribution of governmental investment in hospital building constructions, predisposition of investment allocation was found toward economically developed regions, indicating inequity in investment allocations among different regions. Despite that only two out of four sources of governmental investment, namely central and provincial governmental investments were included in our analysis, such findings were still believed to be robust. Specifically, compared

TABLE 5 | Results of tobit model regression on inefficiency scores and OLS regression on efficiency scores.

Variables	OLS model (1)	Tobit model (2)
GDP per capita	−0.016*	0.044*
	(0.008)	(0.018)
Population	−0.001	0.004*
	(0.001)	(0.000)
Urbanization rate	0.000	−0.000
	(0.000)	(0.000)
Hospital level (reference: primary)		
Secondary	−0.034***	0.077**
	(0.007)	(0.026)
Tertiary	−0.033**	0.072*
	(0.013)	(0.036)
Un–grade	−0.015	0.042
	(0.011)	(0.032)
Whether general (reference: no)		
Yes	0.009	−0.015
	(0.007)	(0.015)
Hospital building area	0.000	0.000
	(0.000)	(0.000)
Amount of investment from provincial and central government	−0.000**	0.000***
	(0.000)	(0.000)
Total number of hospital beds	0.000	−0.000
	(0.000)	(0.000)
Total value of equipment above 10,000 Yuan	0.000	−0.000
	(0.000)	(0.000)
Number of healthcare workers	−0.000	0.000
	(0.000)	(0.000)
Proportion of staff with senior professional titles	0.001	−0.001
	(0.002)	(0.004)
Year dummies	Yes	Yes
N	318	318

GDP is adjusted for inflation rates, and measured in 2016 RMB.
GDP per capita is natural log transformed in regression analysis.
The unit of population is 100,000; the unit of building area is square meter; the units of equipment value and amount of investment from provincial and central government are 10,000 Yuan.
The values of independent variables in the regression model are captured in the year of project beginning.
The dependent variable in the tobit model was transformed via Equation 2, while not in the OLS model.
Robust standard errors shown in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*

TABLE 6 | Robust tests results.

Variables	Tobit model (1)	Tobit model (2)
GDP per capita (reference: lowest quantile)		
Secondary quantile	0.004	−0.003
	(0.017)	(0.015)
Third quantile	0.020	−0.017
	(0.019)	(0.016)
Fourth quantile	0.032	−0.027
	(0.025)	(0.022)
Highest quantile	0.068*	−0.058*
	(0.028)	(0.024)
N	318	318

GDP is adjusted for inflation rates, and measured in 2016 RMB.
In Tobit model (1), the technical efficiency scores were transformed into inefficiency scores as Equation (2), while efficiency score was employed as outcome variable in Tobit model (2).
Robust standard errors shown in parentheses.
$p < 0.05$.

with underdeveloped regions, both municipal and county governments in economically developed regions have more abundant budgets and put more emphasis on healthcare-related projects, thus tend to make more investment in hospital building construction projects. As the result, the inclusion of municipal and county governmental investments in this study, would be very much likely to produce a higher concentration index value which indicates a higher degree of inequity. Based on these considerations, our findings based on the exclusion of both municipal and county governments were considered as conservative results. At present, significant regional disparities reside in western and eastern parts of Sichuan Province in terms of the spatial accessibility to healthcare (29, 30). Under such circumstances, however, the current governmental investment predisposition toward economically developed regions continues to exacerbate the existing inequity thus further widening the gap among different regions. Therefore, optimization of governmental investment in hospital building construction is urgently needed via switching the investment predisposition toward less developed regions.

Another finding of our study was the identification of a negative relationship between the county's GDP per capita and the investment efficiency, which implied that a hospital in a county with higher GDP per capita would implement the project with lower efficiency. The underlying reasons of such negative relationship were explained from the perspectives of both demand and supply. Based on China Health and Nutrition Survey (CHNS) dataset, Xue (70) found that patients living in less developed provinces had less inclination for seeking medical treatment than patients living in economically developed provinces, which could be attributed to the lack of healthcare facilities in less developed regions. Poor spatial accessibility to healthcare typically lays tremendous hinderance for healthcare utilization (71), while there is a poorer spatial accessibility in less developed regions (30). As the consequence, it is not difficult to predict that higher efficiency would be achieved in less developed regions for hospital reconstruction, expansion or branch construction projects as these projects are desperately needed in such underdeveloped regions for meeting residents' healthcare demands. Likewise, projects related to scale upgrade or renewal of hospitals would very much likely to bring about competitive advantages for hospitals engaged in these projects in terms of attracting patients from other hospitals as the lack of large-scaled hospitals remains a critical problem in underdeveloped regions. In contrast, such competitive advantages would be largely weakened in

economically developed regions due to the abundance of large-scaled hospitals in developed areas given the same investment allocations, thus leading to lower investment output and lower investment efficiency.

Despite that hospital building construction project was selected as the only focus in this study, our findings have reflected the overall situation of healthcare infrastructure construction in China to a large extent. It is noteworthy that the geographical inequality embedded in governmental investment allocations tends to escalate in the aspect of medical equipment compared with hospital building constructions. Specifically, hospitals at higher levels mainly concentrate in developed regions and typically require abundant top-tier medical facilities, thus making the predisposition of governmental investments in medical equipment promotion toward developed regions. In addition, our findings related to investment efficiency in this study could also be applied in the aspect of governmental investments in medical equipment promotions, where a list of theories about higher unsatisfied demand, higher marginal output as well as stronger competitive advantage among less developed regions as previously discussed would still be applicable.

Consistent with previous studies (27–33), our findings also provide suggestions for regional predisposition of governmental investment in healthcare infrastructure toward less developed regions. However, previous studies only assessed the locations of existing healthcare facilities from the perspective of distribution equity and failed to capture the investment efficiency across different economically developed regions. In the contrary, our study was designed to measure the investment equity and efficiency simultaneously and aimed to explore what kind of geographical predispositions should be embedded in governmental investment plans for hospital infrastructures from the perspectives of both investment equity and efficiency. Therefore, our study was endowed with the ability to provide more valid evidence-based implications for governmental investment decision-making issues.

Several limitations should be noted in this study. First, because the government funds were applied for by hospital itself, the self-selection problem may lead to the bias of the calculation of concentration index and investment efficiency. However, as most of the public hospitals in China would apply for governmental investment due to the daunting cost of hospital building constructions, such bias induced by the self-selection issue would very much likely be minimized in our study. Second, the calculation of investment efficiency could be biased in this study as we were only able to obtain governmental investment data on hospital building constructions without involving other aspects such as personnel training programs. Nevertheless, the impact of such potential confounders that we failed to involve in this study would very much likely be minimized by the first-order difference of the output variables in the DEA model with a time span of only 2 years. Further, we do not think that the potential biased efficiency scores would make a big difference to the conclusions derived from the results of regression models. In China, municipal or county governments can independently decide the amount of investment (see Text A.1 in the **Supplementary Material** for more details). The amount of governmental investment in hospitals is affected by numerous factors such as level of regional economic development, thought of government leaders and so on. Therefore, it would be prudent to conclude that the unmeasured governmental investments in this study could demonstrate predisposition toward economically developed regions, which indicated actual higher investment inputs based on current outputs in hospitals located in these regions. Thus, the hospitals' efficiency scores in the economically developed regions would very much likely be overestimated, leading to a dilution of the estimated negative relation between regional economic development and investment efficiency. Third, due to the lack of data related to governmental investments in other aspects, we were only able to investigate the short-term effect of hospital building construction via evaluating the investment efficiency instead of further exploring its long-term effect. Therefore, it is highly recommended that such gap be bridged in future studies once the relevant data are obtained.

CONCLUSIONS

In the study, we revealed slight inequity in the distribution of hospital building construction investment in Sichuan province where more investment went to the economically developed regions. We also identified a negative relationship between county's GDP per capita and investment efficiency, which implied that the investment efficiency would be higher where a government prioritized equity. Combining the findings, we advocated that the governments in China should switch governmental investment predisposition in the aspect of healthcare infrastructure construction toward less developed regions from the perspectives of both investment allocation equity and efficiency. Such findings and conclusions were also expected to provide evidence-based implications for other developing countries confronted with similar governmental investment decision-making issues.

DATA AVAILABILITY STATEMENT

The information about all governmental-invested hospital building construction projects is available from the Department of Statistics of Health Commission of Sichuan Province (http://wsjkw.sc.gov.cn/scwsjkw/zsdw1/2019/3/22/9eb15f774d5549ff9a99c979fa8a0e2b.shtml), but restrictions apply to the availability of these data. The data can also be made available from the authors upon reasonable request and with permission of the Health Commission of Sichuan Province. The hospital-level data which were extracted from the hospital annual report are available from Health Commission of Sichuan Province, but restrictions apply to the availability of these data. The county-level data are publicly available, which can be obtained from the statistical yearbook of Sichuan Province. Requests to access these datasets should be directed to Jay Pan, panjie.jay@scu.edu.cn.

AUTHOR CONTRIBUTIONS

JP conceptualized the study. JP and TL collected the data. TL and TC developed the analysis method and implemented the data analysis. TL drafted the manuscript. JP, TL, YH, TC, and YY revised the manuscript. All authors read and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.719839/full#supplementary-material

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Institutional Design and Incentives for Migrant Workers to Participate in Social Insurance in China: Evidence From a Policy Experiment in Chengdu City

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Rural-to-urban migration has increased rapidly in China since the early 1980s, with the number of migrants has reached 376 million by 2020. Despite this sharp trend and the significant contributions that migrants have made to urban development, the migrant workers have had very limited access to the social insurance that the majority of urban workers enjoy. Against the background of the social insurance system adjustment in Chengdu in 2011, this study uses a difference-in-differences (DID) model to empirically test the impacts of changes in the social insurance policy contribution rates on the social insurance participation rates of migrant workers, using the China Migrants Dynamic Survey (CMDS) data for 2009–2016. We find that the social insurance participation rate of migrant workers was significantly reduced after they were incorporated into the urban worker insurance system. There was no significant change in the wages of migrant workers, but the working hours were increased and their consumption level decreased. In other words, simply changing the social insurance model of migrant workers from "comprehensive social insurance" to "urban employee insurance" reduces the incentives for migrant workers to participate in insurance and harms the overall welfare of migrant workers. Our study indicates that the design of the social security policy is an important reason for the lower participation rate of migrants. It is necessary to solve the problem of insufficient incentives through the targeted social security policies; primarily, the formulation of a social security policy contribution rate suitable for the migrants, and the establishment of a comprehensive social security policy and the gradual integration of the social security system.

Keywords: social insurance, contribution rate, participation incentive, migrant workers, difference-in-difference

INTRODUCTION

In recent years, the social insurance system of China has gradually improved, and the social insurance coverage rate for urban workers had reached 54.01% by 2018. However, the social insurance coverage for migrant workers is still far behind that of other groups. **Figure 1** depicts the participation of migrant workers in various insurance types. The number of migrant workers

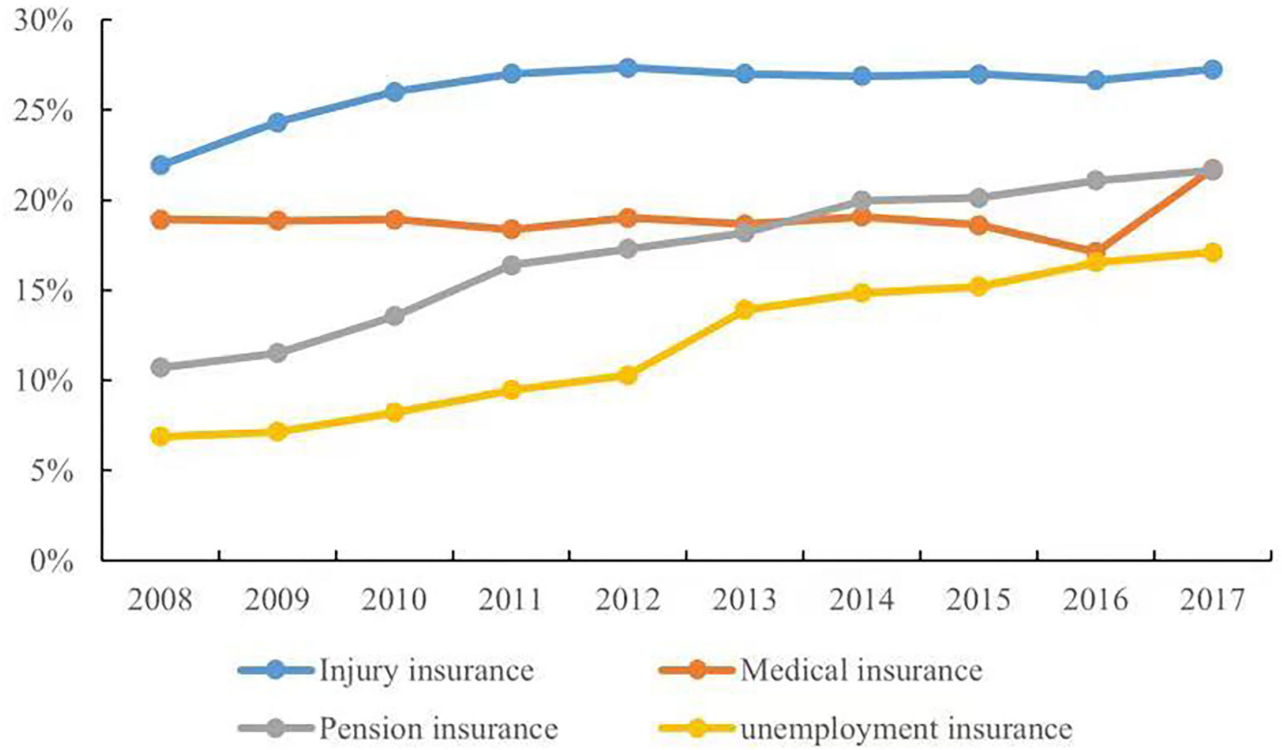

FIGURE 1 | The proportion of migrant workers participating in the urban basic social insurance. Data obtained from the Bulletin of Human Resources and Social Security Development Statistics (2008–2017).

participating in social insurance has increased year by year, but the participation rate in pension and medical insurance is around 20%, while the participation rate in unemployment insurance is only 15%, and the highest participation rate, in injury insurance, is less than 30%. According to the Seventh Census of China, taken in 2020, the number of migrant workers had reached 376 million, accounting for 26.63% of the total population. The migrant workers have made great contributions to urban development, but they do not enjoy the same benefits as the local urban workers (1–4). In China, social insurance is often tied to household registration called hukou; however, the places where they work, are separate from the location of their household registrations. As a result, migrant workers are often excluded from social insurance coverage in inflow cities. Given a large number of migrant workers, participation in basic social insurance in inflow cities is crucial to the smooth urban integration of migrant workers. The general lack of protection for the migrant workers in terms of work injury, unemployment, medical care, and pension will undermine their labor rights and interests, and weaken their resistance to risks, while also increasing social inequality (5–7).

The three causes of this low participation rate have been summarized in the literature. First, the social insurance system for migrant workers in China has poor portability and fragmentation (2). The migrant workers suffer from institutional discrimination in the job market and have difficulty participating in the local social insurance in the inflow cities. In addition, it is difficult to transfer social insurance; for example, the medical insurance purchased by migrant workers in their home location cannot be used in the inflow city (2, 8–11). Second, the demand characteristics of migrant workers are an important reason for their reduced willingness to participate in insurance. The migrant workers, who are relatively less educated, underestimate their risk of illness and lack sufficient far-sightedness to consider the issue of securing a pension for the future. Given the low income of migrant workers, they often choose to increase their current income and give up participating in social security, in the face of a high social insurance premium rate (12, 13). Third, the social insurance for employees is paid by both the firm and the employee in China, with the firm contributing about 80% of the premium. The social insurance cost of employees already accounts for more than 40% of the labor cost of firms in China, which is significantly higher than that in other Asian countries (14). Most firms that employ migrant workers are labor-intensive firms with relatively low-profit margins. The social insurance costs increase the operating burden on the firms. Consequently, many of these firms choose not to provide insurance for their employees (15–21).

With the improvement of the social insurance system, the institutional barriers faced by the migrant workers to participate

Abbreviations: CI, Urban Employee Basic Medical Insurance; UEBMI, Urban Employee Basic Medical Insurance; DID, Difference-in-difference; DDD, Difference-in-difference-in-difference.

in social insurance have gradually been eliminated. However, the problem of insurance evasion by individuals and enterprises due to insufficient incentives for social insurance participation has become increasingly prominent. For the special group of migrant workers, what kinds of trade-offs will they make when facing the costs and benefits of different social insurance patterns? Which would they prefer, a low premium rate and a low social insurance benefit or a high premium rate and a high social insurance benefit? These questions have not been answered well. Given the low participation rate of migrant workers in social insurance, it is necessary to discuss the incentive problem of participation in social insurance from the perspective of social insurance pattern design. Only by considering the particularity of migrant workers and providing sufficient incentives to them to participate in insurance, the coverage of social insurance can be effectively expanded. The insurance incentives for the migrant workers are more flexible, especially when the setting of the policy premium rate is more sensitive, which needs further consideration.

At present, there are two main patterns of social insurance for migrant workers. One is the Urban Employee Basic Medical Insurance (UEBMI), which includes basic pension insurance, basic medical insurance, unemployment insurance, work injury insurance, and maternity insurance; most enterprises will buy complete insurance packages for their employees, but some enterprises only buy some types of insurance to reduce the costs. Comprehensive insurance (CI) is the other type of insurance developed for migrant workers. CI features some important insurance policies, such as work injury insurance and medical insurance. Compared with UEBMI, CI has a lower level of benefits, but the premium rate is also lower as shown in **Table 1**.

Chengdu, the central city in western China, absorbs a large number of migrant workers. According to the data of Chengdu's Seventh Census, taken in 2020, the number of migrant workers has reached 10.72 million, ranking among the top 10 in China. The social insurance pattern of the migrant workers in Chengdu saw a significant shift from CI to UEBMI after 2011, providing a quasi-natural experimental environment to answer these questions. Up to 2011, Chengdu had provided CI for the migrant workers, which included five types of insurance, such as pension insurance and basic medical insurance. The premium for comprehensive reimbursement was 20% of the premium base, of which 14.5% was borne by the enterprises and 5.5% by the migrant workers. After 2011, Chengdu provided UEBMI for migrant workers, and although the insurance benefits were higher, it also increased the burden of payment for both the firms and migrant workers. This reform did not include migrant workers in the construction industry, who continued to be insured by CI, thus providing a control group for this study. Based on the China Migration Dynamics Survey data for 2009–2016, this study uses the difference-in-differences (DID) method to empirically verify the impact of social insurance policy premium rate setting on the insurance participation of migration workers in Chengdu. We attempt to provide a strong complement to analyze the equity of social insurance participation and incentives to participate in the insurance for migrant workers in China.

METHODOLOGY

Data Source

This study used the 2009–2016 data from the China Migrants Dynamic Survey (CMDS), conducted by the National Health Commission, P.R. China. The CMDS subjects are migrant workers from 31 provinces, autonomous regions, municipalities, and Xinjiang Production and Construction Corps, aged 16–59, with agricultural household registrations, and working as employees. These subjects have lived in the place of inflow cities for more than 1 month and do not have local household registration (Hukou). The survey has been conducted annually since 2009 but does not comprise balanced panel data because the sample is not the same from year to year. The data have a long-term span, strong representativeness, and a rich set of variables. The survey not only encompasses the basic characteristics of migrants, but also their work, family members, and insurance participation.

Variables

Participation by migrant workers in injury insurance is the highest and most practical, so this study mainly examines the participation rate in the injury insurance of workers. The key dependent variable in our analysis relates to the decision to participate in injury insurance. Three indicators were utilized: first, whether to participate in injury insurance; second, whether to participate in either injury insurance or medical insurance; and third, whether to participate in any one of injury insurance, medical insurance, or pension insurance. In addition, this study verified the effects of premium rates on the wages, work hours, and consumption of migrant workers.

In the regression analysis, the study also controlled for the variables of the nature of migrant workers' employment units, working years, gender, age, education level, and the number of family members. The nature of the employment units is a dummy variable, which is equal to (1) if the unit of a migrant worker is a state-owned firm, (2) if it is a private firm, (3) if it is a mixed operation firm, and (4) if it is of another nature. The working years refer to the duration migrant workers have worked for since they left their hometowns.

Descriptive Statistics

As shown in **Table 2**, although the social insurance participation rate of the migrant workers has increased over the years, the overall level of participation in insurance was still very low. The participation rates in pension and medical insurance are about 20%, participation in unemployment insurance is less than 20%, and even the highest participation rate, in injury insurance, only averages about 30%. The numbers for maternity insurance and housing provident fund are even lower. The proportion of migrant workers participating in the UEBMI is still relatively low.

As shown in **Table 3**, the migrant workers are mainly engaged in manufacturing, construction, wholesale and retail, catering services, and social service industries. These industries often provide jobs with high labor intensity, low wages, high potential risks, and strong alternatives. **Table 4** lists the social insurance coverage in different industries based on the 2016 survey data,

TABLE 1 | Comparison of the two social insurance models.

Social insurance patterns	Premium rate	Social insurance benefit
Urban Employee Basic Medical Insurance	High	High
Comprehensive Insurance	Low	Low

TABLE 2 | The participation of migrant workers in social insurance from 2009 to 2016.

Year	Pension	Medical insurance	Unemployment insurance	Injury insurance	Maternity Insurance	Housing provident fund
2009	0.259	0.276	0.096	0.461	0.062	0.019
2010	0.125	0.053	0.101	0.287	0.071	0.033
2011	0.229	0.269	0.141	0.313	0.103	0.052
2012	-	0.276	-	-	-	-
2013	0.223	0.214	0.185	0.321	0.069	0.066
2014	0.241	0.228	0.191	0.276	0.138	0.083
2015	-	0.254	-	-	-	-
2016	0.311	0.224	0.274	0.333	0.237	0.123

such as five types of insurance and the housing provident fund. There are two obvious features. First, there are huge differences in social insurance coverage among the industries. The industries with the highest coverage rate of nearly 50% include mining, electricity, coal, water and heat supply, financial insurance, and real estate. However, there are very few migrant workers in these industries (as shown in sample proportion); the relatively low coverage rate of about 10% is found in agriculture, forestry, animal husbandry, fishing, construction, accommodation, catering, and others, and the migrant workers in these industries account for a larger proportion of the workforce. Second, the coverage rates of the five insurances and the housing provident fund are almost the same in different industries. That is, the companies either provide five kinds of insurance and the housing provident fund at the same time or do not provide them at all. Comparatively speaking, the coverage rate of provident funds is the lowest, and work injury insurance is the highest among the five insurances, followed by pension, unemployment, and medical insurance.

Estimation Models

To study whether an increase in the contribution rate of social security policies will reduce the incentives for migrant workers to participate in insurance, it is necessary to compare the changes in the participation of migrant workers in social security before and after the increase. However, other factors affecting the participation of migrant workers in social security also changed during the period under examination. For example, the implementation of the new Social Insurance Law in 2011 had a huge impact on the participation of migrant workers. Therefore, it is necessary to introduce the DID model, which is very suitable for assessing the policy effects. The specific method for constructing the DID model involves the establishment of a "treatment group," which has experienced an increase in the social security contributions, and a "control group," which has not undergone this change. By controlling other factors, comparisons can be made between the treatment group and the control group to test the effects of policy implementation. Chengdu's unique social security policy changes regarding the migrant population provide a good opportunity to build a DID model. The transformation of the social security system of non-urban employees in Chengdu was very different for those in the construction companies and those in other companies. First, those in non-construction enterprises experienced a significant change from CI to UEBMI in 2011, and their social security contribution ratio greatly increased; this can be regarded as the treatment group. The policy for non-urban household registration employees in construction enterprises remained unchanged; however, their social security contribution ratio was stable at 4%. They can, thus, be regarded as the control group. We use the differences in the social security policies of different industries in Chengdu around 2011 to construct the DID model:

$$Insurance_{\mathrm{it}} = \beta_0 + \beta_1 Time_{\mathrm{it}} + \beta_2 Industry_{\mathrm{it}} + \beta_3 Industry_{\mathrm{it}} * Time_{\mathrm{it}} + X_{it}\gamma + \varepsilon_{it} \quad (1)$$

In this equation, *Insurance* represents whether the migrant participates in the basic social insurance. This can be divided into three categories according to the importance and practicability of the insurance: participation in work injury insurance, participation in a work injury or medical insurance, and participation in a work injury, medical, or pension insurance. *Time* represents the time of the policy change, which is set to 1 in 2011 and thereafter, and 0 otherwise. *The industry* represents the industry in which the migrant workers are located and is divided into four categories according to the nature and scale of the work: "construction," "wholesale and retail, and accommodation, and catering," "manufacturing," and "other industries." To test the effects of policy reform, we set the cross-term *Industry* * *Time*, which is set to 1 only when both the treatment group and the time of the change are 1. In other cases, the cross-term was set to 0. In this way, the impact of the reforms from CI to UEBMI can be measured.

Other control variables include the nature of the employer, duration of employment, monthly income, gender, age, ethnicity, education, marital status, family size, number of children under 15 yr of age in the household, monthly household income, and monthly household expenditure.

For the robustness check section, a triple difference model or difference-in-difference-in-difference (DDD) was constructed. *Time* represents the time of change and is set to 1 when the year is 2011 and otherwise to 0. *Treat* represents the treatment group and control group in different industries. The construction industry, as the control group, was set at 0. In light of the analysis in the previous section, the wholesale and retail and accommodation and catering industries are more suitable as the treatment group and their value is 1. *The city* represents the treatment group and the control group by city. Chengdu has undergone the policy reform and so comprises the treatment

TABLE 3 | Industry distribution of migrant workers (%).

Industry	2009	2010	2011	2012	2013	2014	2015	2016
Agriculture	0.31	1.85	2.03	2.29	2.22	2.64	1.95	2.32
Mining	0.37	2.23	2.12	1.76	1.61	1.71	2.12	1.42
Manufacturing	44.34	35.88	36.50	34.64	34.37	31.40	35.61	30.18
Electric, coal and water production and supply	0.48	0.71	0.67	0.77	0.77	0.83	0.58	0.68
Construction	7.67	12.49	14.07	12.51	11.68	11.29	9.61	10.25
Transportation	3.24	4.44	4.35	4.36	4.00	4.31	4.04	4.92
Wholesale and retail	8.80	7.05	6.78	7.91	7.88	7.78	10.74	9.66
Accommodation	11.85	13.51	11.49	12.89	14.07	14.55	11.65	12.73
Financial, Insurance and Real Estate	1.06	0.83	1.22	1.31	1.42	2.05	1.93	3.12
Social service	15.52	14.47	11.32	10.84	11.35	18.66	16.81	18.62
Public administration	0.90	3.02	2.90	3.38	3.76	4.77	4.96	6.09
others	5.45	3.52	6.57	7.33	6.88	0.00	0.00	0.00

TABLE 4 | Social insurance coverage of migrant workers by industry in 2016.

Year	Pension	Medical insurance	Unemployment insurance	Injury insurance	Maternity Insurance	Housing provident fund
Agriculture	0.136	0.064	0.077	0.105	0.073	0.037
Mining	0.544	0.345	0.472	0.650	0.279	0.297
Manufacturing	0.426	0.310	0.386	0.504	0.331	0.157
Electric, coal and water production and supply	0.541	0.384	0.444	0.553	0.377	0.300
Construction	0.114	0.073	0.090	0.181	0.076	0.035
Transportation	0.306	0.234	0.268	0.299	0.217	0.113
Wholesale and retail	0.247	0.182	0.215	0.221	0.198	0.081
Accommodation	0.159	0.105	0.128	0.145	0.107	0.041
Financial, Insurance and Real Estate	0.438	0.338	0.400	0.442	0.371	0.244
Social service	0.292	0.205	0.261	0.281	0.229	0.127
Public administration	0.473	0.375	0.425	0.443	0.395	0.247

group, with the value 1, while the other cities comprise the control group with the value 0. The cross-term coefficients of *Time*, *Treat*, and *City* represent the estimates obtained after the triple difference, reflecting the net effect of the policy on the social security participation of migrants in the wholesale and retail and accommodation and catering industries of Chengdu. This was the focus of this study. The triple-difference model was as follows:

$$\begin{aligned} Insurance_{\mathrm{it}} = {} & \beta_0 + \beta_1 Time_{\mathrm{it}} + \beta_2 \mathrm{Treat}_{\mathrm{it}} + \beta_3 City_{\mathrm{it}} \\ & + \beta_4 Time_{\mathrm{it}} * \mathrm{Treat}_{\mathrm{it}} + \beta_5 Time_{\mathrm{it}} * City_{\mathrm{it}} \\ & + \beta_6 \mathrm{Treat}_{\mathrm{it}} * City_{\mathrm{it}} + \beta_7 Time_{\mathrm{it}} * \mathrm{Treat}_{\mathrm{it}} \\ & * City_{\mathrm{it}} + X_{it}\gamma + \varepsilon_{it} \end{aligned} \quad (2)$$

RESULTS

Impacts of Social Insurance Premium Rates on the Insurance Participation of Migrant Workers

Table 5 presents the estimation results of the DID model. First, there is no significant difference in the participation rates of migrant workers in the construction industry before and after the reform, which means the reform did not change the social security contribution ratio of migrant workers in the construction industry. Second, the migrant workers engaged in wholesale and retail, accommodation and catering, manufacturing, and other industries have significantly higher social insurance participation than those in the construction industry. For construction workers, work injury and medical insurance are extremely important, because they have a higher operating environment risk and are more likely to be accidentally injured or to suffer from various occupational and chronic diseases. Even so, their participation rates are low. Third, the coefficients of the cross-terms are all significantly negative, indicating that the industries affected by the policy have reduced the participation rates of migrant workers due to the increase in the social insurance policy contribution rate (from 20 to nearly 40%). On the one hand, the policy means that the household registration system is no longer an obstacle to the participation of migrant workers in social insurance, allowing migrant workers to enjoy the right to participate in the social insurance on an equal basis and thereby achieving the integration

TABLE 5 | Impacts of social insurance premium rates on the insurance participation of migrant workers: difference-in-differences (DID) estimates results.

	Insurance1	Insurance2	Insurance3
Time	0.0412	0.0117	−0.0139
	(0.0409)	(0.0371)	(0.0375)
Iindustry2 (Wholesale, Retail and Accommodation)	0.336***	0.327***	0.361***
	(0.0290)	(0.0295)	(0.0298)
Iindustry3 (Manufacturing)	0.348***	0.317***	0.313***
	(0.0280)	(0.0286)	(0.0290)
Iindustry4 (Other industries)	0.234***	0.221***	0.237***
	(0.0299)	(0.0307)	(0.0310)
Time*ind_2	−0.252***	−0.182***	−0.199***
	(0.0408)	(0.0363)	(0.0368)
Time*ind_3	−0.0854**	−0.108***	−0.104***
	(0.0435)	(0.0379)	(0.0383)
Time*ind_4	−0.118***	−0.0494	−0.0455
	(0.0419)	(0.0377)	(0.0382)
Unit1(Private enterprise)	−0.125***	−0.181***	−0.190***
	(0.0219)	(0.0181)	(0.0177)
Unit2(Foreign-owned enterprise)	0.0635	0.0496	0.0359
	(0.0465)	(0.0347)	(0.0341)
Unit3(Small business)	−0.404***	−0.469***	−0.486***
	(0.0221)	(0.0184)	(0.0180)
Unit4(Others)	−0.166***	−0.254***	−0.269***
	(0.0604)	(0.0440)	(0.0440)
Working year	0.00887***	0.0116***	0.0126***
	(0.00155)	(0.00136)	(0.00138)
Ln_income	0.0669***	0.0676***	0.0771***
	(0.0159)	(0.0138)	(0.0139)
Gender	−0.00707	−0.0102	−0.0164
	(0.0121)	(0.0105)	(0.0105)
Age	0.00110	0.000338	0.000672
	(0.000832)	(0.000721)	(0.000723)
Ethnic	−0.0154	−0.0245	−0.00816
	(0.0521)	(0.0474)	(0.0474)
Edu1(Junior)	0.0474***	0.0700***	0.0777***
	(0.0164)	(0.0143)	(0.0145)
Edu2(Secondary)	0.179***	0.210***	0.218***
	(0.0203)	(0.0175)	(0.0176)
Edu2(College degree and above)	0.318***	0.339***	0.337***
	(0.0289)	(0.0240)	(0.0239)
Married	0.0104	0.0101	0.0194
	(0.0300)	(0.0268)	(0.0269)
Family members	−0.00368	0.000208	−0.000863
	(0.00803)	(0.00711)	(0.00713)
Child	−0.0272**	−0.0248**	−0.0269***
	(0.0113)	(0.0101)	(0.0101)
Ln_family income	0.00535	−0.00945	−0.0123
	(0.0121)	(0.0112)	(0.0112)
Ln_family expenditure	0.0132*	0.0138*	0.0160**
	(0.00776)	(0.00736)	(0.00725)
Year fixed effect	Yes	Yes	Yes
Observations	5,890	7,994	8,010
R-squared	0.225	0.228	0.239

*(1) Here, the construction industry/work in government agencies or state-owned, collective, associated enterprises/primary schools, and below are set as the benchmark group; (2) ***, **, and * represent the significant level of 1, 5, and 10% respectively, and the numbers in parentheses are robust SEs. Unless with specification, the following are the same.*

of social insurance and reflecting the equity in this field. On the other hand, it has hindered the popularization of social insurance among the groups of migrant workers. The migrant workers often need social insurance more, but due to their low wages, poor bargaining power, low education, and heavy living burden, higher rates deter them. The main difficulty of current social insurance participation by migrant workers is the low coverage. We should first consider the special characteristics of this group and formulate the social insurance coverage and social insurance payment ratios that are suitable for them and gradually promote integration with the urban employees.

Among other control variables, the social insurance participation rates of migrant populations working in party or government agencies and state-owned/collective/associated enterprises are significantly higher than those in other companies, but these companies or agencies employ less than 10% of the total migrant workers. The private enterprises, individual industrial, and commercial entities have lower compliance with the social insurance contributions, but they comprise more than 80% of the migrant workers. The longer migrant workers stay in the local area, the better they can integrate into it, resulting in higher social insurance participation rates. The higher the salary, the better the job, and the stronger the bargaining power in the company, the more likely workers are to obtain the social insurance paid by their companies. Gender, age, ethnicity, and marital status had no significant effect on social insurance participation. The higher the level of education, the more likely workers are to enter a more formal enterprise and enjoy better treatment; at the same time, their awareness of insurance participation is also stronger. Family size does not affect participation in social insurance, but the greater the number of children in the family, the more the economic cost of the education of children; this renders the family unable to afford the insurance costs. The higher the household expenditure, the better the family benefits, and the higher the social insurance participation rate.

Impacts of the Social Insurance Premium Rates on the Wages, Working Hours, and Household Expenditures of Migrants

This study also examines the impact of the policy on the wages, working hours, and welfare of migrant workers. As shown in **Table 6**, after 2011, the wages and benefits of migrant workers in the construction industry significantly improved, and working hours decreased. The wages of workers in the construction industry are higher than those of other industries, which is consistent with common sense; because the construction workers are highly engaged in physical work and face more risks; they should therefore receive higher compensation. However, the household consumption of construction workers is significantly lower than that of other workers, and household consumption is an important indicator of family welfare. The construction workers have a hard time making money and have a heavy burden of living, so their lifestyle is highly constrained. The working hours of the construction workers are similar to those in the manufacturing enterprises, which are higher than those

TABLE 6 | Impacts of the social insurance premium rates on the wages, working hours, and household expenditures of the migrant workers: DID estimation results.

	Income	Work hours	Expenditure
Time	0.502***	−8.752***	0.290***
	(0.0354)	(1.400)	(0.0687)
Iindustry2 (Wholesale, Retail and Accommodation)	−0.209***	−2.304**	0.183***
	(0.0280)	(1.084)	(0.0569)
Iindustry3 (Manufacturing)	−0.175***	0.783	0.121**
	(0.0270)	(1.062)	(0.0525)
Iindustry4 (Other industries)	−0.261***	−2.262**	0.252***
	(0.0298)	(1.119)	(0.0643)
Time*ind_2	−0.0530	3.553***	−0.237***
	(0.0343)	(1.308)	(0.0604)
Time*ind_3	0.0248	4.094***	−0.214***
	(0.0349)	(1.346)	(0.0578)
Time*ind_4	0.00302	3.836***	−0.262***
	(0.0363)	(1.353)	(0.0679)
Observations	8,102	7,082	8,102
R-squared	0.558	0.134	0.461

(1) The first column is monthly salary income; the second column is weekly working hours; the third column is monthly household expenditure. (2) The control variables are consistent with Model 1 and due to space limitations, there is no report here.

TABLE 7 | Impacts of social insurance premium rates on the insurance participation of migrant workers: difference-in-difference-in-difference (DDD) estimates results.

	Insurance1	Insurance2	Insurance3
Time	−0.00629	−0.102***	−0.0944***
	(0.0220)	(0.0202)	(0.0204)
Treat	−0.0210	0.0108	0.0241
	(0.0186)	(0.0187)	(0.0188)
City	−0.157***	−0.133***	−0.125***
	(0.0279)	(0.0288)	(0.0291)
Time*Treat	0.0216	0.0841***	0.0780***
	(0.0217)	(0.0200)	(0.0201)
Time*City	0.0850**	0.121***	0.117***
	(0.0406)	(0.0356)	(0.0360)
Treat*City	0.329***	0.291***	0.310***
	(0.0325)	(0.0335)	(0.0337)
Time*Treat*City	−0.265***	−0.262***	−0.275***
	(0.0461)	(0.0410)	(0.0414)
Year fixed effect	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Observations	11,168	18,174	18,245
R-squared	0.161	0.183	0.194

(1) The control variables are consistent with Model 1. Due to space limitations, there is no report here.

in wholesale, retail, accommodation, and catering. The latter industries have freer and more flexible working hours, and their labor intensity is often lower. The policy did not cause a change in monthly wage income. There may be three possible reasons for this after the social insurance policy contribution rate rises. First, the companies may have maintained the participation status and taken on the higher social insurance fees, choosing to reduce the wages of the migrant workers. Second, the companies may have stopped paying social insurance for employees and subsidized them by increasing wages. Third, the companies may have continued their policy of not paying social insurance and did not change the employee wages. As a result, the overall monthly wages of the migrant workers did not change significantly. However, the weekly working hours of the migrant workers have risen significantly, which may be due to companies passing on the burden of the social insurance costs in disguise by increasing the working hours. Combining these two indicators, the hourly wage of migrant workers has fallen, which has led to a reduction in household consumption. In addition, the decrease in household consumption may also be due to the uncertain expectations of migrant workers about the future employment environment.

In summary, for migrant workers, an increase in the contribution rate of social insurance policies reduces their participation in social insurance. The wages of migrant workers did not significantly change but the working hours have become longer. Their hourly wages have been reduced to compensate for the increased social insurance burden of enterprises, resulting in a decline in their consumption and welfare.

Since the pre-reform period of the data covers only 2009 and 2010, the effective parallel trend testing could not be performed. To avoid the potential risk that the construction industry may have different trends from other industries, we use a DDD model for testing. CMDS also covers data for other cities that have not experienced the policy change or that have not adopted different policy arrangements for the construction and non-construction companies, which provides us with the opportunity to use the DDD model. The 2009 survey sample includes five cities—Beijing, Shanghai, Shenzhen, Chengdu, and Taiyuan—which share a similar development trend. The four cities other than Chengdu were used as the control group.

Table 7 presents the DDD estimation results of the impact of the social insurance policy contribution rate on the participation by migrant workers. We focus on the coefficients of Time * Treat * City. Of the three items measuring the participation of migrant workers, the policy has obvious negative effects on the wholesale, retail, and accommodation industries in Chengdu, which is consistent with the DID results. Therefore, the estimation results of the DDD model show, once again, that an increase in the contribution rate of a social insurance policy will reduce the social insurance participation of migrant workers. At the same time, as shown in **Table 8**, the policy has no significant impact on the wages and incomes of the migrant workers but reduces the welfare level of the migrant workers. Furthermore, cities similar to Chengdu are selected as the control group to carry out the DDD study. First, in Shenzhen, the migrant workers have always followed the basic social insurance system for urban employees, and the social insurance policy on migrant workers did not change around 2011. Second, Chongqing, a city that shares many similar features with Chengdu, also implemented an integration policy in 2011 but did not implement different social insurance policies for different industries. As shown in **Tables 9**, **10**, a consistent conclusion is obtained after changing

TABLE 8 | Impacts of the social insurance premium rates on the wages, working hours, and household expenditures of the migrant workers: DDD estimation results.

	Income	Work hours	Expenditure
Time	0.773***	−9.950***	−0.106**
	(0.0182)	(0.640)	(0.0471)
Treat	−0.158***	−1.511***	0.131**
	(0.0170)	(0.574)	(0.0550)
City	−0.0932***	0.511	−0.173**
	(0.0290)	(1.090)	(0.0678)
Time*Treat	0.00732	1.459**	−0.0958*
	(0.0182)	(0.622)	(0.0557)
Time*City	−0.0202	−0.300	0.360***
	(0.0356)	(1.296)	(0.0712)
Treat*City	−0.0602*	1.087	0.0876
	(0.0323)	(1.194)	(0.0814)
Time*Treat*City	−0.0488	1.194	−0.196**
	(0.0395)	(1.440)	(0.0847)
Year fixed effect	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Observations	18,931	16,006	18,894
R-squared	0.547	0.156	0.489

(1) The control variables are consistent with Model 1. Due to space limitations, there is no report here.

TABLE 9 | Impacts of social insurance premium rates on insurance participation of migrant workers: DDD estimation results using Shenzhen as a control group.

Panel A	Insurance1	Insurance2	Insurance3
Time*Treat*City	−0.221**	−0.172**	−0.179**
	(0.0900)	(0.0787)	(0.0802)
Observations	3,312	4,714	4,726
R–squared	0.248	0.242	0.255
Panel B	income	work hours	expenditure
Time*Treat*City	−0.0445	7.929***	−0.490**
	(0.0849)	(2.449)	(0.249)
Year fixed effect	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Observations	4,784	4,168	4,780
R-squared	0.554	0.154	0.501

(1) The control variables are consistent with Model 1. Due to space limitations, there is no report here.

the control group. For migrant workers, an increase in the social insurance policy contribution rate will reduce the participation of the migrant workers and their welfare level.

DISCUSSION

Main Findings

The essence of incorporating migrant workers into the urban worker insurance system, in other words, social insurance policy change from CI to UEBMI is to improve the welfare of migrant workers and make them enjoy the same benefits as urban workers. Compared with CI, UEBMI has a higher level of benefits and a higher premium rate. This is the essential reason for the migrant workers to be integrated into the inflow cities. However, in view of the special characteristics of migrant workers, the government should consider the choices of migrant workers when they face low-cost insurance with limited coverage vs. high-cost insurance with higher coverage.

TABLE 10 | Impacts of social insurance premium rates on the insurance participation of migrant workers: DDD estimation results using Chongqing as a control group.

Panel A	Insurance1	Insurance2	Insurance3
Time*Treat*City	−0.212***	−0.148**	−0.157**
	(0.0689)	(0.0720)	(0.0739)
Observations	3,893	6,234	6,235
R-squared	0.154	0.171	0.171
Panel B	income	work hours	expenditure
Time*Treat*City	0.260***	6.169**	−0.969**
	(0.0779)	(2.630)	(0.401)
Year fixed effect	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Observations	6,269	5,061	6,267
R-squared	0.476	0.133	0.363

(1) The control variables are consistent with Model 1. Due to space limitations, there is no report in this study.

In this study, based on the large sample data of migrant workers in Chengdu from CMDS, we use DID model to evaluate the effects of social insurance policy change from CI to UEBMI and estimate the policy change on the social insurance participation rate, wages, working hours, and household expenditures of the migrant workers. We provided empirical evidence for deepening the social model reform of the migrant workers in China. This study has interesting findings.

We find that the social insurance participation rate of migrant workers was significantly reduced after they were incorporated into the insurance system of urban workers, even though incorporating into the insurance system of urban workers can bring about an obvious improvement in the insurance benefits. Compared with the insurance system of migrant workers (CI), the insurance system of urban workers (UEBMI) has higher premium rates (high-cost) and benefits (high-coverage). That is, the migrant workers prefer low-cost insurance with limited coverage to high-cost insurance with higher coverage. In terms of policy implementation, it does not have a positive impact on migrant workers. Why should such a policy be implemented? The intended goal of the policy is to improve the welfare of migrant workers by combining social insurance; however, what is apparently not taken into account is that the increased level of coverage will also cause an increase in the burden of social insurance for the enterprises. Most small and medium-sized enterprises may transfer the increased burden to their employees because migrant workers do not have bargaining power due to their vulnerable position in the labor market. What is more,

given the low wages, low education, and heavy living burden, the migrant workers often choose to increase their current disposable income and give up participating in social insurance when facing a high social insurance premium rate (12, 13).

Meanwhile, the migrant workers have made great contributions to urban development, but they do not enjoy the same benefits as the local urban workers (1–4) because of household registration. The policy change means that the household registration is no longer an obstacle to the participation of migrant workers in social insurance, allowing migrant workers to enjoy the right to participate in social insurance on an equal basis and thereby achieving the integration of social insurance and reflecting the equity in this field. However, the findings demonstrate that the policy change did not have a positive incentive to the popularization of social insurance among the groups of migrant workers but a negative effect.

The unreasonable design of the social insurance pattern is an important reason for this problem; this is mainly reflected in two features. First, the "fragmentation" characteristic of social insurance in China has made it very difficult for migrant workers to transfer their social insurance across regions. Second, the premium rate of social insurance for the migrant workers is high, and the rate of social insurance premiums borne by the migrant workers in most regions is over 10%, which is a high cost for migrant workers to participate in the social insurance. The entrepreneurs in China have complained about the challenging operating environment, with too many regulations and a very high social insurance burden. The urban employee pension scheme requires a contribution equal to 28% of the payroll, 20% from the employer, and 8% from the employee. The 28% contribution rate is above that of the principal Organization for Economic Co-operation and Development (OECD) countries, such as Japan (15.4%), the United States (12.4%), and South Korea (9%). In the 2019 government work report of the 13th National People's Congress, Premier Li Keqiang proposed reducing the basic old-age pension contribution rate of urban employees. The policymakers anticipated that lowering the contribution rate of social insurance could reduce labor costs, promote investment, and create jobs.

Strengths and Limitations

This study focuses on the social insurance institution design and study the choices of migrant workers when they face different contribution rates and benefits. There are four main contributions: (1) The design of the social insurance system for the migrant workers in Chengdu provides a very unique context for institutional transformation from CI to UEBMI, providing solid evidence for the policymakers to design better social models. This is because direct comparisons of social insurance models across regions can easily be confounded by other factors. Instead, examining the transition process from one model to another in Chengdu allows for clearer identification of the impact of changes in the social insurance models. (2) Based on a nationally representative large sample of survey data for migrant workers, and a double difference (DID) model and triple difference (DDD) model are developed to identify the impact of social insurance patterns on participation and living standards of the migrant workers. This provides an accurate decision basis for the policymakers. (3) This study not only focuses on the impact of social insurance patterns on the incentives of migrant workers to participate in insurance but also examines the possible changes in wages and living standards as a result. Combining changes in the participation rates with changes in wages and living standards allows for a more comprehensive evaluation of the welfare impacts of changes in the social insurance patterns.

However, we studied the impact of social insurance policy premium rate setting on the insurance participation of migrant workers only and paid little attention to the poor portability and fragmentation. Improving the portability and fragmentation of the social insurance system for migrant workers is vital to enhance the welfare of migrant workers. Lacking this discussion made our paper incomplete and this is supposed to be discussed in detail in the future.

Policy Implications

Therefore, it is necessary to solve the problem of insufficient incentives for migrant workers to participate in social security by formulating the localized social insurance policies.

First, it is necessary to formulate a social security policy premium rate suitable for migrants. After appropriately reducing the employee social security contribution rate, the migrant workers should be included in the employee social security system to achieve uniform contributions and benefits. The current social security contribution rate in China is too high, placing a great burden on labor-intensive enterprises. The small and medium-sized enterprises, where migrant workers are concentrated, are far less able to pay contributions than the large enterprises. Before the social insurance rates are lowered, the inclusion of migrant workers in the urban employee social insurance system would most likely lead to a decrease in their participation rate. Considering the actual situation of the migrant workers, the social insurance premium rate of migrant workers should be reduced to be more practical and to increase their willingness to purchase insurance. The burden on migrant workers can also be reduced by cutting the premium base and by subsidizing or even exempting some social premium costs. In this way, these migrant workers can truly enjoy the benefits of social insurance, thereby increasing the willingness of migrant workers to participate in insurance and maximizing social insurance coverage.

Second, establishing a comprehensive social insurance policy enhances the portability of social security between the regions. This is very important for migrant workers. It is important to gradually integrate CI, UEBMI, and other insurance types into unified insurance, fundamentally changing the fragmented nature of the insurance system. A unified social insurance system with multi-level payment ratios and social insurance benefits that are suitable for different groups of people can truly realize the nationalization and flexibility of the social insurance system.

CONCLUSION

This study shows that the migrant workers preferred lower premium rates and that higher premium rates significantly reduced the participation rate of migrant workers in social insurance after being incorporated into the social system of city workers. With an increase in the policy premium rate, the incentive of migrant workers to participate in the social insurance decreased, even if the social insurance benefits correspondingly improved. At the same time, the salaries of migrant workers did not change significantly, but their working hours became longer, and their consumption decreased. Because the government paid little attention to the poor portability and fragmentation of migrant workers, it cannot explore the effects of these policy changes. This is an important direction for some research on the insurance reform of migrant workers in the future.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: China Migrants Dynamic Survey https://chinaldrk.org.cn/wjw/#/home.

AUTHOR CONTRIBUTIONS

SZ led and designed the study, led the data collection, analysis, and interpretation. YC contributed to the study design, provided input into the data analysis, and wrote the first draft of the manuscript. YT and MZ contributed to the study design, reviewed the manuscript, and helped the writing of the final draft manuscript. All the authors read and approved the final manuscript.

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Cost-Effectiveness of Portable Electrocardiogram for Screening Cardiovascular Diseases at a Primary Health Center in Ahmedabad District, India

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Background: District Health Authority in Ahmedabad, Gujarat has introduced Project Lifeline, 12-lead portable ECG devices across all primary health centers (PHC) in the district to screen cardiac abnormalities among high-risk and symptomatic adults for providing primary management and proper timely referral. The prime purpose of the study was to assess the cost-effectiveness of portable ECG for the screening of cardiovascular diseases (CVD) among high-risk and symptomatic adults at the PHC in Ahmedabad, Gujarat.

Methods: Cost-effective analysis was conducted using a societal perspective. An incremental costing approach was adapted, and cost-effectiveness analysis was done using a decision-analytic model. We surveyed 73 patients who screened positive for cardiac abnormality, documented the type of ECG abnormalities, and diagnosed CVD. The program cost was obtained from the implementers. Transition probabilities were derived from primary data supported by expert opinion for the intervention arm, while a systematic search of the literature was undertaken to derive transition probabilities for the control arm.

Results: The ECG screening at PHC saves 2.90 life years at an incremental cost of 89.97 USD (6657.47 INR), yielding a cost-effectiveness ratio of 31.07 USD (2,299.06 INR) per life-year saved, which is below the willingness to pay threshold. The budget impact analysis was also performed. Results are sensitive to the relative risk reduction associated with the non-participation and the cost of initial screening.

Conclusion: Cost-effectiveness analysis clearly shows that the facility to screen cardiac abnormality at the PHC level is highly recommended for high-risk adults and symptomatic cases.

Keywords: health technology assessment (HTA), cost-effectiveness (CE), portable electrocardiogram devices, primary health center-PHC, India, Asia—Pacific

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INTRODUCTION

Cardiovascular diseases (CVD) are emerging as the number one cause of death across the globe. Globally 70% of all deaths are due to non-communicable diseases (NCDs) (1). In India, 26% risk of death can be attributed to CVDs. About 23% of those with heart attacks do not survive due to delay in treatment leading to the death of around 1.7 million Indians (2).

Considering the silent progression of the disease and the requirement of specific expertise for diagnosis and treatment, early diagnosis and treatment facilities are extremely limited at primary health centers (PHCs). Advancement in diagnostic methods has provided handheld portable electrocardiography (ECG) technology that can effectively screen some cardiac abnormalities in the absence of conventional ECG machines, especially at the PHC level. Prompt screening, early identification of true cases and prompt management, especially with thrombolytic and aspirins with timely referral in "GOLDEN HOUR" (the first 60 min of a heart attack) is, of utmost importance.

Usage of portable ECG facilities in various forms such as single lead and 12-lead handheld instruments has been studied by many for effective management and early identification of cardiac abnormalities in various health care settings (3–5). It was found to be a cost- and clinically effective strategy of screening in patients of atrial fibrillation and elderly population (>70 years) as it significantly reduces the risk of stroke and any other cardiac event due to early diagnosis and management (3). Economic evaluation studies reported that opportunistic screening for atrial fibrillation in primary care has the potential to be cost-effective (3, 6). However, the competency of primary care practitioners and nurses for interpreting the ECG readings needs to be considered for the successful implementation of such a screening program. Begg et al. in their work suggested that primary care practitioners were less experienced and less confident with ECG interpretation than cardiologists and require support in interpreting ECG readings (7). In scenarios with limited capabilities, solutions such as telecardiology (bringing expert ECG interpretation to primary care) can save time, money, and lives. Both primary care physicians (PHC-Medical Officer—PHC-MO) and patients benefit from the ease of access, speed of diagnosis, management efficiency, and the freeing up of resources (8). As PHC-MOs remain the main point of contact within the primary health care system for most of the population, they play an instrumental role in the early detection and management of CVDs.

In Gujarat, the Government has established ECG facilities, but it is limited to medical colleges (MC), district hospitals (DH), and subdistrict hospitals (SDH), and Community Health Centers (CHC). PHCs are not yet equipped with these facilities. To screen all the high-risk and symptomatic adults, the District Health Authority in Ahmedabad, Gujarat, has introduced a 12-lead portable ECG machine across 40 PHCs in the district for the first time in the state. Linkage was established with a cardiologist to read ECG through a web-based interface (WhatsApp) to identify and confirm CVDs and provide primary management (with thrombolytic and antiplatelet such as Aspirin) coupled with a timely referral. For timely ECG reading and guidance from cardiologists, the incentive of 0.41 USD (30 INR) per reading (per case) was provisioned in the program. Under this initiative, PHC-MOs were trained using the cascade model, wherein these PHC-MOs then trained the PHC staff within 3 days of receiving the ECG device at the PHCs. The District Health Authority, Ahmedabad, requested the Regional Resource Center for Health Technology Assessment at the Indian Institute of Public Health Gandhinagar to conduct a cost-effectiveness study of the Project Lifeline.

The objective of the present work was to assess the cost-effectiveness of introducing a portable ECG facility at PHCs for the screening of CVD among high-risk and symptomatic adults, and to estimate budgetary implications for the scale-up of the ECG facility. The Technical Advisory Committee at the Department of Health Research, Government of India, approved the study.

MATERIALS AND METHODS

Cost-effectiveness analysis was done using decision-analytic modeling (**Figure 1**) with a societal perspective on health care costs and benefits.

A decision tree was parameterized on the Microsoft-Excel spreadsheet to estimate the incremental cost-effectiveness ratio. The target population for the study was high-risk and symptomatic adults, which included adults having diabetes, hypertension, cardio-metabolic syndrome, family history of cardiac disease, or signs and symptoms suggestive of CVD. Intervention scenario, viz. screening of population with portable ECG machine for early detection of cardiac abnormalities at the PHC, was compared with no routine care scenario. Early diagnosis, prompt treatment of CVD, and life-years saved were the outcome measures. The number of patients screened using a portable ECG device and the number of patients identified with abnormality were derived from the secondary data maintained at District Panchayat, Ahmedabad.

The ECG abnormalities identified during the screening were categorized into five major disorders based on the primary data and expert opinion. The five cardiovascular disorders reported in the high-risk adults mentioned in **Table 1** were considered for building the decision tree model. We have accessed the data of 12,105 individuals who visited PHC screened for CVD using portable ECG devices during the period from 2018 to 2019. Of this, 208 individuals screened with abnormalities were selected from the OPD database maintained at the District Panchayat, Ahmedabad. Of the patients screened positive, 127 were pregnant women, 73 were high-risk symptomatic adults, and 10 were children. Since the objective of this work was to assess the cost-effectiveness of screening high-risk and symptomatic adults in a primary healthcare setting, the analysis reported here is restricted to this particular population. Further follow-up of 73 high-risk symptomatic adults led to 54 individuals who were diagnosed positive for CVD. **Table 1** categorized the ECG abnormalities based on expert opinion.

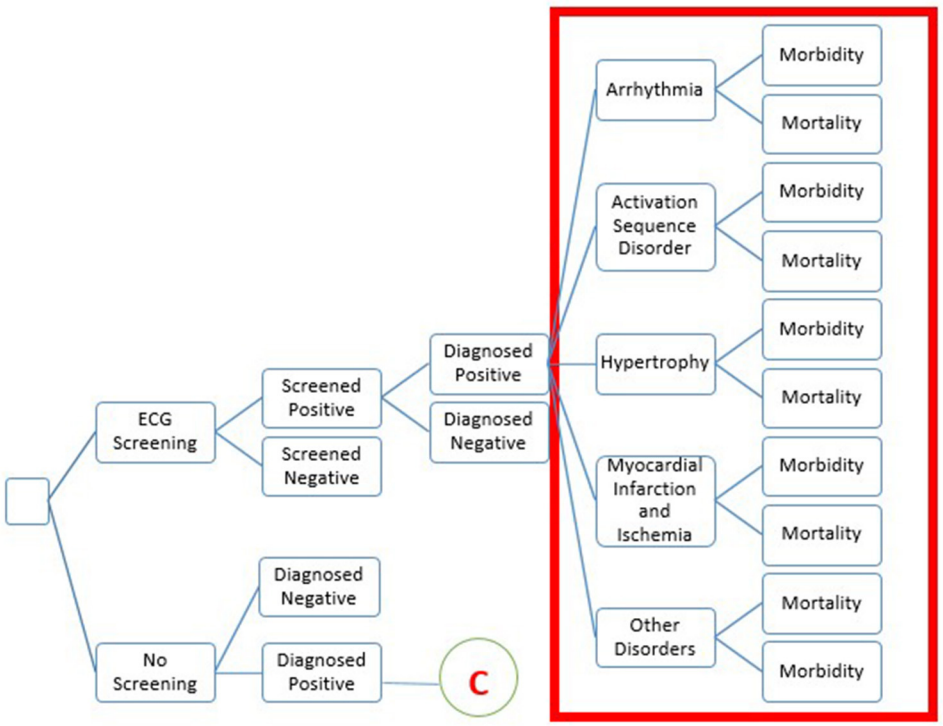

FIGURE 1 | The structure of decision-tree model. The decision tree describes the pathway of a patient presenting to primary care with signs or symptoms who will be screened using the ECG device. Diagnosed positive cases will be further classified into five sets of diseases. During this period, some patients will have a diagnosis and start treatment or die. The second arm, no screening will be considered to follow similar pathways for diagnosed positive.

TABLE 1 | Categorization of ECG abnormalities based on expert opinion.

Cardiovascular disorders	ECG abnormalities
Arrhythmia	• Supraventricular arrhythmia • Ventricular arrhythmia
Action sequence conduction defect	• Atrioventricular conduction defect (block) • Bundle branch block
Increase in wall thickness or size of atria or ventricles	• Atrial hypertrophy • Ventricular hypertrophy
Myocardial ischemia	• Myocardial ischemia or infarction
Others	• Valvular issues

Assumptions Used for Modeling

There are data gaps in screening at the primary care facilities. Therefore, we had no relevant comparator. We compared screening with routine treatment scenarios where CVD abnormalities are not currently performed at the primary care level.

The purpose of introducing ECG was to enable the early identification of CVD abnormalities, thereby preventing severe morbidity and mortality. Due to the lack of relevant data on outcomes of screened negative and diagnosed negative in both arms, we could not demonstrate it in modeling, which is a limitation of the study. We tried finding evidence of clinical validity of the diagnostic tests for specific abnormalities identified through a systematic review of the literature, but could not find it. Hence, all screened positive cases were subjected to the gold standard diagnostic test to predict the disease to establish the clinical validity of the screening test.

The number of people diagnosed with the screening ECG is lower than in the non-screening arm as well as differences in the age group in both arms are evident. This is because the data of the intervention arm reflects the data collected from the primary study where patients were followed-up for the diagnosis, whereas in the comparator arm data was taken from CREATE registry of India, which is available in the public domain. This data reflects the population who consulted for diagnosis on the occurrence of severe symptoms and when the disease is expressed.

Derivation of the Cost Data

As the study adopted using a societal perspective, both the program cost, i.e., the cost borne by the health system for implementing the ECG program and the direct and indirect medical cost incurred by the patients were considered. The program cost was obtained from the implementers under two cost heads, capital cost and annual implementation cost. Capital costs included start-up costs such as ECG equipment and orientation training cost since the launch of the program. The

capital cost, including start-up cost, was annualized, assuming the life year of the ECG device to be 10 years. The recurrent costs consisted of the annual maintenance cost, incentives provided to physicians for interpretation of ECG reading, shared human resource cost, and other contingency costs such as meeting, training of PHC staff by MO, and cost of ECG screening materials (prints, cartridge, etc.). To estimate the programmatic cost, financial records of District Panchayat, Ahmedabad were used and a time-motion study was undertaken to estimate the shared human resource cost.

All costs were reported in Indian Rupees and USD at 74 INR per dollar. In addition to the programmatic cost, the out-of-pocket expenditure (OOPE) of the patient was estimated using published literature (9), which comprised of cost of medications, transportation, wage loss of the patient, and the caretaker. Both the recurrent and capital costs were collected and summed up to arrive at the total cost. All costs were presented in INR. Costs were converted to constant values and reported as annualized costs in the 2018–2019 price.

For deriving the cost of treatment, a group of physicians were consulted for their opinion on the line of treatment. The cost of interventions (as suggested by the experts) were taken from Pradhan Mantri Jan Arogya Yojana (PMJAY) Package (10). Since the cost for undergoing a diagnostic test was already included in the PMJAY, we have not added additional diagnostic costs to avoid overcalculation of the treatment cost.

Derivation of Data on Transition Probabilities

Transition probabilities were derived from primary data supported by expert opinion for the intervention arm, and a systematic literature search was undertaken to derive transition probabilities for the control arm. Three experts included two prominent cardiologists from Gujarat and one community medicine expert from Maharashtra with substantive experience. We used the following indicators for calculating transition probabilities:

1. Total number of high-risk and symptomatic adults who underwent ECG screening at PHC
2. Number of patients referred and underwent a diagnostic test
3. Type of ECG abnormality
4. Type of treatment

The survival rates for each abnormality were derived by applying hazard ratio (11) to the survival rates reported in the published literature for each cardiovascular disorder mentioned in **Table 1**.

The transition probabilities in the control arm were derived through a systematic search of published literature. Indian data was used for all the transition probabilities except for the survival rate of Action Sequence Conduction Defect, which was obtained globally. In addition to this, due to the unavailability of disorder-specific data on QALY, the cost-effectiveness analysis was done using life years (LYs) saved as an outcome indicator.

To estimate LYs saved, the average age of high-risk adults who underwent the ECG screening was 54.6 years (average age of cohort in the intervention arm) as per the collected data, while that for the control arm was considered 57.5 years as mentioned in the CREATE registry (12). It was assumed that the loss to follow-up of abnormal cases screened was negligible considering that the patients were highly motivated to seek healthcare for their condition in the first place, as they approached the PHCs for treatment. In addition, PHC-MOs were asked to follow-up the cases screened positive for abnormality to ensure that the patients visited higher healthcare centers, underwent diagnostic tests, and were on treatment.

TABLE 2 | Details of the program cost in INR (USD).

Items	Units	Unit price	Annualized cost
ECG machines	40	70,000.00 (945.95)	4,20,000.00 (5,675.68)
Maintenance and consumables	40	35,000.00 (472.97)	1,40,000.00 (1,891.89)
Expert consultation	12,105	30.00 (0.41)	3,63,150.00 (4,907.43)
Contingency	-	-	75,000.00 (1,013.51)
Training	-	-	75,000.00 (1,013.51)
Shared HR cost	-	-	6,19,777.00 (8,375.36)
Total			16,92,927.00 (22,877.39)

Sensitivity Analysis and Budget Impact Analysis

One-way Sensitivity analyses were performed to account for uncertainty in model assumptions and to address variability. Sensitivity analysis was performed using low and high absolute estimates for mortality and the cost of treatment. Budget impact analysis (BIA) was performed to estimate the cost for scaling up the ECG program at the District, State, and National levels at 2020 prices. The BIA depicted the budget allocation for the 1st, 2nd, 5th, and 10th year.

RESULTS

We surveyed 73 patients who screened positive for abnormality to document the type of ECG abnormalities and their further diagnosis.

Program Cost

The costs incurred toward implementing the program were collected. The cost of the ECG machine has been annualized to estimate the programmatic cost. Details of the program cost are presented in **Table 2**.

The time–motion study was used to estimate shared human resource costs. It was found that an approximate time of 12 min of staff nurses was used toward the ECG program, and its estimated annual cost was 209.38 USD (15,494.43 INR). The annualized cost incurred by the program implementers

TABLE 3 | Cost data used to populate the model for high risk population.

Parameter	Cost*	Calculation
Intervention arm		
Cost of screening	139.85 (1.89)	Derived from primary data
Out-of-pocket expenditure (OOPE)	63,539 (858.64)	(9)
Cost of treating arrhythmia	1,28,728.85 (1,739.58)	Cost of treatment as per PMJAY package data + OOPE + cost of screening and diagnosis
Cost of treating action sequence defect	3,75,478.85 (5,074.04)	
Cost of treating hypertrophy	1,56,328.85 (2,112.55)	
Cost of treating MI	1,73,478.85 (2344.31)	
Cost of treating other disorders	70,078.85 (947.01)	
Control arm		
Cost of treating arrhythmia	1,28,589 (1737.69)	Cost of treatment as per PMJAY package data + OOPE+ cost of diagnosis
Cost of treating action sequence defect	3,75,339 (5072.15)	
Cost of treating hypertrophy	1,56,189 (2110.66)	
Cost of treating MI	1,73,339 (2342.42)	
Cost of treating other disorders	69,939 (945.12)	

**Cost presented in INR (USD).*

was estimated to be 1.69 million. With this investment, around 12,105 patients were screened. The calculated cost per case screened amounted to 1.89 USD (139.85 INR). The **Table 3** shows various costs that were considered for the purpose of decision-analytic modeling in the intervention and control arm.

Cost-Effectiveness Analysis

Transition probabilities were used to populate the decision-tree model, as shown in **Figure 1**. **Supplementary Table 1** presents transition probabilities.

The cost of the intervention arm was 97.07 USD (7,183.64 INR) with 14 life-years saved, whereas the cost incurred in the comparator arm (routine care scenario) was 7.11 USD (526.16 INR) for 11 life-years saved. The ECG screening intervention in primary care has proved to be highly cost-effective for high-risk adult and symptomatic populations, saving around 2.896 life-years at an incremental cost of ∼89.97 USD (6,657.47 INR) with ICER of 31.07 USD (2,299.06 INR) per life-year saved (**Figure 2**).

The intervention is cost-effective as the ICER lies well-below the CE Plane or willingness to pay threshold fixed at GDP per capita. The intervention is considered cost-effective if it is <2,009 USD (INR 1,48,666), the GDP per capita of India at 2018 price. The one-way sensitivity analysis indicates that parameters have the most significant effect on ICER when they are varied individually. **Figure 3** presents a tornado diagram depicting sensitivity analysis and **Table 4** depicts computed sensitivity analysis.

Budget Impact Analysis

While performing BIA, the budget of the 1st year incorporated major capital investment required in the 1st year of program scale-up. The budget for the 2nd, 5th, and 10th year depicted the incurred annual implementation cost. In addition, the budget of the 5th year was estimated by considering the need for short refresher training to the health workers.

Supplementary Tables 2a,b provides the budget calculation for 1st, 2nd, 5th, and 10th year of implementation cost in Indian Rupees. The state-wide scale-up cost across 1,474 PHCs in 33 districts of Gujarat for the ECG program is estimated to be around 155.2 million for the 1st year, while the nation-wide scale-up cost was calculated for 24029 PHCs and 720 districts (13) was 2,706 million in the 1st year. This budget was calculated by projecting the annualized cost of implementation in the Ahmedabad district.

DISCUSSION

Opportunities to screen coronary heart disease and its risk factors are missed at the primary healthcare level (14–16). Project Lifeline, the ECG at PHC level at Ahmedabad, primarily addresses this concern and screens all the high-risk cases for cardiac abnormalities in the primary care setting.

The effectiveness of ECG technology for screening in primary care settings in developed countries is promising (4, 12, 17, 18); however, evidence in the low and middle-income country context is limited. The present work validates the evidence on the cost-effectiveness of ECG screening in a primary care setting in the Indian context when individuals at high risk of developing CVD undergo screening. The cost-effectiveness analysis shows that the ICER lies in the first quadrant of the cost-effective plane, which suggests that an additional cost of 31.07 USD (2,299.06 INR) is incurred for saving one additional life-year making the intervention cost-effective.

Previous cost-effectiveness study using a 12-lead ECG device with the general population concluded the effectiveness of the ECG with an at-risk population (19). Other two studies conducted in young athletes were also cost-effective for pre-participation screening for the study group (18, 20). The findings and recommendations of the present study are consistent with many studies conducted in the past (3–6, 18, 20–23) that recommend ECG screening for high-risk cases (young athletes and elderly and symptomatic adults).

We assumed that with early screening and identification of cardiac abnormality, there might be an initial spurt in the case-load at referral health care centers for seeking care, but it may eventually reduce the burden due to timely management of cases. Thus, active screening of high-risk populations with ECG can be a clinical and cost-effective strategy when introduced at the peripheral level of healthcare. In a population being characterized

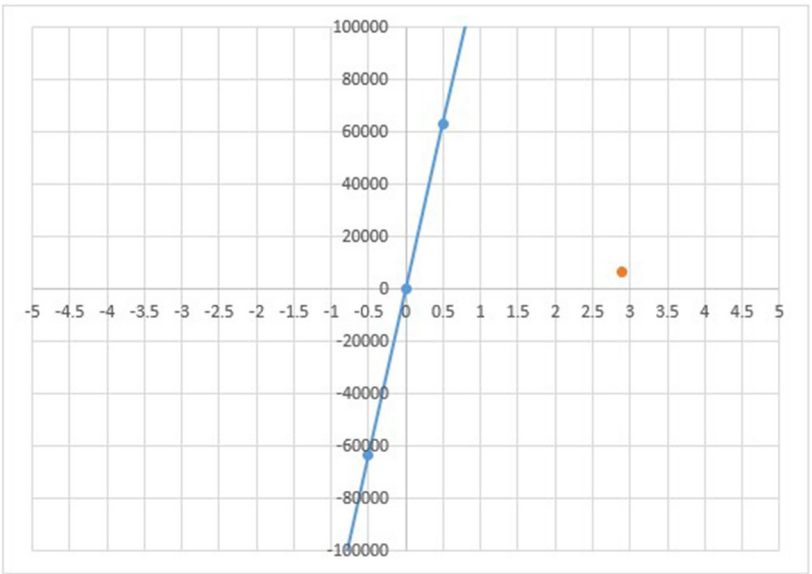

FIGURE 2 | Cost-effectiveness plane in INR. The cost-effectiveness plane depicts ICER (orange dot) lying in the first quadrant because incremental cost of 89.97 USD incurred is saving 2.9 incremental life years. The CER lies below the CE Plane or willingness to pay threshold thus, intervention is cost-effective.

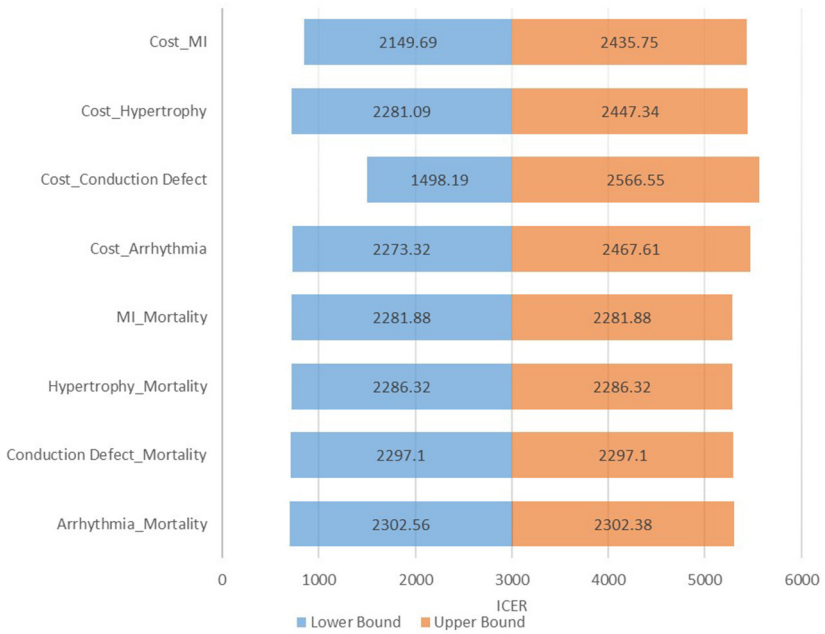

FIGURE 3 | Tornado diagram. The tornado diagram depicts minor variation in ICER after controlling one variable at a time, indicating robustness of the model and its interpretation.

as high-risk, active screening through ECG can be an effective strategy (5, 6, 17–27). A standardized risk-stratification tool (such as Framingham risk score or SCORE tool) can potentially assist in identifying high-risk populations, and only those identified for high risk should be subjected to ECG screening. The Framingham risk score (28) is an algorithm used to estimate the 10-year cardiovascular risk of an individual. This tool was first developed based on data obtained from the Framingham Heart

TABLE 4 | One-way sensitivity analysis.

Intervention arm: varying the probabilities of mortality			
Scenario 1	Using the lower bound mortality for arrythmia	Scenario 2	Using the upper bound mortality for arrythmia
Probability	0.167	Probability	0.25
ICER	2323.56	ICER	2323.56
Scenario 3	Using the lower bound mortality for action sequence conduction defect	Scenario 4	Using the upper bound mortality for action sequence conduction defect
Probability	0.032	Probability	0.048
ICER	2325.37	ICER	2325.37
Scenario 5	Using the lower bound mortality for hypertrophy	Scenario 6	Using the upper bound mortality for hypertrophy
Probability	0.083	Probability	0.125
ICER	2325.67	ICER	2325.67
Scenario 7	Using the lower bound mortality for MI	Scenario 8	Using the upper bound mortality for MI
Probability	0.074	Probability	0.111
ICER	2325.03	ICER	2325.03
Intervention arm: varying the cost of intervention with lower bounds (assumption: early screening will lead to early diagnosis and reduced cost of care)			
Scenario 9: Arrhythmia	Cost: 1,15,478.85	ICER	2,294.81
Scenario 10: Conduction defect	Cost: 70,078	ICER	1,519.68
Scenario 11: Hypertrophy	Cost: 1,51,728.85	ICER	2,302.58
Scenario 12: MI	Cost: 1,27,578	ICER	2,171.17
Control arm: varying the cost of treatment with upper bounds (assumption: delayed diagnosis may lead to identification in later stage of disease leading to higher cost of care)			
Scenario 9: Arrhythmia	Cost: 2,15,339	ICER	2,320.55
Scenario 10: Conduction defect	Cost: 4,77,339	ICER	2,320.55
Scenario 11: Hypertrophy	Cost: 1,94,139	ICER	2,320.55
Scenario 12: MI	Cost: 2,15,339	ICER	2,293.46

Study (29). The Systematic Coronary Risk Evaluation (SCORE) is high and low cardiovascular risk charts based on gender, age, total cholesterol, systolic blood pressure and smoking status, with relative risk chart, qualifiers and instructions (30–32).

Strengths and Limitations of the Study

The study has calculated the cost of screening cardiac abnormalities through ECG devices in the primary healthcare setting in the Indian context. To the best of our knowledge, such a study cumulatively assessing the clinical and cost-effectiveness of the portable ECG device in the primary healthcare setting has not been studied.

For assessing the cost-effectiveness, there were several data gaps in terms of disorder-specific data on QALY, OOPE, and data on the line of treatment in the Indian context. Thus, the cost-effectiveness analysis was performed using LYs saved as an outcome measure. Considering the project is not matured enough, we could not do the follow-up of patients after treatment. Thus, long-term consequences could not be studied. The OOPE for CVD, in general, was considered for modeling. In addition to this, data gap in disorder-specific management such as line of treatment for arrhythmia, action sequence conduction defect, increase in wall thickness of atria and ventricle, myocardial ischemia, and other disorders was sought by consulting a group of experts. More research is recommended for addressing these limitations in the future by taking a larger sample size and longer study duration.

CONCLUSION

The use of a 12-lead portable ECG facility to screen cardiac abnormalities among high-risk and symptomatic adults, supported with expert consultation for interpretation of ECG results, is both reasonable in cost and effective at saving lives. The screening facility at the primary health care level may lead to early identification of the disease and prompt management. Further, cost data should be validated on a larger cohort prospectively.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Ethics Committee, Indian Institute of Public Health Gandhinagar. The patients/participants

provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

KS, SS, and PK conceptualized the study. CD facilitated data for the study. AP substantially contributed to the acquisition, data analysis, and drafted manuscript. SG, DS, and TP provided technical inputs and critically reviewed the manuscript. All authors contributed significantly to the manuscript and provided approval for publication of the content.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.753443/full#supplementary-material

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How Do Institutional Conflicts of Interest Between Pharmaceutical Companies and the Healthcare Sector Become Corrupt? A Case Study of Scholarship Donations Between Department of Clinical Anesthesiology, Mie University, and Ono Pharmaceutical in Japan

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Institutional conflicts of interest (ICOIs) with pharmaceutical companies can bias internal operation of healthcare organizations. Naturally, a scholarship donation—which is a donation scheme unique to Japan, provided to healthcare organizations and their subunits to encourage educational and academic activities related to the development of new drugs—fall into the ICOI category. While anecdotal evidence exists that scholarship donations have been used as bribes by pharmaceutical companies, there has been little case study research that would illuminate the workings of this "gray area" mechanism. From this perspective, we offer an in-depth analysis of a recent scandal involving the Department of Clinical Anesthesiology, Mie University and Ono Pharmaceutical, where a scholarship donation was used by a pharmaceutical company to increase the prescription of one of its key drugs at a hospital department. Available evidence also suggests that a professor based within the department originally requested a scholarship donation from the company, which became an initial trigger of the scandal. We argue that by scrutinizing scholarship donations we can gain insight into problems specific to ICOIs between the pharmaceutical companies and the healthcare sector in Japan. In addition, scholarship donations can be understood as a form of "gifts" which have been found to underpin certain forms of pharmaceutical companies' promotional activities in Japan but also in other countries. We conclude by highlighting potential institutional remedies, which may alleviate ICOIs and corrupt behavior affecting the healthcare sector.

Keywords: conflicts of interest, ethics, Japan, pharmaceutical companies, Mie University, anesthesiology

INSTITUTIONAL CONFLICTS OF INTEREST

Conflicts of interests (COIs) between pharmaceutical companies and the healthcare sector have long been a source of concern because of their adverse impacts on health policy, clinical practice, and research (1). Recent transparency initiatives have accelerated investigations into this issue, mainly in the US (2), Europe (2), Australia (3), and Japan (4). COIs between pharmaceutical companies and the healthcare sector can be principally categorized into individual COIs and institutional COIs (ICOIs). Unlike individual COIs, which refer to COIs between pharmaceutical companies and healthcare professionals (HCPs), ICOIs can reportedly arise when healthcare organizations (HCOs), any of their representatives, and their subunits (e.g., departments and institutes based within medical institutions), have financial relationships with pharmaceutical companies, and when organizational representatives have individual COIs with pharmaceutical companies (5). Although ICOIs have been relatively less studied compared with individual COIs (6), it has been reported that ICOIs could be at least just as damaging for the health and well-being of patients and general public by biasing internal operations of and research conducted in HCOs in ways which prioritize commercial interests of pharmaceutical companies over patients' and public health needs (5).

ICOIs have primarily been considered to-date in the context of research activities undertaken in the US. There are two plausible explanations. First, the introduction of the Bayh-Dole Act in 1980 has encouraged research collaborations between pharmaceutical companies and HCOs, thereby creating contexts where ICOIs can arise in relation to research activities (5). Second, the death of 18 year-old Jesse Gelsinger in 1999 highlighted how ICOIs could bias a healthy conduct of clinical trials and harm patients (7, 8). Gelsinger died 4 days after an infusion of novel adenovirus vector carrying a corrected gene while participating in its Phase 1 clinical trial, led by Dr. James Wilson, who presumably held a share of the biotech company Genovo, which was supposed to gain from the trial, at 28.5 to 33 million USD at that time (8). Further, it is reported that, in the trial, there was much space for improvement in securing informed consent from participants, particularly in terms of safety of the gene therapy (8). Currently, there are several federal rules related to ICOIs in the US, including the Open Payments Program involving disclosure of payments made by pharmaceutical and medical device companies to teaching hospitals (9).

SCHOLARSHIP DONATIONS: NOTABLE SOURCE OF INSTITUTIONAL CONFLICTS OF INTEREST IN JAPAN

Japan is the world's third largest market of pharmaceuticals with the annual sales of 79 billion USD in 2019 (10), only followed by United States and China, and is another country in which a research scandal relating to ICOIs triggered the establishment of regulatory frameworks to manage ICOIs between pharmaceutical companies and the healthcare sector. From the 2000s to early 2010s multiple instances of unethical or illicit marketing of the hypertension drug Valsartan (Diovan®, Novartis Pharma) triggered the development of legal and other regulations of ICOIs, as detailed in our previous article (11). Most importantly, the Clinical Trial Act of 2018 sought to improve ICOI regulation and transparency in clinical trials (12). Separately, in 2011 the Japan Pharmaceutical Manufacturers Associations (JPMA) published transparency guidelines for its member companies to help them govern COIs with the healthcare sector, including ICOIs, by way of publishing payments made by pharmaceutical companies, with the first public payment disclosure in the fiscal year of 2013 (http://www.jpma.or.jp/english/policies_guidelines/pdf/transparency_gl_intro_2018.pdf). Nevertheless, the JPMA has not created a single central database of payments covering all member companies or non-member companies observing its guidelines voluntarily, following the example of some European countries, such as the UK and Ireland (6, 13, 14). In light of this, Japanese investigative and medical non-profit organizations, including some of authors of this article, have independently created an open-access database for these payments, including ICOIs, starting from the fiscal year of 2016 (4, 15).

A key, yet thus far not fully explored, source of ICOIs involved in the above-mentioned Diovan Scandal is payments to HCOs taking the form of "scholarship donations" (*Shogaku-kifu* (奨学寄附) in Japanese) (4). Specifically, the five trials related to Diovan Scandal, which were conducted at the Kyoto Prefectural University of Medicine, Jikei University School of Medicine, Shiga University of Medical Science, Chiba University, and Nagoya University, were backed up by Novartis Pharma with a total of 1,130 million JPY (9.9 million USD; the exchange rate of 113.9 JPY per 1 USD as of October 30, 2021) of scholarship donations to these universities (16), alongside other logistic support, including statistical analyses.

Scholarship donations are a unique payment type which, to the best of our knowledge, does not exist outside of Japan. The JPMA transparency guidelines define them as donations provided to HCOs and their subunits to encourage educational and academic activities related to the development of new drugs (payment Subcategory B1 falling under Category B "Academic research support expenses"). Full details of the amounts of scholarship donations and their recipients are required to be disclosed annually by companies on their websites (4). Contracts between HCOs, or and their subunits (such as departments), and pharmaceutical companies typically undergo formal review at administrative offices of recipient HCOs (17). However, these contracts do not have to document specific purposes, costs, or time periods associated with scholarship donations (17). Further, not only can scholarship donations cover direct research expenses but also indirect costs, such as clerical support (17). Therefore, recipients of scholarship donations have much discretion in spending them, and, consequently, and because of this flexibility, scholarship donations have played an important role in the operations of many HCOs (17). For example, a 2012 survey conducted among 86 Japanese universities showed that scholarship donations from private entities accounted for 31.4% of their total research budgets (17). Further, according to Ozaki et al., they are ubiquitous in the Japanese medical field, with 71 JPMA members paying 22.1 billion JPY (194 million USD) in total in 2016 (4).

A flip side of the high discretion associated in spending scholarship donations by HCOs means that pharmaceutical companies are not allowed to specify how the HCOs are expected to use these donations (17). However, importantly, the Diovan Scandal suggests that some pharmaceutical companies have used scholarship donations to fund research on their own products (17). While the enactment of the Clinical Trials Act might have decreased such incidents, a critical shortcoming of the existing law is that it does not govern any uses of scholarship donations outside of research as its name implies (12). Indeed, they have been sometimes been used as kickbacks or informal gifts demonstrating gratitude to HCOs, or their subunits, for prescribing specific drugs (4). Therefore, the amount of scholarship donations has tended to reflect "contributions" of HCOs measured by the volume of prescriptions (4).

Given their potential implications for inducing reciprocity from HCOs, which prioritizes pharmaceutical companies' commercial interests, scholarship donations may be harming patients in routine clinical practice. However, empirical evidence is still lacking regarding motivations of HCOs and pharmaceutical companies to give or accept scholarship donations and roles played by HCPs and staff of pharmaceutical companies in this process. Further, no assessment has been done regarding the extent to which scholarship donations may originate in the Japanese tradition to emphasize *giri*, or reciprocity, in business and social interactions, as famously described in the anthropology classic "Chrysanthemum and the Sword" by Ruth Benedict (18). Finally, we lack clarity regarding the impact of this "gray" custom of scholarship donations on clinical practice in Japan.

Here, we provide a glimpse into this phenomenon using the case of a recent scandal in Department of Clinical Anesthesiology, Mie University and Ono Pharmaceutical in Japan. In so doing, we mainly drew on to the Report of the External Investigation Committee on the Issue of Scholarship Donations to the Faculty of Medicine, Mie University, which was published by Ono Pharmaceutical on August 6, 2021, otherwise indicated (17). We also use this case to draw broader lessons for ICOI management in Japan and beyond.

THE ROLE OF SCHOLARSHIP DONATIONS IN THE SCANDAL INVOLVING DEPARTMENT OF CLINICAL ANESTHESIOLOGY, MIE UNIVERSITY AND ONO PHARMACEUTICAL

A recent scandal related to scholarship donations involved a full Professor (hereafter called "A") and an Associate Professor (hereafter called "B") at the Department of Clinical Anesthesiology, Mie University, and two employees belonging to Chubu Sales Department at Ono Pharmaceutical (hereafter called "C" and "D": C was D's line manager). A graduated from the National Defense Medical College in Japan in 1993 and was appointed an Associate Professor at the Department of Clinical Anesthesiology, Mie University in April 2016. He was promoted to full Professor at the department in April 2018, and B was appointed as the Associate Professor at the department at the same time.

From December 2017 to March 2018, Professor A asked D to transfer 2.0 million JPY (17.6 thousand USD) of scholarship donations to his department to amplify its research budget, which directly preceded A's move there as professor since April 2018. A reportedly had been trying to bring junior doctors from his former workplace to Mie University to grow his research capacity, but he was limited in doing so due to a lack of research funds. A also informed D about his intention to increase the use of Landiolol Hydrochloride (Onoact®, Ono Pharmaceutical)—which is approved for several types of tachyarrhythmia (atrial fibrillation, atrial flutter, and sinus tachycardia) in Japan, saying "With 2.0 million JPY of scholarship donations, I'll make Onoact's sales at the university the best in the country." D apparently understood Professor A's strong motivation to increase the use of Landiolol Hydrochloride and considered this as a business opportunity for Ono Pharmaceutical, and thus he outlined a plan to his boss, C, involving making a scholarship donation to A's department. Initially launched in Japan in 2002, Landiolol Hydrochloride was not a leading product for Ono Pharmaceutical, accounting only for 1.8% of its total sales (5 billion JPY [43.9 million USD]/280 billion JPY [2.5 billion USD]) in 2018. In light of this, C initially declined D's plan.

However, C was notified at the end of 2017 that some slots for scholarship donations, which were managed by Ono Pharmaceutical's head office, happened to be left in the fiscal year of 2017 (April 2017 to March 2018). Also, each regional sales director, including C, was instructed to identify candidates for receiving the scholarship donations to use up the budget. Thus, C confirmed with his line manager E at the company's head office that Department of Clinical Anesthesiology at Mie University could be a candidate for obtaining the remaining slots of scholarship donations. Thus, under C's instructions, D discussed with Professor A how many vials of Landiolol Hydrochloride A and his staff would be able to utilize if a scholarship donation was made following to A's department. For example, on January 23, 2017, D wrote to C, "Last night, we (A and D) improved the report's pile-up chart and had a concrete discussion. 500V (vials) is the target and he (A) says it is possible. I have been told that it is possible to reach the 500V mark." Further, around February 2018, A and D prepared an extensive document known as a "case accumulation table" to calculate in detail how much Landiolol Hydrochloride could be prescribed at the Mie University Hospital. The document stated, for example, how many vials of Landiolol Hydrochloride would be prescribed if the drugs were used during and after a cardiac operation, how many operations could be expected, and so on. Following this, C received a response from E by February 15, 2021 at the latest, "Okay, let it go through that way." On this basis, C thought that he had obtained the head office's approval for the contribution of scholarship donations to the Department of Clinical Anesthesiology at Mie University. By February 26, 2018, the General Affairs Department at Ono Pharmaceutical's head office approved a donation to the Department of Clinical Anesthesiology at Mie University, and on March 20, 2018, a scholarship donation of 2 million JPY (17.6

thousand USD) was transferred to a savings account in the name of Mie University.

On March 22, 2018, Professor A sent an email to the staff at the Department of Clinical Anesthesiology with the following remarks: "Ono (Pharmaceutical) has agreed to give us 2 million (JPY) in March; we want Ono (Pharmaceutical) to become our mainstay and we want to become the top (department) in Japan in terms of Onoact use; from April, in the prevention and treatment of tachycardia during extubation, I would like to increase the use of Onoact in a discreet manner (even if it is not used), with 50 mg 1 A as the basic usage; please consider this in your own cases; It's hard to talk about the above publicly. Anyway, I want to get ahead in research, so please understand my intention and do well."

Acting on Professor A's instructions, Associate Professor B began to dissolve and prepare 50 mg vials of Landiolol Hydrochloride for use in operations other than those in which he was in charge from around April 2018, regardless of whether he used it or not. In October 2018, B further began to dissolve and prepare 150 mg vials of Landiolol Hydrochloride, many of which were thrown away without being used for concerned cases (neither C nor D were reportedly aware of the discarding taking place). To create the impression that the discarded Landiolol Hydrochloride had been used for patients, B began to make false entries in the usage history of their electronic medical records. Consequently, the annual sales of Landiolol Hydrochloride to Mie University Hospital increased rapidly from 1.1 million JPY (9.6 thousand USD) in 2017 to 2.5 million JPY (21.5 thousand USD) in 2018 and 5.0 million JPY (43.5 thousand USD) in 2019. In the first half of 2020, when the issue of problematic scholarship donations was made public, the figure had fallen sharply to 410 thousand JPY (3.6 thousand USD). Needless to say, a considerable part of the increase seems to have been accounted for by the disposal of unused portions by Associate Professor B. This suggests that, in exchange for the scholarship donation, A and B used fraudulent means to help increase sales of Landiolol Hydrochloride, which, in turn, led to an increase in the amount of Landiolol Hydrochloride prescribed and sold at Mie University Hospital.

A whistleblower divulged this scandal, and unfortunately, ten anesthesiologists resigned from the Mie University (six in September 2020 and four in October 2020) for unknown reasons and only four active anesthesiologists remained in the department (19), delivering a significant blow to local patient care. The scandal also led to the suspension of the anesthesiology residency program at the university in October 2020, and some of those who resigned highlighted the suspension as the reason of their leave (19).

Associate Professor B was arrested by the Tsu District Local Prosecutor's Office on December 3, 2020 (20), and the remaining three involved in the scheme were arrested by the same office on January 27, 2021. The trial of Associate Professor B, who had falsified medical records and made fraudulent claims, started in March 4, 2021, and was sentenced by the Tsu District Court on April 22, 2021 to two years and six months in prison and four years probation on charges of fraudulent production of public electromagnetic records, fraudulent use of public electromagnetic records, and fraud. Then, the trials of C and D started in May 14, 2021, and both fully admitted to using scholarship donations as kickbacks for increasing prescriptions at the Department of Clinical Anesthesiology, Mie University. On June 29, 2021, the Tsu District Court sentenced them equally to eight months' imprisonment and three years' probation. The trial of Professor A has not been started yet as of November 20, 2021.

Following the arrest of two employees of Ono Pharmaceutical on January 27, 2021, Mie University suspended its business relationships with Ono Pharmaceutical from January 27 to September 26, 2021 (21). Further, Ono Pharmaceutical dismissed C and D with admonition as of July 31, 2021, with other notable disciplinary actions including the demotion of the general manager of the sales division and a 3-month pay cut of 30% for the company president, who had a background in sales (22). To the best of our knowledge, E, who eventually permitted a contribution of scholarship donations to Mie University, apparently avoided a severe penalty. Reportedly, E did not remember well about this decision of himself. Consequently, in this case where the decision was made by the head office of Ono Pharmaceutical, the employees at the end of the line suffered the heaviest punishment. The external investigation committee of this incident claimed that it would be going too far to immediately dismiss the company's lack of compliance by making two arrests. The company also announced that it would discontinue the scholarship donations in 2021, and that it would consider a different method of funding for 2022 and beyond (22). The JPMA suspended the membership of Ono Pharmaceutical on September 16, 2021.

GENERALIZABILITY AND UNIQUENESS OF THIS CASE

It is true that there may be some aspects that cannot be generalized just with this single case study, but this case clearly shows the risk of scholarship donations being used as kickbacks or briberies to increase the level of prescriptions of specific drugs within HCOs. It is also important to recognize that the professor of the department (A) and some staff of Ono Pharmaceutical cooperated and conspired in drawing the scholarship donation from the company and increasing the prescriptions and sales of drugs in return. At last, contrary to his wish to expand his department, which would potentially benefit local residents and patients in Mie Prefecture, clinical anesthesiology department at the university collapsed. While Japanese culture underlines *giri*, or reciprocity, in business and daily interactions (18), it may not be reasonable to consider scholarship donations as its example because the relationships described here are predominantly based on financial incentives of both parties rather than a deep social bond where *giri* is expected to arise (18).

Instead, we should rather interpret scholarship donations as an expression of the industry's promotional activities, including those targeting HCOs. In this respect, the "Study on Corruption in the Healthcare Sector," published by the European Commission, offers particularly valuable insights (23). According to the study's criteria for categorizing corruption, this case, which

TABLE 1 | Improper marketing relations between Department of Clinical Anesthesiology, Mie University, and Ono Pharmaceutical through scholarship donations.

Actors	Professor and Associate Professor at Department of Clinical Anesthesiology Employees of Ono Pharmaceutical
Subtypes	Direct prescription influencing
Features	Improper marketing relationships were created through money.
Drivers	To increase research budgets
Prevalence	Seventy-one Japanese pharmaceutical companies belonging to Japan Pharmaceutical Manufacturers Association payed 22.1 billion JPY (194 million USD, an exchange rate of 113.9 JPY per 1 USD as of October 30, 2021) of scholarship donations in total in 2016, though this is the only example that has developed into a criminal case.

used gifts to influence prescribing practices, can be categorized as an example of Improper Marketing Relations (**Table 1**) (23). While a simple generalization is difficult, like other gifts involved in unethical or illicit marketing, scholarship donations may be instrumental in establishing a "pharmaceutical gift cycle" (24). This mechanism involves "extended" or "generalized" reciprocity between donors and recipients. That is, gifts made by pharmaceutical companies do not need to be reciprocated immediately, and they do not necessarily involve a quid pro quo—put differently, those who make gifts do not necessarily state explicitly what they want to see in return. This means that they may not be straightforward bribes, but an incentive to maintain positive long-term relationships between the two sides. Notably, even small gifts may impact physician's prescribing behavior (25) or actions taken by patient organizations (26). Similar pharmaceutical gift cycles have been reported in other Asian countries such as China (27).

What makes this case unique, however, was Professor A's motivation involving not self-enrichment but increasing the research budget of his hospital department, according to his words cited above (17). Indeed, it seems that this motivation compromised all ethical and other professional standards that he should have upheld as a medical doctor, but we can also speculate that A was responding to increasingly difficult financial circumstances that surround Japanese universities as well as the broader incentive structure in the Japanese medical milieu, and particularly in the field of anesthesiology.

In the Japanese medical field, research outputs have been regarded as a key factor in academic promotion, including securing professorial positions or being appointed an executive board member of a medical schools and/or professional associations. Importantly, the tendency to maximize research outputs, while potentially compromising rules of good scientific and medical practice, seems particularly strong among some Japanese anesthesiologists, as suggested by the relatively high prevalence of scientific misconduct in this medical specialty in Japan. For example, according to the Retraction Watch, an online platform tracking retracted scientific publications, Japanese anesthesiologists Drs. Yoshitaka Fujii and Yuhji Saitoh were respectively ranked as the first (183 publications) and seventh position (53 publications) in the number of retracted articles globally (28). Further, Dr. Hironobu Ueshima, a Japanese anesthesiologist was found guilty of fabricating data and other misconduct in 142 publications in 2021, a majority of which have not been retracted yet (29). One possible reason of the notoriety of the Japanese anesthesiology field is that anesthesiologists enjoy fewer career choices compared to other medical specialties in Japan. For example, it is common for mid-career Japanese doctors to start their own clinics, which is advantageous for work-life balance and personal finances. However, this path is typically unavailable for anesthesiologists given the nature of this specialty. Thus, competition for academic excellence may be more intense in anesthesiology than elsewhere.

It is possible that Professor A saw a higher research budget as instrumental in maximizing the quality and quantity of research outputs published by himself and his research team. Indeed, he might have sought to use an increased research budget, and the improved publication prospects, as a way of attracting young and promising anesthesiologists, according to his words cited above (17). In this context, we cannot overlook the fact that a total value of Management Expenses Grants, formal governmental supports on national universities in Japan, has dropped from 1.2 trillion JPY (10.8 billion USD) in 2004 to 1.1 trillion JPY (9.3 billion USD) in 2020 (30). Indeed, these trends have placed extra pressure on university staff in gaining research budgets, including Professor A, and have made them to pursue private funders, including pharmaceutical companies, ultimately sometimes leading to their corrupt behavior as accentuated in this case.

Another important discussion point is the interpretation of the falsified medical records and fraudulent claims made by Associate Professor B. Although it is difficult to conclusively decipher B's motivations with the available evidence, his conduct demonstrates distorted governance which prioritized following instructions given by Professor A over ethical rules that should be binding for medical doctors. In general, professors have strong discretion in shaping the operation of their departments in Japanese university hospitals, which are typically characterized by strong hierarchical structures (31). Another problem is the lack of external oversight mechanisms and thorough reporting by HCO subunits on their financial relationships with industry, a challenge also identified in collaborations between pharmaceutical companies and public hospitals in England (32).

What is similarly important to discuss is a lack of proper ethical governance in Ono Pharmaceutical. In this case, the need to spend the budget for scholarship donations was prioritized over a proper assessment of A's department. In addition, the individual who permitted this contribution at the head office did not remember his decision clearly. Further, strict penalties of dismissal were applied to the staff directly involved, while the senior staff responsible for managing them suffered only much lighter penalties. These observations suggest problems in the governance not only of scholarship donations but also wider problems in the organizational culture of the company. Indeed, similar problematic organizational culture was revealed in the scandal of Astellas Pharma in the Europe (33).

POTENTIAL REMEDIES OF SCHOLARSHIP DONATIONS AND BROADER PERSPECTIVE ON INSTITUTIONAL CONFLICTS OF INTEREST

This case offers important lessons for the central government, university hospitals, and pharmaceutical companies in Japan. With regards to the central government, they should reformulate the scholarship donation scheme, originally designed to supplement a shortage of research budgets in universities just with public research grants. While the scheme achieved its original goal to some extent, insufficient consideration was given to the possibility of scholarship donations exacerbating ICOIs with pharmaceutical companies. Thus, government should propose a more transparent scheme of donations by private entities particularly with regards to university hospitals, where ICOIs would jeopardize patients' health and well-being. Further, we propose the government to consider interventions that would help university hospitals become financially more independent, such as an increase of medical fees related to treatments using cutting-edge technology, including chimeric antigen receptor T-cell therapy and robot assisted surgery.

With regards to university hospitals, governance within their subunits should be revisited so as to improve transparency. A concerning fact is that stricter regulation within university hospitals might lead to the development of spin-off organizations among their staff so that they can collect funding while avoiding hospital regulations (34). Indeed, Professor A and Associate Professor B developed the spin-off organization for that purpose and used it to accept bribery from the medical device company Nihon Kohden Corporation, leading to another criminal case (17). While we aim to cover this incident in our future work, at this stage, we can at least propose that there should be external oversight mechanisms to detect corrupt behaviors in subunits of university hospitals, including their use of spin-off organization outside of the hospitals.

With regards to pharmaceutical companies, the abolishment, or at least an overhaul of, scholarship donations is necessary. Indeed, we can see an increasing trend among pharmaceutical companies to revisit disadvantages of scholarship donations, which includes unclearness in the purpose for making the donations. For example, leading domestic pharmaceutical companies, including Takeda Pharmaceutical Company (2021) and Astellas Pharma (2019), have abolished scholarship donations. In addition, as a lesson of this case, the entire governance from pharmaceutical companies is in need of improvement. We also believe that the general public, patients, and policymakers in Japan and other countries around the world should enhance their awareness on social responsibility of pharmaceutical companies conduct. While Ono Pharmaceutical was suspended for the JPMA's membership following the incident described in this paper, the company did not experience substantial social damages such as dropped stock prices despite its questionable disciplinary actions, which reflects the apparent lack of financial impact of a recent scandal involving off-label drug promotion by Astellas Pharma in Europe (33).

Also, from a broader perspective, this case demonstrates how ICOIs can bias the internal operation of HCOs and compromise the standard of clinical practice, indicating the need for specific regulations to control its negative impact on patient care. In the United States, pharmaceutical companies only pay for laboratories under research contracts, because unrestricted donations in exchange for prescription can be considered as a bribery or kick-back (35). Further, in the United Kingdom, the industry's self-regulatory body, the Prescription Medicines Code of Practice Authority, operating under the Association of the British Pharmaceutical Industry, adopts strategies to name and shame the offending companies by publishing reports of all cases it considers on its website irrespective of the verdict (https://journals.sagepub.com/doi/pdf/10.1177/2631309X20970477). In contrast, there is no solid framework to regulate ICOIs within and/or outside of the JPMA in Japan, indicating the urgent need for a broader initiative to govern ICOIs beyond clinical trials. Incorporating regulations similar to those adopted in other leading countries would likely improve ICOI governance in Japan. Further, countermeasures placing more emphasis on loss aversion such as suspension of medical licenses in these problematic behaviors among medical doctors may be important (36). Given that the social mechanisms underpinning scholarship donations can be found in other forms of gifts involved in pharmaceutical promotion, we believe that the lessons emerging from our study would be similarly applicable to other nations that have not incorporated such legal- or self-regulation frameworks yet.

DATA AVAILABILITY STATEMENT

All the data and evidences cited in this article are publicly available. Further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

AO wrote the manuscript. All the authors contributed to the conception and design of the study, critical revision of the paper, and read and approved the final manuscript.

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Disempowered Mothers Have Undernourished Children: How Strong Is the Intrinsic Agency?

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Objective: Undernutrition is one of the leading causes of morbidity and mortality among under-five children, particularly in low-and-middle-income countries. Since women, including mothers, are the primary caregivers of their children, their empowerment status can inherently influence children's nutritional status. Empowerment is, mainly, an intrinsic agency developed as an affective domain trajectory or attitude that guides the skill or behavior. This study aimed to assess the association between women's empowerment and nutritional status of their children.

Methods: A cross-sectional study was carried out among 300 mothers having children aged 6–59 month in rural municipalities of Kaski district in Nepal. Face to face interview and various anthropometric measurements were used to collect data. Chi-square test was performed to assess the association between women's empowerment and children's nutritional status, and multivariable logistic regression was used to assess the strength of association.

Results: Of 300 mothers having 6–59 months' children, nearly half (49%) were highly empowered while around 38% children were in poor nutritional status. More than one-fourth (26.7%) children were stunted, 7% were wasted, 17.7% were underweight, and in overall, nearly 38% were in poor nutrition. There was a five-fold increase in odds of wasting, thirty-fold increase in odds of stunting, and twenty-nine-fold increase in odds of underweight among children whose mothers had low empowerment status compared to their counterparts.

Conclusion: Overall, this study exhibited that maternal empowerment strongly affected children's nutritional status, especially stunting and underweight. Thus, intrinsic factor, mainly education and community membership are suggested to empower them for making their own decisions. Interventions aiming to improve nutritional status of children should include women empowerment incorporating dimensions of material resources. Further empirical evidence is required from trials and cohort studies.

Keywords: autonomy, children, empowerment, rural, undernutrition, women, intrinsic agency

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INTRODUCTION

Health, physical growth and development, academic performance, and progress in life are determined by the nutritional status of children (1). Undernutrition is one of the leading causes of morbidity and mortality among under-five children in low-and-middle-income countries (LMICs) (2), and estimated to prevail among one-third of children worldwide (3). The lack of appropriate care for both women and children is one of the underlying factors of undernutrition among children (4). These underlying trends have been largely affected by health expenditures in low and middle income countries (LMICs) in recent decades (5). Development assistance for health (DAH) provided to the largest multilateral agencies by donors among wealthiest OECD countries appears to be shrinking (6), yet national spending on health and social insurance including early childhood support continues to grow across LMICs (7). Leaders in such a growth across the Global South remain the emerging markets such as the Brazil, Russia, India, China, and South Africa (BRICS) (8) and the countries of emerging seven markets (EM7) (9).

Although the global trend of child nutritional status in LMICs has improved in the last few decades, still 28% of under-five children are stunted. One of the core causes for child undernutrition is the lack of appropriate care for women and children (4, 10). It is extensively acknowledged that women play a vigorous role in children's nurture and also for enhancing child health capabilities throughout the childhood period (11). Enhancing women's status both at domestic and public spheres is important to enhance child wellbeing including the empowerment of nutritional status. Scholars define women empowerment as women's sense of self-worth; their right to have and determine choices; access to opportunities and resources; and power to control their own lives, both within and outside their home (12). Women empowerment is a multidimensional attribute having some 200 indicators (13) roughly rounding off under three latent group of variables- the assets [information, household (HH) material resources, and house/land ownership], the instrumental agency (financial autonomy/purchasing decision, decisions in healthcare, and family planning), and intrinsic agency (group membership, education, spousal communication, and attitude toward intimate partner violence) (14–17). Basically, the third one, intrinsic agency, is more inherent, having sense of self-worth, developed as an attitudinal belief that guides certain skills and behaviors and also orthogonal and deterministic to the instrumental agency like decision makings (18, 19).

By 2030, ending preventable deaths of newborns and under-five children, ensuring women's full and effective participation and equal opportunities for leadership at all levels of decision making in political, economic, and public life in all countries were the established target of Goal 3 and Goal 5 of the sustainable development goals (SDG) (20). In this scenario, this study aimed to assess the relationship between women's empowerment and nutritional status of their children.

MATERIALS AND METHODS

Study Design

A cross-sectional analytical study was conducted in four rural municipalities of Kaski district in Nepal. The study participants were mothers having children aged 6–59 months.

Sample Size Calculation and Technique

The sample size was determined as 300 by using the formula for cross-sectional studies taking the prevalence (p) of stunting as 28.9% (that yielded higher sample size than wasting (5.8%) and underweight (14.9%) (21) with a 95% confidence interval, allowable error of 5%, and applying a finite population correction.

From a list of 6,023 eligible children in rural municipalities, sample size for each of the 25 clusters have been calculated by probability proportional to size (PPS) technique. In order to select the first sample in each cluster, we used WHO EPI method (22).

Measures

Face to face interview and anthropometric measurements were used as data collection techniques. Women's empowerment was assessed using a women empowerment index (WEI) which includes five indicators, i.e., women's involvement in household decision-making, women's membership in community groups, women's cash earning, women's ownership of house/land and women's education (14). Tools were translated in the Nepali language, translation validity maintained with iterative process, and used for the interviews. Economic status was calculated based on the international wealth index (IWI) (23). Anthropometric measurements of the children were assessed by the researcher as per the WHO guidelines (24). Age of the child was determined by asking with respondent and further cross-checked with birth certificate or immunization card. Children up to 24 months and not able to stand by their own were weighed with the analog Salter type baby weighing scale with nearest 0.01 Kg and those aged 25–59 months were weighed using bathroom scale with the nearest 0.5 Kg (25). In order to check the validity of salter scale and weighing scale, weights that were proven valid by Nepal Bureau of Standards and Metrology were used. After measuring the weight of every five children scales were rechecked by using standard weights of 5 kg and manually adjusted. Height of the child was measured to the nearest 0.1 cm and to validate, we repeated the measurement twice to obtain two readings within 0.2 cm and the average of two closest measurements were recorded (25).

Study Variables and Statistical Analyses

We included socio-demographic variables as background variables in the study and dummied as confounders. Sociodemographic variables included age of mother and child, religion, ethnicity, type of family, number of U5 children, the women had, household economic status and the sex of child. The independent variable was women's empowerment and included five indicators- decision-making; involvement in community groups; independent cash earing; house/land

TABLE 1 | Socio-demographic characteristics (n = 300).

	Frequency (n = 300)	Percent (%)
Age of mother		
<20 years	11	3.7
20–34 years	262	87.3
≥35 years	27	9.0
Religion of mother		
Hindu	254	84.6
Buddhist	32	10.7
Muslim	14	4.7
Ethnicity of mother		
Dalit	98	32.6
Disadvantaged indigenous ethnicity	37	12.3
Religious minorities	14	4.7
Relatively advantaged indigenous ethnicity	59	19.7
Brahmin and Chhetri	92	30.7
Type of family		
Nuclear	145	48.3
Joint	155	51.7
Number of U5 children		
Have only one child	267	89.0
Have two or more child	33	11.0
The economic status of a family		
Lowest quintile	20	6.7
Second quintile	12	4.0
Third quintile	54	18.0
Fourth quintile	171	57.0
Highest quintile	43	14.3
Age of the child		
<24 months	89	29.7
≥24	211	70.3
Sex of the child		
Male	161	53.7
Female	139	46.3

TABLE 2 | Maternal empowerment and its various dimensions.

Empowerment level	Frequency (n = 300)	%
Low empowerment	22	7.3
Moderate empowerment	131	43.7
High empowerment	147	49.0
Dimension of WEI*		
Decision making in healthcare	262	87.3
Decision making in household goods purchasing	260	86.7
Freedom to visit relatives	244	81.3
Having membership of community groups	186	62.0
Earn cash independently	110	36.7
Ownership of house/land	76	25.3
Maternal educational status		
No formal education	10	3.3
Primary education	111	37.0
Secondary and above education	179	59.7

WEI, Women's empowerment index.

ownership; and educational status. Empowerment level was categorized as low, moderate, and high. The dependent variable of the study was the nutritional status and assessed as stunting, wasting, and underweight. Socio-demographic variables, mother's empowerment, and nutritional status of 6–59 months children were described per protocol. In the first analysis, the mother's empowerment status was associated to children's nutritional status using chi-square and unadjusted odds ratio. For the adjustment, then, we filtered out and selected only the significant ($p < 0.05$) two socio-demographic variables-maternal age ($p = 0.025$), and number of children ($p = 0.003$); from the seven variables included in primary analysis. We also checked autocorrelation of these two variables with maternal empowerment where the highest correlation, among all, was observed as $r = 0.18$ ($p = 0.002$) between the number of children and maternal empowerment score. Since it was low ($r = 0.18$), so, we proceeded for the second step for adjustment and calculated the adjusted odds ratios.

Ethical Consideration

Ethical approval was obtained from the Institutional Review Committee (IRC), Pokhara University. Written informed consent were taken from selected rural municipalities for conduction of study in those areas. Participants were not subjected to any sort of harm and they were informed about their autonomy to withdraw from the study at any time during the study. Confidentiality of their information was fully maintained. Children identified as malnourished were referred to the nearest health facility and information was provided to the respective municipalities about the number of malnourished children.

RESULTS

Socio-Demographic Characteristics

Among the 300 mothers interviewed, majority (87.3%) were from the age group of 24–34 years and followed Hindu religion (84.7%). The proportion of Dalit participants among the ethnic group was the highest (32.7%). Richer group as per IWI (fourth quintile), consisted the majority (57%), followed by third quintile (18%). The majority children (70.3%) were aged above 24 months. More than half (53.7%) of the children were male (**Table 1**).

Women Empowerment and Its Various Dimension

Around 60% of women had completed secondary level and above whereas few (3.3%) had never been to school. Almost every nine out of 10 women themselves took the decisions related to healthcare and household goods purchasing. More than 80% reported having freedom to visit their relatives whereas 62% were members of any community groups. More than one-third of women earned cash income independently and one-fourth were the owners of a house or land. In aggregate, nearly half of the

TABLE 3 | Nutritional status of children, n (%).

	Male (n = 161)	Female (n = 139)	Total (n = 300)
Stunting (height for age)			
Severely stunted child	9 (5.6)	6 (4.3)	15 (5.0)
Moderately stunted child	32 (19.9)	33 (23.7)	65 (21.7)
Normal child	120 (74.5)	100 (72.0)	220 (73.3)
Wasting (weight for height)			
Severely wasted child	3 (1.9)	1 (0.7)	4 (1.3)
Moderately wasted child	12 (7.5)	5 (3.6)	17 (5.7)
Normal child	146 (90.6)	133 (95.7)	279 (93)
Underweight (weight for age)			
Severely underweight	5 (3.1)	2 (1.4)	7 (2.3)
Moderately underweight	26 (16.1)	20 (14.4)	46 (15.3)
Normal child	130 (80.8)	177 (84.2)	247 (82.3)
Overall nutrition status			
Poor nutritional status	63 (39.1)	56 (40.3)	119 (37.7)
Good nutritional status	98 (60.9)	83 (59.7)	181 (60.3)

mothers had a high empowerment level followed by moderate and low (**Table 2**).

Nutritional Status of the Children

Among 300 children, more than half (53.5%) were found to be stunted. The proportion of stunting among male and female children was almost similar at 25.5 and 27%, respectively. Similarly, severe and moderate stunting was noted among 5 and 21.7%, respectively. Around 14% were found wasted. Wasting among male child (9.4%) was almost two-fold as compared to female child (4.3%). Similarly, more than one third (34.7%) of the children were found underweight. The proportion of underweight among male children was slightly greater than the female child (19.2 vs. 15.8%, respectively). Overall, 60.3% children were felled under the normal category (with no stunting, wasting, and/or underweight) whereas remaining was categorized as having poor nutritional status (37.7%) (**Table 3**).

Association Between Women's Empowerment Level and Children's Nutrition Status

In preliminary analysis, only two background variables, maternal age (dummies; <26 or ≥26 yrs.) and number of children in a family (dummies; 1 or >1), were found significant with children's nutritional status, so entered as confounders in the multivariate models. Mothers with low empowerment were almost 30 (AOR = 29.5; 95% CI = 9.1–95.2) times; nearly 5 (AOR = 5.4; 95% CI = 1.1–27.1) times; nearly 29 (AOR = 29.4; 95% CI = 7.9–110.0) times; and 37 (AOR = 37.0; 95% CI =9.8–142.8) times more likely to have their children being stunted, wasted, underweight, and in poor (overall) nutritional status in reference to highly empowered mothers. Moderate empowerment level among women was also associated with children's stunting, underweight, wasting, and overall nutritional status but with lower strengths (**Table 4**).

Association Between the Various Dimension of Women Empowerment Level and Children's Nutritional Status

The results show that all the dimensions of the women's empowerment index were significantly associated with children's nutritional status. The decision making in health care, decision making in household good purchasing, having membership in the community, earning cash independently, ownership of house/land, and education status showed a strong association with children's nutritional status (**Table 5**).

DISCUSSION

Children's nutritional status and the maternal empowerment level are analyzed and the findings are compared with that of the NDHS reports, other similar studies, and further discussed. Seminal literature has confirmed strong relationship between early childhood undernourishment and lowest income groups (26). This causality has been documented in diverse world regions ranging from Sub-Saharan Africa (27), Syria (28), India (15, 29), Yugoslavia (30), and both Koreas (31) alike. This study showed 26.7, 7, and 17.6% of children being stunted, wasted, and underweight, respectively. These are less than the findings of the NDHS preliminary report 2016 (21) at national level, but, are very close to the data of Gandaki province where the study areas (rural municipalities) are located, i.e., 28.9% stunting, 5.8% wasting, and 14.9% underweight. The contrasting figures of the study findings with that of national level may be due to higher socio-economic and literacy rates of Kaski district.

The study showed that low and moderate level of empowerment (with reference to high) were moderate to strongly associated with undernutrition of the children: Stunting (AOR, around 30 and 16, respectively), wasting (AOR, 5 and 4, respectively), and underweight (AOR, 29 and 13, respectively) (all $p < 0.05$). These findings are consistent with another study in Nepal, which found women's empowerment positively associated with nutritional status of their children (32). Nonetheless the study from Pakistan showed an insignificant effect on child nutrition (33). However, in a systematic review of 39 studies, only 20% of all the significant associations (weighted) showed relationship of higher women empowerment with lower children's nutritional status, and 3% (weighted) were in the opposite direction (13).

This study showed that women's involvement in household decision-making (a component of empowerment) was statistically significant with the nutritional status of children. These verdicts were accord with another study from Northern Benin, which showed positive correlation between women's empowerment and leadership while decision making was correlated with wasting and underweight among children (34). An RCT conducted in Burkina Faso also showed that improved women empowerment, especially in decision making in health and household purchasing, contributed to reducing the wasting of their children (16). These findings also harmonize with ours.

Our study showed that women's engagement in a community group was associated with child nutrition. The result is coinciding

TABLE 4 | Strength of association between maternal empowerment and children's nutrition.

	Child's nutritional status-frequency (%)		ξ^2-statistic (*p*-value)	UOR (95% CI)	AOR (95% CI)†	Nagelkerke R^2
	Stunted	**Normal**				
Low	14 (63.6)	8 (36.4)	74.05 (<0.001)**	35.0 (11.0–110.9)	29.5 (9.1–95.2)	0.368
Moderate	59 (45.0)	72 (55.0)		16.4 (7.1–37.7)	15.9 (6.9–36.8)	
High	7 (4.8)	140 (95.2)		Ref		
	Wasted	**Normal**				
Low	3 (13.6)	19 (86.4)	8.87 (0.012)*	5.6 (1.2–27.2)	5.4 (1.1–27.1)	0.074
Moderate	14 (10.7)	117 (89.3)		4.3 (1.4–13.4)	4.2 (1.4–13.3)	
High	4 (2.7)	143 (97.3)		Ref		
	Under-wt.	**Normal**				
Low	11 (50)	11 (50)	53.50# (<0.001)**	35.8 (9.8–131.0)	29.4 (7.9–110.0)	0.294
Moderate	37 (28.2)	94 (71.8)		14.1 (4.9–40.8)	13.4 (4.6–39.1)	
High	4 (2.7)	143 (87.3)		Ref		
	Malnourished	**Normal**				
Low	7 (31.8)	15 (68.2)	31.53# (<0.001)**	11.0 (3.3–36.9)	9.5 (2.7–32.7)	0.188
Moderate	33 (25.2)	98 (74.8)		7.9 (3.2–19.6)	7.6 (3.1–18.8)	
High	6 (4.1)	141 (95.9)		Ref		
	Overall nutrition					
	Poor	**Good**				
Low	19 (86.4)	3 (13.6)	90.86 (<0.001)**	42.7 (11.5–158.1)	37.0 (9.8–142.8)	0.399
Moderate	81 (61.8)	50 (38.2)		10.9 (6.0–19.8)	10.9 (5.9–20.0)	
High	19 (12.9)	128 (87.1)		Ref		

*$p < 0.05$; **$p < 0.001$; †*Adjusted to number of children and maternal age; #Max. likelihood ratio.*

with the cross-sectional study from Andhra Pradesh, which showed that larger and more literate social networks are associated with better length-for-age of 1-year-old children (35). Another study from India found that high maternal cognitive social capital was associated with the highest level of stunting (36). Children in communities with a high proportion of women autonomy in healthcare or movement or money separately had a lower risk of being stunted, underweight, or wasted (37).

In this study, the cash earning that leads to higher women's empowerment level was strongly associated with child nutrition. The finding concurred with the study from rural Karnataka, which showed a strong association with maternal employment and children's underweight (38).

In this study, although ownership of house or land that comprised a part of women's empowerment, was associated with children's nutrition, the findings are consistent with the study from Nepal which found that women who own land are significantly more likely to have the final say in household decisions (OR = 1.48), a measure of empowerment (37) but a study from Uganda found that ownership exhibited no differentials with child stunting (39). When only land/house ownership should be taken, it should be reassessed with further clarifications.

In this study, the level of education, which is a factor for high women's empowerment, was strongly associated with a child's nutrition. The finding is accordant with the study from Nairobi that found mother who passed the primary level have high (43%) stunted children compared to the mothers who passed the secondary level of education (40). Our study is also unfailing with the study from the region of Tanzania which showed that maternal education is one of the predictors of stunting (OR 2.31; 95% CI: 1.43–3.64) and parental education as the predictor of underweight (OR 1.76; 95% CI: 1.07–2.89) (41). The children whose parents are illiterate or having a low level of education are more vulnerable to the nutritional problem. These findings coincide with several previous studies (42–46). Similarly the another study from a country of east Africa, Mozambique which used Multiple Indicators Multiple Causes (MIMIC) shows the educational level of the mother are positively correlated with the nutritional status of children (17). So, parental education is, probably, the most consistent factor found associated with child's health and nutritional outcome. Furthermore, the maternal education has shown to be an essential factor driving female inclusion into the workforce of domestic society, increasing their income and social security (47). Degree of sexual revolution taking place in an observed society is also closely related to the emancipation of women and their absorption into the labor market (48). This was proven to be a lengthy historical process with way different outcomes and stages in different world regions from Latin America (49) to the South Asia (50) and ASEAN (51). Final consequences turned out to be mostly positive in terms of growing female wages and social independence capacity inclusive of ability to raise children (52). Yet male—female disparity in revenues remains significant even amongst some of the wealthiest OECD countries (53). In addition, alternative social protection financial mechanisms were created in exceptionally rich societies

TABLE 5 | Association between various dimensions of maternal empowerment and children's nutrition.

WEI dimension[#]	Nutritional status, *n* (%)		Df	ξ^2	*p*-value
	Good	Poor			
Decision making in health care					
Yes	174 (66.4)	88 (33.6)	1	31.938	<0.001**
No	17 (18.4)	31 (81.6)			
Decision making in household goods purchasing					
Yes	173 (66.5)	87 (33.5)	1	10.674	<0.001**
No	8 (20.0)	32 (80.0)			
Freedom to visit relatives					
Yes	158 (64.8)	86 (35.2)	1	10.674	0.001*
No	23 (41.1)	33 (58.9)			
Having membership of community group					
Yes	131 (70.4)	55 (29.6)	1	20.850	<0.001**
No	50 (43.9)	64 (56.1)			
Earning cash independently					
Yes	97 (88.2)	13 (11.8)	1	56.283	<0.001**
No	84 (42.2)	106 (55.8)			
Ownership of house/land					
Yes	67 (88.2)	9 (11.8)	1	32.928	<0.001**
No	114 (50.9)	110 (49.1)			
Education status					
No formal education	2 (20.0)	8 (80.0)	2	19.879	<0.001**
Primary education	54 (48.6)	57 (51.4)			
Secondary education and above	125 (69.8)	54 (30.2)			

*$p < 0.05$; **$p < 0.001$.

such as Switzerland (54) or Japan to provide financial support to unemployed mothers raising their own children in the capacity of housewives (55). Such solutions remain hardly accessible to less wealthy economies (56).

However, it is not clear from the literature that how women's empowerment is associated with children's nutritional status. A systematic review summed up (from 62 quantitative studies) as 82 and 84 percent of the weighted cases, stunting and wasting, respectively, were not found significant with women empowerment. For this, the authors have blamed the study designs rather than the embedded underlying associations (13).

To sum up, education (40, 41), income (47), and social protection for the unemployed (53, 55), decision making (16), sexual and reproductive health rights (48–51), and social networking and engagement (35, 36) have been discussed as the sustainable and long-term strategies. In addition, nutritional gain through behavior change communication focusing on knowledge and skills, increased control over income from the sale of targeted commodities (57), family approach with fixed empowerment goal, and problem reflection and critical thinking (58) can be taken as instantaneous strategies which are significant for nutrition-sensitive interventions, too. Although there is a variation of indicators of women's empowerment scale the internal agency component, which includes spousal communication, attitude toward intimate partner violence, seems promising and so, be taken for granted and applied in policy cautiously. Financial autonomy further needs to be tested with trial study whereas decision making with longitudinal design. Developing the context-specific valid scale is also deemed imperative.

CONCLUSION

Our results demonstrate that 7%, more than one in every four, and more than one in every six children were wasted, stunted and underweight, respectively. Similarly, almost half of the mothers were highly empowered. There was nearly a five-fold increase in odds of wasting, thirty-fold increase in odds of stunting and twenty-nine-fold increase in underweight, among children whose mother had low empowerment status compared to their counterparts. Empowerment dimensions like women's education and their community membership are cautiously warranted so as to impact on their decision making, thereby positively contributing to children's nutritional status. Dimensions of material resources like independent cash earning and house/land ownership need further empirical evidences from stronger study designs.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Pokhara University Research Center (PURC), Pokhara University, Nepal. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SP and CA conceptualized the research and analyzed the data. SP collected the data. SP, CA, RKY, and MJ prepared the first draft. SP, CA, DKY, and DKT prepared the second draft by addressing the comments from the reviewers. All authors reviewed the first draft, contributed for improvement, reviewed the final draft, read, and agreed to the final version of the manuscript.

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How Fast Are the Asian Countries Progressing Toward Green Economy? Implications for Public Health

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Monitoring progress toward green economy has been a key policy focus globally. The purpose of our study is to assess Asian countries' green development performance and also the progress toward green economy overtime. To achieve this goal, we propose a green development index (GDI) to assess the level and ranking of green development for Asian countries, and then we measure the progress toward green economy by the method based on the compound annual growth rate (CAGR). The result shows that the northeast Asian countries together with Singapore and Israel are leaders in green development performance across Asia, but the most progress toward green economy has been achieved by some medium green development level countries, like China. Countries with the fastest movement away from green economy are some laggard countries with poor green development performance, such as Syria and Yemen. More generally, the leading countries have reached a high green development level, and the medium ones move fast toward green economy, whereas some laggards get worse. We also discuss the implications for public health in environmental protection, green consumption, and green production.

Keywords: green economy, measuring progress, entropy method, indicators, environmental assessment, Asia

INTRODUCTION

Monitoring progress toward green economy or green development has been the focus of both researchers and international organizations (1–3). Many international organizations and statistical institutions are continuously focusing on the implementation of green development or green economy policies, like the UN Statistical Commission, Eurostat (4, 5). Some researchers also attempt to set SDG indices for green development assessment (6, 7). In addition, there are many composite indices built to measure the performance and ranking of green development, such as the human green development index (8).

In existing green economy studies, the focus is often the global or European countries' assessment and ranking at a certain time point or period. Throughout these assessments and rankings, European and other OECD countries tend to come out on the top, whereas African countries on the bottom (8, 9). Within the Europe, the best green development performance is always found in the Scandinavian countries (10, 11). However, although these studies measure the green development level at a certain time point or period, they do not propose a method to indicate whether countries have moved toward or away from green economy over time and how fast they have moved, which is also very important (12).

Recently, a growing list of studies have pointed the importance of monitoring progress toward green economy over time and proposed a new method to measure it (3, 5, 13). This method, based on the compound annual growth rate (CAGR), could be used to assess development over time also in the absence of quantified policy targets (12). This CAGR method is adopted to study the EU members' progress toward SDGs, which has resulted that strong movement toward SDGs is found in those southern and eastern European countries with relatively low sustainable development level (Hametner and Kostetckaia).

However, Asia, as the largest continent with more than 4 billion people, has not received enough attention in studies of green economy measurement and progress. Some studies have measured the green development level of some Asian countries, like 12 developing Asian countries (14) and 6 Southeast Asian countries (15). Koirala and Pradhan (16) studied the determinants of green development in 12 Asian countries for the 1990–2014 period. But there are still many issues concerning the green development of Asian countries that need attention: (1) What is the green development performance and rankings of Asian countries? (2) Which countries are moving forward or away from green economy? (3) And how fast? (4) Is there a relationship between a country's green development level and the rate of progress toward green economy? (5) What's the implications for public health? These research questions are attempted to be answered in this paper.

The results of this paper are relevant for both researchers and policy-makers. First, this paper supports the viewpoint of Hametner and Kostetckaia (3), that is, it is not sufficient to calculate composite development indices and rankings at a time point or period, and it is necessary to monitor progress toward green economy over time. Second, our research will help to strengthen the understanding of green economy and green development. Many studies have paid attention to the environmental dimension while ignoring the essence of green development, namely coordinated development in economic, environmental, and social dimensions. Last, the result shows that the laggard countries in Asia move the fastest away from green economy, which implies that it is important to help these countries improve green development level.

The rest of the paper is organized into five sections. Section 2 is literature review. Section 3 describes the methods for measuring the green development performance and the progress toward green economy, as well as the data source. Section 4 is result, namely the green development ranking and progress score. Section 5 is a comparison between GDI and other similar composite indices. Section 6 concludes and derives some implications for public health.

LITERATURE REVIEW

Green Economy and Green Development

Since the "green economy" has been put forward by Pearce et al. (17), it has gradually become the focus of governments and researchers. As Pearce et al. (17) have pointed, green economy is an economic development mode that the natural environment and human beings can bear, which does not lead to ecological crisis and social division due to the pursuit of economic growth, and which does not lead to unsustainable economic development due to the depletion of natural resources. Also Reardon (18) further defines "green economy" as "the maximization of human happiness under the constraints of resources and ecology."

Therefore, green economy is a kind of "green development" mode that coordinates economic and environmental development (8). The core of green development is "give consideration to both green and development," and the goal is to achieve the harmony of green and development (19). On one hand, if were to only protect the environment and make the economy stagnation, this would not represent a green development mode. On the other hand, if were to promote economic growth at the cost of environment, that would also not be a green development (9). Green economy and green development are proposed based on the contradiction between economic growth and resources, environment and ecology, but not only does it mean to deny economic growth, but it also helps to seek a new way of economic growth (8). Stable economic growth, sustainability of resources and environment are very important for both developed and developing countries (20).

Indices for Green Economy Assessment

A growing list of indices have been proposed for green economy or green development assessment (21). The indices in early times put more attention on environmental sustainability. For example, Hall and Kerr (22) proposed the Green Index to monitor the national environmental health in USA. Recently, scholars begin to pay attention to the coordinated development of environment and economy. Kumar and Kumar (23) suggested that developing countries can achieve low-carbon development through low pollution and high efficiency production technology. Halle (24) argued that accountability mechanism played an important role in the green development. Li et al. (8) built the human green development index by adding indicators of resources and environment to the Human Development Index. In addition, some international organizations also built green economy assessment indices, such as the WAVES (25), the green economy index (26), etc.

TABLE 1 | The structure of green development index.

Index	Dimension	Factor	Indicator	Premise
Green development index (GDI)	Economic- social dimension	Economic growth	Real GDP growth	+
		Education	Expected years of schooling	+
		Health	Life expectancy index	+
		Income level	Income index	+
		Economic structure	Employment in services (% of total employment)	+
	Resource- environmental dimension	Climate	CO_2 emissions per capita	−
		Air quality	PM2.5	−
		Forest	Forest area (% of total land area)	+
		Arable land	Arable land per person	+
		Energy	Renewable energy consumption (% of total final energy consumption)	+

(1) The weight of each indicator is given by the Entropy Method described below. (2) The descriptions and data source of the 10 indicators can be found in ***Appendix Table A1****.*

METHODS AND DATA

Methods for Green Economy Measure: Green Development Index

According to the concept of green economy and the existing studies, this paper established the Green development index (GDI) with two dimensions, namely economic-social dimension, and resource–environmental dimension.

The Framework of the Green Development Index

According to the definition of green economy, the government should set green development as a comprehensive goal including economic–social and resource–environmental dimensions. Therefore, a composite index for green development assessment should include these dimensions (27). Jin et al. (9) suggested that a green development index should contain these factors, namely "economic growth," "income level," "education," "health," and "economic structure" in economic–social dimension, "climate," "air quality," "forest," "arable land," and "energy" in resource–environmental dimension. They believe that these are the basic indicators to coordinate the common development of human society and natural environment, and also the basic goal of human pursuit of green development.

The GDI is an attempt to be a concise, acceptable, and complete index, and so the five principles below should be followed when selecting the corresponding indicator for each factor: (1) indicators should be representative, and preferably mature and stable ones in existing studies; (2) the quantity of indicators should not be too many, making the composite index concise and acceptable (8); (3) indicators should be continuous and comparable over time (28, 29); (4) indicators must be quantifiable and have strong operability; (5) availability and reliability of the source of data (30). According to the principles above, we select one indicator for each factor so as to build the framework of GDI (see **Table 1**), while the selection process of indicators is in the next section.

The Selection Process of Each Indicator

The representativeness and typicality of the selected indicators (variables) are related to the measurement and practical value of the GDI. Thus, it was very important to choose one indicator in each of the 10 areas related to green development. According to the criteria for choosing indicators and referring to the advanced practices of well-known indices, we formulated meticulous operation steps for indicator selection. Taking the selection process of the "Education" indicator as an example, the details are as follows.

(1) Searching relative indicators

There are more than 20 indicators for the factor of "education," such as "government expenditure on education," "government expenditure per student," "gross intake ratio in first grade of primary education," "literacy rate (adult)," "progression to secondary school," "school enrolment, secondary," "primary school enrolment," "trained teachers in primary education," "primary completion rate," "mean years of schooling," and so on. We studied and compared these indicators and chose the most representative and suitable indicator in each field based on the selection criteria and existing well-known indices.

(2) Comparing all indicators

According to the indicator selection criteria above, we compared all indicators and investigated their representativeness, comparability, continuity, and availability. For example, "government expenditure on education" can represent government spending and emphasis on education, but cannot effectively measure current education quality and future education development. The data for "trained teachers in primary education" are not available in more than 120 countries. Fortunately, these indicators for education are all continuous and comparable. Thus, we eliminated the indicators that lacked representativeness and availability.

(3) Choosing the most suitable and representative one

Due to the third criterion, we chose only one indicator for education to make the GDI concise and easily accepted; thus, that indicator had to be the most suitable and representative one. "Literacy rate (adult)" and "Mean years of schooling" are

relatively representative and available as education indicators, and they are widely used to measure the education level of a country. We finally chose the "Mean years of schooling" as the education indicator. The first reason is that adult literacy rate is not "fair" for developing countries, and could not represent future education development. Many developing countries became independent after World War II, some even in the 1990s. The older generation in these countries grew up in chaotic wartime, which led to a very low literacy rate. Although the "Mean years of schooling" will be affected by the age structure too, as an average indicator, the impact of age structure on it can be minimized to a large extent. Secondly, adult literacy rate lacks differentiation, especially for countries with a high economic development level, where the level reaches almost 100%. Thirdly, we were able to gather more samples if we chose the "mean years of schooling" indicator.

The selection process of the "education" indicator is briefly described above. It is similar to the selection process of the remaining 9 indicators. Due to the limitation of space, we will not explain the selection process of each indicator in detail. As **Table 1** shows, the GDI is a simple and clear systematic composite index with 10 indicators. These indicators are the most basic and primary goals for green development, for the protection of the world's environment, and for sustainable utilization of natural resources.

The Entropy Method for Weighting

The entropy method is a more scientific and objective weighting method than other traditional methods (31). There are some popular weighting methods presented in existing literatures, like equal weights, factor analysis, expert weights, and entropy method (8, 9, 32). Among them, equal weights and expert weights methods are lack of objectivity (8). The factor analysis can only estimate weights if correlation exists between indicators (32). The entropy method is a weighting technique that makes weight judgments based on the size of the data information load[1], which makes it considered as a scientific and objective method compared with other ones (31). According to the principle of entropy method, the weight of each indicator can be calculated through the following steps.

Normalization is the first step. There are many kinds of normalization methods, such as "ranking," "distance to target," "Z-score," "min–max" (34). The min–max method is generally used for normalization in entropy method because it is simple, mature, and widely used (32, 35). The min–max method can also fully reflect the data information load of an indicator, according to the idea and principle of information entropy (33). Before the min–max normalization method, these 12 indicators are divided into "positive indicators" and "negative indicators." Positive indicators refer to those indicators whose higher values mean better performance of green development, like air quality and education, and negative indicators are the ones whose lower values represent better performance, such as the PM2.5. The min–max normalization formula for positive index and negative index is shown in equation (1) and equation (2) respectively.

$$\tilde{x}_{ij} = \frac{X_{ij} - minX_{ij}}{\max X_{ij} - minX_{ij}} \tag{1}$$

$$\tilde{x}_{ij} = 1 - \frac{X_{ij} - minX_{ij}}{\max X_{ij} - minX_{ij}} \tag{2}$$

In the equations above, X is the raw data value, min(X) is the minimum observed value of the indicator, max(X) is the maximum observed value of the indicator, X_{ij} is the indicator j of country i, and $\tilde{x}_{ij}$ is the result of normalization.

The entropy value e_j of indicator j could be obtained, as shown in equations (3) and (4).

$$k = 1/ln(n) \tag{3}$$

$$e_j = -k \sum_{i=1}^{n} \tilde{x}_{ij} \ln \tilde{x}_{ij} \tag{4}$$

The information utility value of indicator j is calculated, namely g_j in equation (5).

$$g_j = 1 - e_j \tag{5}$$

Finally, we can get the weight of indicator j, namely ω_j, as shown in equation (6), and the results of entropy method could be obtained by the Stata 15.0.

$$\omega_j = g_j / \sum_{j=1}^{p} g_j \tag{6}$$

Methods for Progress Measure

The progress measure method adopted in our study is based on the method used by Hametner and Kostetckaia (3), that is calculating the compound average growth rate (CAGR) between two points in time. The CAGR technique has 3 main merits: (1) could provide results in %-change per year that can be compared across different time spans (5); (2) its application does not need the existence of quantitative targets (12); (3) it is sufficient if the desired direction in which an indicator should evolve from an green development point of view is known (3). The CAGR formula is shown as equation (7):

$$CAGR = \left(\frac{y_t}{y_{t_0}}\right)^{\frac{1}{t - t_0}} - 1, \tag{7}$$

where t_0 = base year, t= most recent year (that is 2016), y_{t_0} = indicator value in base year, y_t = indicator value in the most recent year (2016).

Referring to the work of Hametner and Kostetckaia (3), we calculate CAGR for two time spans, namely the past 3-year period

[1]Entropy Method is a weighting technique based on the idea of entropy from information theory. Specifically, information is a measure of the order degree and entropy is a measure of the disorder degree in a system; hence, the smaller entropy of the indicator, the more information provided by the indicator, the greater its role and weight in the comprehensive evaluation (31, 33). As Zhang et al. (33) have pointed, the weight measured by the Entropy Method represents the relative rate of change of the indicator in a composite index system, while the relative level of each indicator should be figured by the standardized value of its data.

and the past 6-year period. This distinction provides information about whether a development continues over the whole time period, or whether recent trends have changed (5). Moreover, it can also compare the progress toward green economy in different periods.

Data and Imputation

This study selects 45 Asian countries from 2010 to 2016 for the green development assessment (see **Table 3** for the list of countries). These countries were selected by two criteria: (1) the data of all 10 indicators is available, for example, North Korea was not selected because of the unavailability of data; (2) internationally recognized non-sovereign entities were not selected, such as Macau, China. In general, the 45 selected countries include most of the Asian countries, covering more than 95% of the population and land in Asia. The data source can be seen in **Appendix Table A1**.

The current studies prefer to adopt imputation method to fill missing data rather than missing out information (6). So, we adopt various imputation methods to address missing the data missing problem following the actual situation. Firstly, the mean value interpolation method. For example, average value of 2011 and 2013 is used for replacing the value of 2012, if the data of 2011 and 2013 are available, but the data of 2012 is missing. Secondly, the nearest neighbor interpolation method. This method is used to deal with missing data for the variables that are very stable over time, like the arable land. These imputations in instances can distort the results but losing out data might prove costlier to some countries (32).

RESULTS

GDI Measurement and Ranking

The weight of each indicator is calculated by entropy method, as shown in the last column of **Table 2**. As a result, the weights of economic–social and resource–environmental dimensions are 51.58 and 48.42%, respectively. The weights of the two dimensions are very close. It means that stable economic growth, harmonious social development, rational resources utilization, and environmental protection are all important for the green development of a country. From a perspective of indicator, the four indicators with the highest weight are education, energy, health, and income level, whose weights are 14.03, 13.40, 13.16, and 13.02% respectively. It indicates the four indicators are the most important determinants of green development: (1) fair and abundant income is the most basic material security, but also reflects the wealth and capital adequacy of a country; (2) education is an important measure for the accumulation and development of national human capital; (3) health embodies human's basic pursuit for the right to life and the longevity; (4) and energy reflects the demand of current generations for energy consumption, and also reflects the opportunity and guarantee for future generations to utilize energy and develop economy.

Table 3 reports the average GDI and its ranking of 45 Asian countries. As a result, the mean value of GDI ranges from 0.3278 to 0.7575. Among these 45 countries, the top five are Singapore (0.7575), Japan (0.7156), Brunei Darussalam (0.6829), Israel (0.6652), and South Korea (0.6536), whereas the bottom five are Syria (0.4483), Pakistan (0.4109), Nepal (0.3676), Yemen (0.3449), and Afghanistan (0.3278).

The GDI ranking of each country showed distinct characteristics in income level. These countries are divided into four categories according to income levels following World Bank's standard (in 2016), namely high, upper-middle, lower-middle, and low income countries. As **Table 3** shows, countries with high GDI tended to be with high income level, like the top 5 countries are all high-income countries. On the contrary, most of low-GDI countries are low or lower-middle countries, such as the bottom five ones. This means that there may be a positive correlation between income level and green development level. Of course, income level, as an important subindicator of GDI, is the direct and superficial reasons for this correlation. The fundamental reasons are: (1) those low-income countries have very limited fiscal revenue, leading to insufficient supply of public goods, such as education, medical care, public health, environmental protection, etc. (36). (2) Some developing countries promote economic growth at the cost of resources and environment, while they are inefficient in resource utilization, inadequate in environmental protection and management (37).

However, there are also many exceptions, that is, those rich Middle East countries perform poorly in GDI ranking. For example, Saudi Arabia, Qatar, and Bahrain are global top rich countries with very high per capita GDP and income, but their GDI ranking is, respectively, 16, 23, and 25 among these Asian countries. These countries are considered as high HDI countries because the HDI lacks environmental indicators. But the GDI is a relatively complete green development index, which puts a stop to the "celebration" of "gas-guzzling developed countries" clearly (35, 38).

Figure 1 shows the geographical distribution of GDI in Asia. It should be noted that the darker the blue, the higher the GDI and green development level. **Figures 1A–C** present the geographical distribution of GDI in 2010, 2013, and 2016, respectively. As a result, GDI ranking always maintains a similar geographical distribution pattern in these three time points. Specifically, the countries in Northeast and Southeast Asia have the deepest blue and the highest green development level, such as Japan, South Korea, and Brunei. The Western Asian countries close to Europe also have good performance in green development, such as Israel. On the contrary, countries in South and Central Asia are the lightest in blue, which means that green development is at the bottom level, such as Nepal and Afghanistan. In sum, the geographical distribution of GDI shows the characteristic, which is high in the east and west Asia, while low in the middle. Moreover, this characteristic is further supported in **Figure 1D**.

Progress of GDI in Each Country

This paper measures the progress toward green economy in Asia countries at different time horizons (t-3 years, t-6 years), as well as the ranking of progress score, based on GDI, *via* the CAGR method. The information of progress score and its ranking are included in **Table 4** and **Figure 2**. "Progress (t-3)" refers to the progress in the past 3-year period (namely 2013–2016), while

TABLE 2 | The weight of each indicator in green development index.

Index	Dimension	Factor	Indicator	Weights
Green development index (GDI)	Economic- social dimension	Economic growth	Real GDP growth	5.34%
		Education	Expected years of schooling	14.03%
		Health	Life expectancy index	13.16%
		Income level	Income index	13.02%
		Economic structure	Employment in services (% of total employment)	6.03%
	Resource- environmental dimension	Climate	CO_2 emissions per capita	11.01%
		Air quality	PM2.5	7.56%
		Forest	Forest area (% of total land area)	9.02%
		Arable land	Arable land per person	7.43%
		Energy	Renewable energy consumption (% of total final energy consumption)	13.40%

TABLE 3 | The mean value of GDI and its ranking from 2010 to 2016.

Country	GDI	Rank	Income level	Country	GDI	Rank	Income level
Singapore	0.7575	1	High	Armenia	0.5373	24	Upper-middle
Japan	0.7156	2	High	Qatar	0.5356	25	High
Brunei Darussalam	0.6829	3	High	Iran	0.5327	26	Upper-middle
Israel	0.6652	4	High	Jordan	0.5249	27	Upper-middle
Korea (Rep.)	0.6536	5	High	Azerbaijan	0.5247	28	Upper-middle
Malaysia	0.6454	6	Upper-middle	Kyrgyzstan	0.5100	29	Lower-middle
Turkey	0.6040	7	Upper-middle	India	0.5072	30	Lower-middle
Oman	0.6030	8	High	Vietnam	0.5055	31	Lower-middle
Georgia	0.5874	9	Upper-middle	Bhutan	0.5050	32	Lower-middle
Lebanon	0.5834	10	Upper-middle	Turkmenistan	0.4958	33	Upper-middle
Maldives	0.5753	11	Upper-middle	Mongolia	0.4912	34	Lower-middle
Kuwait	0.5743	12	High	Uzbekistan	0.4781	35	Lower-middle
Indonesia	0.5738	13	Upper-middle	Myanmar	0.4715	36	Lower-middle
United Arab Emirates	0.5665	14	High	Cambodia	0.4652	37	Lower-middle
China	0.5656	15	Upper-middle	Tajikistan	0.4640	38	Low
Saudi Arabia	0.5558	16	High	Bangladesh	0.4627	39	Lower-middle
Lao	0.5502	17	Lower-middle	Iraq	0.4515	40	Upper-middle
Kazakhstan	0.5499	18	Upper-middle	Syria	0.4483	41	Low
Thailand	0.5487	19	Upper-middle	Pakistan	0.4109	42	Lower-middle
Timor-Leste	0.5486	20	Lower-middle	Nepal	0.3676	43	Lower-middle
Sri Lanka	0.5479	21	Lower-middle	Yemen	0.3449	44	Low
Philippines	0.5464	22	Lower-middle	Afghanistan	0.3278	45	Low
Bahrain	0.5435	23	High				

The income level (2016) is given by the World Bank.

"Progress (t-6)" refers to that in past 6-year period (namely 2010–2016), which is calculated by the CAGR. Hence, the progress score indicates the progress toward green economy, which is a result in %-change per year. For example, the progress (t-3) score of Japan is −0.78, which means that the CAGR in the past 3-year period is −0.78%. If the progress score is positive, it means that the green development level is improved in the that period, and vice versa. The greater the absolute value of progress score, the faster the improvement or decline of green development level.

Table 4 and **Figure 2** report the progress scores and rankings of Asian countries in the two time periods. In the past 3-year period, the five countries with the fastest increase in the green development level are China, Iraq, Bangladesh, Thailand, and Iran, while the five countries with the fastest decrease are Jordan, Lebanon, Syria, Timor Leste, and Yemen. In the past 6-year period, the five countries with the fastest progress toward green development are Pakistan, Cambodia, Bangladesh, China, and Vietnam, while the five countries with the fastest decrease are Lebanon, Qatar, Timor Leste, Yemen, and Syria. Among these

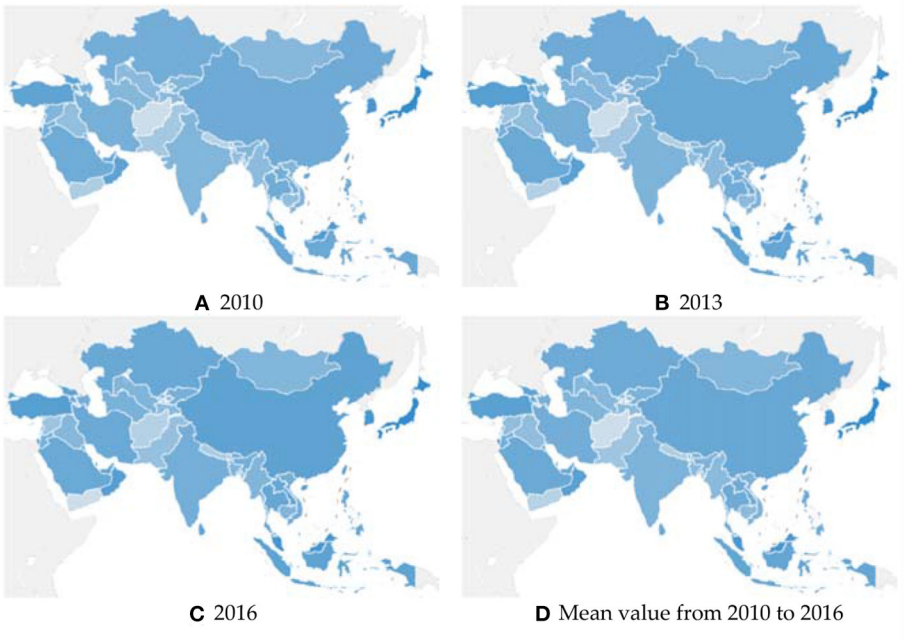

FIGURE 1 | Geographical distribution of GDI in Asia. Subfigure **(A)** is the geographical distribution of GDI in 2010; **(B)** is the geographical distribution of GDI in 2013; **(C)** is the geographical distribution of GDI in 2016; and **(D)** is the geographical distribution of the mean value of GDI from 2010 to 2016.

countries, China and Bangladesh scored high in both periods, while Lebanon, Timor Leste, Yemen, and Syria scored low.

The relationship between GDI ranking and progress score has three interesting characteristics:

First, those GDI leading countries seem to have stagnated at a high level, and some of them even experienced a slight retrogression. For example, Japan, South Korea, and Singapore are all the top-level Asian countries in the green development performance, but their progress scores are negative in the two time periods. The reason why GDI leading countries do not progress overall further toward green economy might be that they have already exploited most of the synergies that exist between the different aspects of green economy, where progress in one area helps achieve progress in another (12). So, those countries have to increasingly face trade-offs between the different aspects of green development, whereby further progress in one aspect is made at the cost of others (39, 40). In the study of European countries, there is a similar phenomenon: sustainable development leading countries, with the highest levels of SDG achievement, have stagnated at this level over the past 15 years, like Sweden, Denmark, and Netherlands (3). It is reasonable to assume that these countries have already reached a high level of green development, so the room for further progress is very limited.

Second, some of countries with medium level GDI have achieved the fastest progress toward green economy. For example, China and Thailand are the countries with the medium level of GDI ranking, but they show a very fast movement toward green economy in both two time periods. This is mainly contributed by the economic growth and environmental protection of these countries in recent years. On the one hand, these countries have achieved rapid economic growth in the past decades, but the insufficient environmental protection and social welfare has led to the medium level of green development. On the other hand, in recent years, these countries have a growing amount of fiscal revenue and enough ability to improve social welfare or govern environment, which makes them have a strong progress momentum toward green economy.

Last, some countries with very low green development level have still moved fast away from green economy. For example, the GDI is rapidly reduced in Syria and Yemen which are definitely low green development countries. "High GDI countries are always alike; but each low GDI country is un-green in its own way"[2]. Some of the countries that are getting worse at green development are due to political instability, such as Syria and Yemen; and some are due to problems in economic system environmental governance. It is clear that some low GDI countries are getting worse in these two periods.

Overall, those green development leading countries seem to have stagnated at this level, and some of them even experienced a slight retrogression; some countries with medium green development level have achieved the fastest progress; whereas the laggards get worse over the past 3- and 6-year periods.

[2]Similar to Leo Tolstoy's famous remark "Happy families are all alike; each unhappy family is unhappy in its own way".

TABLE 4 | The progress score in different time spans.

GDI rank (2010–2016)	Country	Progress (t-3)		Progress (t-6)	
		Score	Rank	Score	Rank
1	Singapore	−0.52	25	−0.29	36
2	Japan	−0.78	28	−0.19	34
3	Brunei Darussalam	−1.25	37	−0.37	38
4	Israel	−0.81	30	−0.26	35
5	Korea (Rep.)	−0.78	29	−0.36	37
6	Malaysia	0.12	15	0.46	14
7	Turkey	−0.87	33	0.28	24
8	Oman	−0.39	23	0.19	27
9	Georgia	−0.85	32	−0.10	32
10	Lebanon	−1.69	42	−0.90	41
11	Maldives	−0.57	26	0.12	29
12	Kuwait	−0.32	21	0.45	15
13	Indonesia	−0.38	22	0.38	17
14	United Arab Emirates	−0.11	17	0.26	26
15	China	0.90	1	0.94	4
16	Saudi Arabia	−1.00	35	0.03	30
17	Lao	0.50	6	0.72	8
18	Kazakhstan	−0.48	24	0.33	21
19	Thailand	0.59	4	0.38	18
20	Timor-Leste	−2.50	44	−1.66	43
21	Sri Lanka	0.33	12	0.56	11
22	Philippines	−0.16	18	0.44	16
23	Bahrain	0.40	8	0.33	22
24	Armenia	−0.68	27	0.14	28
25	Qatar	−1.08	36	−1.58	42
26	Iran	0.55	5	0.65	9
27	Jordan	−1.56	41	−0.82	40
28	Azerbaijan	−0.83	31	−0.07	31
29	Kyrgyzstan	−0.92	34	0.52	13
30	India	0.40	7	0.74	7
31	Vietnam	0.16	14	0.80	5
32	Bhutan	0.35	11	0.35	20
33	Turkmenistan	0.01	16	0.53	12
34	Mongolia	−1.29	38	−0.13	33
35	Uzbekistan	−0.30	20	0.28	25
36	Myanmar	0.24	13	0.62	10
37	Cambodia	0.36	10	1.04	2
38	Tajikistan	−1.55	40	−0.66	39
39	Bangladesh	0.61	3	0.99	3
40	Iraq	0.77	2	0.79	6
41	Syria	−2.18	43	−3.52	45
42	Pakistan	0.38	9	1.04	1
43	Nepal	−1.36	39	0.35	19
44	Yemen	−5.35	45	−3.28	44
45	Afghanistan	−0.19	19	0.32	23

The order of the first column on the right is the ranking of GDI mean in ***Table 3****.*

DISCUSSION: A COMPARISON BETWEEN GDI AND OTHER INDICES

The GDI could be seen as an improvement index of the HDI because it is built based on the HDI by adding some indicators with the connotation of green development. Beside the GDI, many researchers have built the improvement indices of HDI by adding environmental indicators, such as the Human Sustainable Development Index (35) and the Human Green Development Index (8). So, we make a comparison about these green development indices.

Since 1990, the HDI is reported annually as part of the Human Development Report of the UNDP, and has gradually become a widely used and cited index for sustainability assessment due to its simple composition and rich connotation. It consists of three (equal weighted) subindices which are aggregated by an arithmetic mean: education, income, and life expectancy. Although the composition is simple, its connotation is very rich. The HDI is based on the theory of welfare economics with fairness and substantial freedom, which contains a deep understanding of the main concept of human development. In the past, the traditional meaning of "development" was strictly economic, as it dealt only with the economic side of development. For instance, per capita GDP used to be a basic indicator for development trend and level. In subsequent years, more and more scholars have moved toward a new concept of development in which economic growth is seen as a condition that is necessary but not sufficient to explain the degree of development of a country. They pay more attention to the real welfare that people enjoy, namely human development. The essential abilities for human development are therefore the abilities to lead a long, healthy life, to obtain knowledge, to access the resources needed for a decent standard of living, and to take part in the life of the community. Based on the above theories and ideas, the HDI is born to measure the human development in national level. Therefore, the HDI gradually becomes one of the most widely used composite index for measuring development.

Human Sustainable Development Index (HSDI), Human Green Development Index (HGDI), and GDI are regarded as improvement indices of the HDI, but they are quite different in composition and connotation. As mentioned earlier, the HDI focuses on the ability and sustainability of human. But no matter the poor, the rich, and even the developing or the developed countries, they must act under the constraints of the earth environment. Human actions and activities are carried out on the earth, and the impact of the actions of each country on its own country is subject to the natural conditions of the world. So, Bravo (35) considers that the environment is also an important part of human sustainable development, and builds the HSDI by adding an indicator (per capita CO_2 emissions) to present environmental dimension based on the HDI, as is shown in **Table 5**. Besides, with the process of human development, resource crisis has been exposed, especially the problems of excessive energy consumption and land pollution. Thus, the ability and sustainability of human is under the constraints of the resource on the earth. From these considerations, the

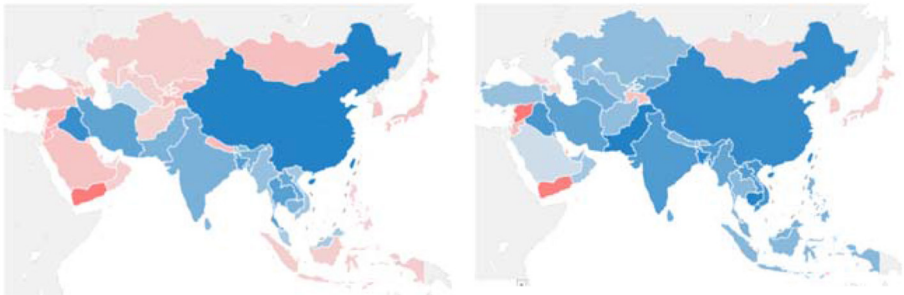

FIGURE 2 | Progress score in different time spans. **(A)** Subfigure a is the geographical distribution of progress score in the past 3-year period (namely 2013–2016), while Subfigure b is that in the past 6-year period (namely 2010–2016), which calculated by the CAGR; **(B)** Blue indicates progress toward to green economy, red indicates movement away from green economy. The darker the color, the stronger the progress or movement away that occurred over the respective time span.

TABLE 5 | The relation and difference of indices.

Index	Indicators				Weight
	Economic	**Environmental**	**Social**	**Resource**	
HDI	Income		Education Life expectancy		Equal
HSDI	Income	CO_2 emissions	Education Life expectancy		Equal
HGDI	Income	CO_2 emissions PM10 Forest area (%) Proportion of threatened animals (%) Land conservation area (%)	Education Life expectancy Population using improved drinking-water sources (%) Population using improved sanitation facilities (%) Population below the minimum food energy (%)	Utilization ratio of primary energy (%)	Equal
GDI	Income Economic growth Economic structure	CO_2 emissions PM2.5 Forest area (%)	Education Life expectancy	Renewable energy consumption (%) Arable land	Entropy Method

HGDI is constructed by adding some indicators both in resource and environmental dimensions (see **Table 6**). However, green development is to coordinate the economic-social, and resource–environmental development, to balance the intragenerational welfare and maximize the total welfare of generations. Therefore, we should pursue economic growth to ensure the welfare of present generations, while protecting the ecological environment and rationally utilizing the natural resource to ensure the welfare of future generations. If we just want to protect the environment and make the economy stagnate, it is also not a sustainable development mode. Finally, the GDI is built with economic–social and resource–environmental dimensions and 10 indicators (see **Table 5**).

The ranking results of above indices are shown in **Table 6**. We find that the ranking results of these three green development indices are quite different with that of HDI, especially for the Middle east countries. It shows that the Middle east countries have a high HDI ranking and low GDI, HSDI, and HGDI ranking. For example, Saudi Arabia ranks 6 in HDI, while GDI, HSDI, and HGDI rank 29, 45, and 41, respectively (see **Table 6**). This is mainly because the HDI does not include environmental indicators, whereas HSDI, HGDI, and GDI do. It is thus clear that the GDI, HSDI, HGDI put a stop to the "celebration" of "gas-guzzling developed countries".

From the analysis above, GDI, HSDI, and HGDI are all modifications or improvements of HDI. The HSDI adds per capita CO_2 emissions to HDI, which is a breakthrough of HDI in the environmental dimension. The HGDI has a number of resource and environmental indicators, which can not only reflect sustainable development in the environmental dimension, but also represent the sustainable utilization of resources, while the GDI fully considers the dimensions of economy, society, and resources and environment. Moreover, the GDI adopts the entropy method to weight all subindicators, which represents a scientific and objective method compared with equal weighted method. To sum up, the GDI represents a small step ahead from the HDI, HSDI, and HGDI.

CONCLUSION

The purpose of our study is to assess Asian countries' green development performance, and also the progress toward green

TABLE 6 | The comparison of GDI and other index rankings in 2015.

Country	GDI	HDI	HSDI	HGDI	Country	GDI	HDI	HSDI	HGDI
Singapore	1	1	1	6	Timor-Leste	24	33	31	30
Japan	2	2	3	1	Azerbaijan	25	17	10	20
Brunei Darussalam	3	8	22	3	Iran	26	14	9	24
Israel	4	3	2	8	India	27	34	32	40
Korea (Rep.)	5	4	4	2	Jordan	28	24	12	21
Malaysia	6	13	7	4	**Qatar**	29	6	45	41
Turkey	7	15	6	14	Kyrgyzstan	30	31	26	19
Oman	8	10	13	26	Vietnam	31	29	25	12
Georgia	9	16	5	7	Bhutan	32	35	34	5
China	10	20	17	29	Turkmenistan	33	26	30	25
United Arab Emirates	11	5	24	23	Mongolia	34	23	18	35
Indonesia	12	28	23	11	Uzbekistan	35	37	36	–
Kuwait	13	11	33	32	Myanmar	36	40	39	27
Maldives	14	25	19	16	Cambodia	37	39	38	22
Lebanon	15	18	11	17	Bangladesh	38	38	37	37
Lao	16	36	35	9	Tajikistan	39	32	29	28
Kazakhstan	17	12	16	18	Iraq	40	30	28	39
Thailand	18	22	14	10	Pakistan	41	42	41	38
Philippines	19	27	21	15	Syria	42	44	44	–
Sri Lanka	20	21	20	–	Nepal	43	41	40	34
Bahrain	21	9	27	31	Afghanistan	44	43	42	43
Saudi Arabia	22	7	15	33	Yemen	45	45	43	42
Armenia	23	19	8	13					

The data of HGDI is not available for Uzbekistan, Syria and Sri Lanka.

economy over time. Although the result shows that the northeast Asian countries together with the Singapore and Israel are leaders in green development performance across the Asia, we find that the most progress toward green economy over the past 3- and 6-year periods has been achieved by some medium green development level countries, like China and Bangladesh, while some laggard countries get worse in green development, such as Syria and Yemen. It indicates that the leading countries have reached a high level of green development, and the medium ones move fast toward green economy, while the laggards get worse over the past 3- and 6-year periods.

This paper further demonstrates the viewpoint of Hametner and Kostetckaia (3), that is, it is not sufficient to calculate composite development indices and rankings at a time point or period, and necessary to monitor progress toward green economy over time. As our result shows, a country is a green development leader or laggard does not mean that it can be guaranteed to achieve the fastest progress. In other words, it's uncertain that whether leading green development countries can maintain the progress toward green economy, or whether the laggards have the higher potential for progress. Therefore, monitor progress is necessary.

We derived some policy implications for public health based on our research:

First, clarifying the concept of green economy and strengthening the idea of green economy will helps to cultivate public awareness of environmental protection and environmental ethics, leading to a good public health state. The cultivation of public awareness of environmental protection needs public opinion to make green development a broad consensus. Therefore, to make clear what is green economy or development is the prerequisite for public to understand and put it into practice.

Second, strengthening the idea of green economy is helpful to cultivate the public green consumption that increase the quality level of public health (41). Green consumption is considered to be a consumption mode conducive to ecological and environmental protection, such as driving electric vehicles instead of gasoline vehicles. With the rapid economic growth, the consumption level of consumers has been greatly improved. The public demand for electronic products, plastic products, rubber products and disposable products is increasing (42). This will inevitably exert pressure on natural resources and ecological environment (43). Therefore, to strengthen and publicize the concept of green economy is helpful to cultivate public green consumption psychology, such as reducing the consumption of plastic products (41).

Last, green consumption will further improve the green production willingness of enterprises. Green production refers to an environment-friendly production process or output with high efficiency and low pollution (44). The purpose of enterprise is to meet the needs of consumers and then maximize profits. When green economy and green consumption become the consensus of most people, enterprises will improve production technology,

reform production mode, and provide green products to meet green consumption demand, so as to reduce environmental pollution (45). It is beneficial for public health soundness. For example, the market of green food and organic food is becoming larger and larger, which may be beneficial to green development.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://www.sustainabledevelopmentindex.org.

AUTHOR CONTRIBUTIONS

MS conceived, designed the research, provided guidance throughout the entire research process, and wrote and supplemented the English paper. MJ participated in data analysis. HJ and F-ST reviewed and edited and paper and are responsible for all R&R works. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Characteristics Associated With Financial or Non-financial Barriers to Healthcare in a Universal Health Insurance System: A Longitudinal Analysis of Korea Health Panel Survey Data

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While many studies have explored the financial barriers to healthcare, there is little evidence regarding the non-financial barriers to healthcare. This study identified characteristics associated with financial and non-financial barriers to healthcare and quantified the effects of these characteristics in South Korea, using a nationally representative longitudinal survey dataset. Overall, 68,930 observations of 16,535 individuals aged 19 years and above were sampled from Korea Health Panel survey data (2014–2018). From self-reported information about respondents' experiences of unmet healthcare needs, a trichotomous dependent variable—no barrier, non-financial barrier, and financial barrier—was derived. Sociodemographics, physical and health conditions were included as explanatory variables. The average adjusted probability (AAP) of experiencing each barrier was predicted using multivariable and panel multinomial logistic regression analyses. According to the results, the percentage of people experiencing non-financial barriers was much higher than that of people experiencing financial barriers in 2018 (9.6 vs. 2.5%). Women showed higher AAPs of experiencing both non-financial (9.9 vs. 8.3%) and financial barriers (3.6 vs. 2.5%) than men. Men living in the Seoul metropolitan area showed higher AAPs of experiencing non-financial (8.7 vs. 8.0%) and financial barriers (3.4 vs. 2.1%) than those living outside it. Household income showed no significant associations in the AAP of experiencing a non-financial barrier. People with a functional limitation exhibited a higher AAP of experiencing a non-financial barrier, for both men (17.8 vs. 7.8%) and women (17.4 vs. 9.0%), than those without it. In conclusion, people in South Korea, like those in most European countries, fail to meet their healthcare needs more often due to non-financial barriers than financial barriers. In addition, the characteristics associated with non-financial barriers to healthcare differed from those associated with financial barriers. This finding suggests that although financial barriers may be minimised through various policies, a considerable degree of unmet

healthcare needs and disparity among individuals is very likely to persist due to non-financial barriers. Therefore, current universal health insurance systems need targeted policy instruments to minimise non-financial barriers to healthcare to ensure effective universal health coverage.

Keywords: unmet healthcare needs, financial and non-financial healthcare barriers, panel multinomial logistic regression, average adjusted probability, Korea Health Panel survey, South Korea

INTRODUCTION

To ensure that citizens have timely and adequate access to healthcare services, many countries strive to identify and minimise barriers to healthcare by providing a universal health coverage system (1, 2). Furthermore, efforts to lower financial barriers to healthcare, irrespective of individuals' income, such as reducing the financial burden on individuals or households in obtaining healthcare services, have often been undertaken. Numerous studies have emphasised the detrimental effects of financial barriers to healthcare on the utilisation of healthcare services (3, 4). An awareness of such barriers and a determination that healthcare coverage not be compromised are clearly expressed in various definitions of universal health coverage: "Universal health coverage means that all people have access to the health services they need, when and where they need them, *without financial hardship*" (1) and "Universal health coverage is about ensuring that people have access to the healthcare they need *without suffering financial hardship*" (2).

However, in the last decade, certain studies have warned against overlooking the importance of non-financial barriers to healthcare (5–8). Non-financial barriers continue to be a serious public health threat to disadvantaged populations in many countries. A recent report documented that, in 2019, 2.2% of those aged 16 years and above in European countries did not receive healthcare due to a non-financial barrier in the 12 months prior to taking the survey (9). This percentage is much higher than that of those who faced a financial barrier (0.9%).

Nevertheless, no study has distinguished between non-financial and financial barriers or sought to determine which barrier type negatively affects individuals' access to healthcare more severely. Several researchers have categorised barriers to healthcare into different groups (10–13). For example, the cost of utilising healthcare services, that is, the financial barrier to healthcare is categorised in terms of "affordability" in one study (11) and in terms of "accessibility" in another (10). As these categorisations vary largely across studies in terms of number and content based on their study purposes, it is difficult to examine the association between individuals' characteristics and their experience of non-financial and financial barriers. Consequently, it can be challenging to examine the association between individuals' characteristics and their experience of non-financial and financial barriers, which further impedes the development of appropriate policies. Further, no study has performed an in-depth analysis regarding how individual characteristics associated with non-financial barriers differ from those associated with financial barriers in a country with a universal health insurance system.

Therefore, the present study aimed to address this substantial gap in the literature by categorising barriers leading to unmet healthcare needs into two types, namely, non-financial and financial barriers, and to determine how these two types of barrier affected healthcare, through analysing self-reported data on unmet healthcare needs. A nationwide panel survey dataset from South Korea was used to conduct multivariable, panel multinomial logit model analyses and explore the characteristics associated with each type of barrier to healthcare. It is important to examine the factors associated with both non-financial and financial barriers to aid researchers in developing and testing new theories about the utilisation of healthcare services. Furthermore, the study results can help policy-makers apply targeted policies to reduce each type of barrier to healthcare effectively. Given that advanced countries/regions in Asia such as Japan, Chinese Taipei, and South Korea have universal health insurance systems based on those of European countries and modified to fit into their own socioeconomic circumstances, the results of the present study are likely to provide insights to countries/regions in both Europe and Asia regarding potential improvements to their universal health coverage systems.

SOUTH KOREA'S HEALTHCARE SYSTEM

South Korea (hereafter, Korea) has provided financial support for healthcare to its entire population *via* two public financially secured healthcare protection programmes since 1989, namely, the Medical Care Aid (MCA) programme, a public in-kind aid programme for the poor, which covers ∼3% of the population, and the National Health Insurance (NHI) programme, a social health insurance programme for the remaining population (14). The NHI is operated by a single public funder, the National Health Insurance Service (NHIS), under the direction and supervision of the Korean Ministry of Health and Welfare. As such, both the contribution schedule and benefits coverage are identical throughout the country. The financing of the NHI depends mainly on contributions imposed on employment income and property. Healthcare delivery relies very heavily on private providers, and physicians and hospitals—whether public or private—are mostly reimbursed based on fee-for-service payment.

Individuals can select the physicians and hospitals of their choice for their outpatient needs. Most clinics in Korea also provide patients with inpatient services, which may be because the referral system is not well-established. Another reason for this may be the lack of primary care physicians such as general

practitioners in the United Kingdom (UK) and gatekeepers in managed care organisations in the United States of America (USA). In Korea, the percentage of general practitioners is extremely low, with 6% recorded in 2017 (15). Non-essential healthcare services not covered under the NHI programme are provided along with essential healthcare services and the prices for such services are not regulated by the government. Therefore, the out-of-pocket payments for non-essential healthcare services are incurred through co-payments (or coinsurance rates) and expenses for healthcare services not covered by the NHI programmes. Individuals pay out-of-pocket payments either through direct payment or private health insurance, or both (14).

Compared to the Organisation for Economic Cooperation and Development (OECD) member countries, the number of practising doctors per 1,000 people in Korea is very low (2.3 in 2017), as is the number of practising nurses per 1,000 people (6.9 in 2017) (15). Although the annual growth rate in health expenditure per capita between 2013 and 2018 was high (7.3%), health expenditure as a percentage of the gross domestic product was lower (8.1% in 2018) than the average percentage in 36 OECD member countries (8.8%). The rate of healthcare utilisation was found to be high, with 16.6 doctor consultations reported per person, and the average length of stay in hospital was 18.5 days, in 2017. Life expectancy at birth was higher (82.7 years in 2017) than that in 36 OECD member countries (80.7 years in 2017), but the percentage of the population aged 65 years and above was lower (13.8% in 2017) than that in 36 OECD member countries (17.4% in 2017) (15).

METHODS

Data Source and Study Sample

This study analysed data collected from the Korea Health Panel (KHP) survey (version 1.7). The KHP survey is a national non-institutionalised civilian population survey conducted by the Korea Institute for Health and Social Affairs and the NHIS. Sample households are selected using two-stage, clustered probability sampling on population census data collated by Statistics Korea. The KHP survey includes data from all eligible household members, obtained using a computer-assisted personal interviewing technique once a year during notified weekdays, which takes ∼1 h to complete. The individuals in the sample are interviewed regarding individual healthcare utilisation, health expenditure, sociodemographic characteristics, lifestyle, and health-related factors. Although the KHP survey started in 2008, in this study, data from 2014 to 2018 are utilised because of changes introduced in the dataset on information concerning chronic diseases from 2014.

From a total of 72,867 observations of individuals aged 19 years and above, this study excluded cases involving non-reporting of information regarding unmet healthcare needs and explanatory variables. Therefore, the final study sample consisted of an unbalanced panel sample comprising 68,930 observations (31,838 from men and 37,092 from women; 94.6%) of 16,535 individuals (7,864 men and 8,671 women), with an average of 4.17 observations per individual (standard deviation = 1.40, range = 1–5).

Measurements

Outcome Variable

An individual's experience of having a non-financial or financial barrier to healthcare was determined by their answers to two questions from the KHP survey: "Was there at least one type of medical care or examination (other than dental care and examination) during the last year (12 months) that you did not receive although you needed it?" and, for the individuals who answered "yes", the accompanying question was: "Among the following, what was the major reason for not receiving the needed medical care or examination?" The reasons were listed as follows: (1) Financial reasons (burden of medical expenditure); (2) Health facilities were too far away; (3) It was difficult to visit a healthcare facility due to either functional limitation or poor health; (4) I had no one to take care of the children; (5) I felt my symptom was not severe; (6) I had no information on where to go; (7) I had no time to visit a healthcare facility; (8) I could not make a reservation at a proper time; (9) I had no regular doctor; (10) Other reasons.

Individuals who answered "yes" to the first question indicated that they had failed in meeting their healthcare needs due to a barrier to healthcare. This study categorised all respondents into three groups, namely, no barrier, financial barrier, and non-financial barrier groups. The individuals who answered "no" to the first question were categorised into the no barrier group; those individuals who answered "yes" to the first question and who chose the financial reasons option in the second question were categorised into the financial barrier group and those who answered "yes" to the first question and who chose any one of the listed reasons apart from financial reasons for the second question were categorised into the non-financial barrier group.

Explanatory Variables

The explanatory variables consisted of sociodemographic characteristics as well as physical and health conditions. The sociodemographic characteristics were as follows: gender (men and women); age; marital status (married and non-married, where non-married included never married, separated, widowed, or divorced); residential area (Seoul metropolitan area, including Seoul, Incheon, and Gyeonggi province; and areas outside of the Seoul metropolitan area); the highest level of formal education completed (lower than college, and college, or higher); occupation (no job, blue-collar job, and white-collar job, where no job included the unemployed and individuals outside of economic activity, such as house-keepers, students, and retired individuals); household income (lowest, medium, and highest quintile, where for each wave, household income was adjusted for household size using the square root's equivalence scale, and the medium included the three middle quintiles) (16); status of public financially secured protection programmes (NHI and MCA programmes); status of private health insurance ("yes" or "no", indicating whether an individual is a beneficiary of at least one private health insurance plan).

Physical and health conditions were as follows: functional limitation ("yes" or "no"); current smoker ("yes" or "no"); alcohol consumer ("yes" or "no"); active routine of physical exercise activity ("yes" or "no"); obese ("yes" or "no"); poor self-assessed health ("yes" or "no"); number of chronic diseases (none, one to

three, or four or more); hypertension ("yes" or "no"); diabetes mellitus ("yes" or "no"); and dyslipidaemia ("yes" or "no"). Functional limitation was based on an individual's answer to the question: "Is your routine of daily living (conducting work, housekeeping, study, and social, leisure, or familiar activities) limited due to a disease or an injury?" An active routine of physical exercise activity was defined based on an individual's answers when assessing their engagement in any three kinds of physical exercise (walking, medium-level, or high-level exercise) for 30 min or longer at least thrice a week. Based on an individual's answer to questions on height and weight, obesity was defined in terms of an individual's body mass index being at least 25 kg/m^2, which is in line with the recommendation in the Asia-Pacific criteria concerning obesity status provided by the World Health Organisation Western Pacific Region (17). Poor self-assessed health involved an individual's self-rating of their general health as "poor" or "very poor" among the options of "excellent, very good, fair, poor, or very poor". Chronic disease was determined based on self-reported answers on whether an individual was suffering from any chronic disease diagnosed by a physician at the time of the survey.

Statistical Analyses

In conducting this study, it was considered that comparing the percentage of people experiencing non-financial or financial barriers to healthcare across European countries with those in Korea would further advance the understanding on this matter. To undertake the comparison, in this study, data derived from the European Union Statistics on Income and Living Conditions (EU-SILC) provided by the statistical office of the European Union (EUROSTAT) (9) for 37 European countries and the analysed data collected from the KHP survey were used. The EU-SILC contains data on individuals' experiences of having unmet medical care needs in the 12 months prior to providing such information and their major reason for their unmet healthcare needs each year since 2008. The data obtained concerned individuals aged 16 years and above in European Union member states, European Economic Area countries, and Switzerland. As the COVID-19 pandemic began in late 2019 and is very likely to have influenced health service utilisation worldwide, this study selected 2018 as the reference year.

When exploring the characteristics associated with non-financial or financial barriers to healthcare in Korea, three types of barriers to healthcare (no barrier, financial barrier, and non-financial barrier) were observed. A mixed multinomial logit model was utilised to analyse the panel data. This model is known to relax the assumption of the independence of irrelevant alternative property of conventional logit and probit models for polychotomous choice situations (18–20).

First, the distributions of the three types of barriers to healthcare each year were examined and, on determining that the distributions differed between genders for each year ($p < 0.05$), all the analyses were stratified by gender. Second, for multivariable analysis, each of the explanatory variables was continually re-categorised and their reference categories were also redefined, with the age variable centred around the median (53). Consequently, the model did not exhibit any considerable multicollinearity, with the value of the variance inflation factor being <3.32 for each gender.

Third, it was deemed to be difficult to understand how an individual's probability of experiencing each type of barrier to healthcare varies across individual characteristics based only on the results obtained from the mixed multinomial logit model. Therefore, this study employed the average marginal effects method (18) and computed the average adjusted probability (AAP) that an individual with a particular characteristic would experience each of the three types of barriers to healthcare, with all other characteristics of the individual being the same, and estimated the 95% confidence intervals of those AAPs. In addition, for ease of understanding, this study depicted the changes in the AAPs across different age groups by gender with the help of visual curves. All characteristics were considered time varying (i.e., could change with time). Statistical analyses were performed using SAS 9.4 software (SAS Institute, Cary, NC, USA) and STATA 17 software (StataCorp, College Station, TX, USA).

RESULTS

Percentage of People Experiencing Each Type of Barrier to Healthcare Across Selected Countries

In 2018, the percentage of people experiencing a barrier to healthcare leading to unmet healthcare needs in the past 12 months was, on average, 5.6% for the 38 countries considered in this study including Korea (**Figure 1**).

This total percentage ranged from 0.4% in Austria and Spain to 21.5% in Albania. The percentage of people experiencing a non-financial barrier was found to be much higher than that of people experiencing a financial barrier. The percentage of people experiencing a non-financial barrier was, on average, 3.8%, ranging from 0.3% in Austria, Cyprus, and Spain to 18.3% in Estonia. By contrast, the percentage of people experiencing a financial barrier was, on average, 1.8%, ranging from 0.1% or lower in Austria, Czechia (the Czech Republic), Finland, Germany, Malta, the Netherlands, Slovenia, Spain, Sweden, and the UK to 13.7% in Albania. In the case of Korea, the percentage of people experiencing a barrier generally was 12.1%, of which 9.6% involved a non-financial barrier and 2.5% involved a financial barrier. Notably, each of the three percentages varied markedly across the 38 countries and, on average, non-financial barriers appeared to lead to unmet healthcare needs among individuals more often than financial barriers.

Percentage of People Experiencing Each Type of Barrier to Healthcare by Gender in Korea

In 2018, 12.1% of the individuals in the sample (11.0% in men; 13.0% in women) reported that they had experienced a barrier leading to unmet healthcare needs in the last 12 months. The percentage of people experiencing a non-financial barrier was much higher than that of those experiencing a financial barrier (9.6 vs. 2.5% in total; 9.0 vs. 2.0% in men; 10.2 vs. 2.8% in women). The percentage of people experiencing a barrier leading

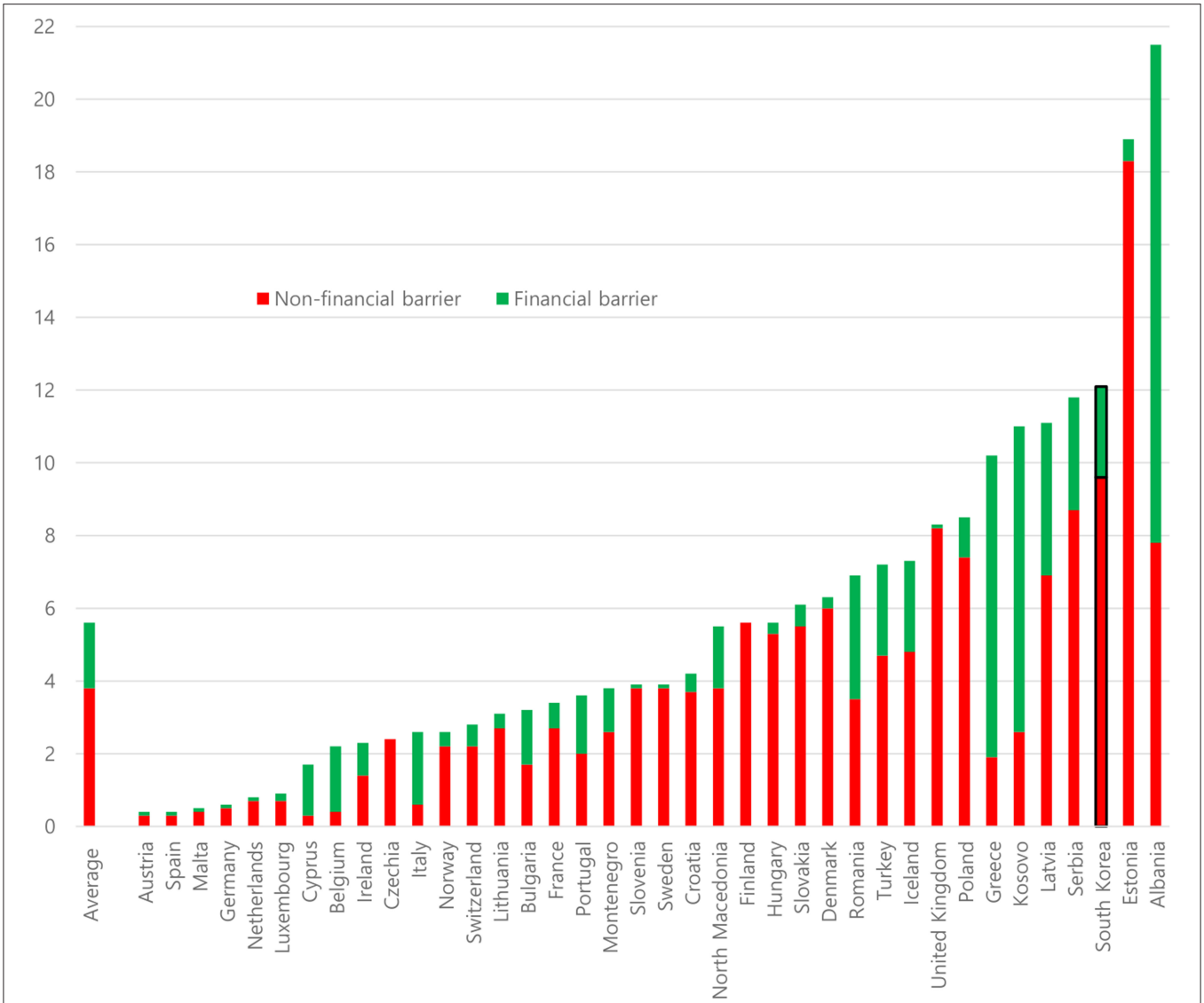

FIGURE 1 | Percentage of people experiencing either non-financial or financial barriers in 2018 across selected countries. Unmet needs for medical examination or treatment for multiple reasons in the previous 12 months. Individuals included those aged 16 years and above (37 European countries) and individuals aged 19 years and above (South Korea). Sources: EUROSTAT Database (EU-SILC, 2018) and the Korea Health Panel survey data (2018).

to unmet healthcare needs between 2014 and 2018 was 14.1%, of which 10.1% involved a non-financial barrier and 4.0% involved a financial barrier. Clear gender differences were revealed in terms of experiencing a barrier, a non-financial barrier, or a financial barrier (12.5, 9.3, and 3.2%, respectively, among men vs. 15.4, 10.8, and 4.6%, respectively, among women). The sample characteristics and descriptive statistics for each year between 2014 and 2018 are displayed in **Table 1** for men and **Table 2** for women.

Average Adjusted Probability of Experiencing Each Type of Barrier Across Characteristics by Gender in Korea

Except for obesity, all characteristics under investigation were associated with the AAP of experiencing non-financial or financial barriers at a significance level of 0.1 or less (**Table 3**; **Figure 2**).

The AAP of experiencing a non-financial barrier was higher than that of experiencing a financial barrier in both men (8.3 vs. 2.5%) and women (9.6 vs. 3.6%). However, both AAPs were higher in women than in men (**Table 3**). Both AAPs varied across age groups and between genders (**Figure 1**). The AAP of experiencing a financial barrier increased and then decreased with age in both men and women. However, the AAP of experiencing a non-financial barrier increased and then decreased with age in men, whereas the AAP continued to increase with age in women.

Men living in the Seoul metropolitan area showed higher values in the AAPs of experiencing both non-financial and financial barriers than those living outside (8.7 vs. 8.0%; 3.4 vs. 2.1%) (**Table 3**). In contrast, women living in the

TABLE 1 | Sample characteristics and their descriptive statistics for each year among men.

Characteristics	2014 (n = 6,842)		2015 (n = 6,494)		2016 (n = 6,196)		2017 (n = 6,164)		2018 (n = 6,142)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Barrier to healthcare	0.112	(0.004)	0.123	(0.004)	0.097	(0.004)	0.096	(0.004)	0.110	(0.004)
Non-financial barrier	0.084	(0.003)	0.091	(0.004)	0.073	(0.003)	0.076	(0.003)	0.090	(0.004)
Financial barrier	0.028	(0.002)	0.032	(0.002)	0.024	(0.002)	0.020	(0.002)	0.020	(0.002)
Sociodemographics										
Age (years)	50.781	(0.204)	51.407	(0.212)	52.094	(0.219)	52.332	(0.223)	52.564	(0.227)
Non-married	0.266	(0.005)	0.271	(0.006)	0.274	(0.006)	0.284	(0.006)	0.293	(0.006)
Seoul metropolitan area	0.381	(0.006)	0.379	(0.006)	0.376	(0.006)	0.379	(0.006)	0.380	(0.006)
College or higher	0.355	(0.006)	0.361	(0.006)	0.368	(0.006)	0.377	(0.006)	0.385	(0.006)
Occupation										
No job	0.272	(0.005)	0.294	(0.006)	0.283	(0.006)	0.281	(0.006)	0.277	(0.006)
Blue-collar job	0.510	(0.006)	0.494	(0.006)	0.502	(0.006)	0.501	(0.006)	0.502	(0.006)
White-collar job	0.218	(0.005)	0.213	(0.005)	0.215	(0.005)	0.218	(0.005)	0.221	(0.005)
Household income										
Lowest quintile	0.172	(0.005)	0.175	(0.005)	0.169	(0.005)	0.166	(0.005)	0.164	(0.005)
Medium	0.615	(0.006)	0.613	(0.006)	0.619	(0.006)	0.621	(0.006)	0.618	(0.006)
Highest quintile	0.213	(0.005)	0.212	(0.005)	0.213	(0.005)	0.213	(0.005)	0.218	(0.005)
Medical care aid	0.025	(0.002)	0.027	(0.002)	0.030	(0.002)	0.029	(0.002)	0.029	(0.002)
Private health insurance	0.669	(0.006)	0.697	(0.006)	0.711	(0.006)	0.728	(0.006)	0.740	(0.006)
Physical and health conditions										
Functional limitation	0.052	(0.003)	0.063	(0.003)	0.057	(0.003)	0.050	(0.003)	0.053	(0.003)
Current smoker	0.414	(0.006)	0.367	(0.006)	0.367	(0.006)	0.354	(0.006)	0.345	(0.006)
Alcohol consumer	0.784	(0.005)	0.780	(0.005)	0.776	(0.005)	0.781	(0.005)	0.782	(0.005)
Active routine of physical exercise activity	0.409	(0.006)	0.419	(0.006)	0.430	(0.006)	0.413	(0.006)	0.403	(0.006)
Obese	0.281	(0.005)	0.286	(0.006)	0.294	(0.006)	0.321	(0.006)	0.323	(0.006)
Poor self-assessed health	0.128	(0.004)	0.105	(0.004)	0.112	(0.004)	0.109	(0.004)	0.114	(0.004)
Number of chronic diseases										
None	0.420	(0.006)	0.418	(0.006)	0.405	(0.006)	0.420	(0.006)	0.418	(0.006)
One to three	0.434	(0.006)	0.429	(0.006)	0.433	(0.006)	0.436	(0.006)	0.420	(0.006)
Four or more	0.146	(0.004)	0.153	(0.004)	0.163	(0.005)	0.145	(0.004)	0.163	(0.005)
Hypertension	0.230	(0.005)	0.239	(0.005)	0.246	(0.005)	0.239	(0.005)	0.243	(0.005)
Diabetes mellitus	0.094	(0.004)	0.100	(0.004)	0.108	(0.004)	0.105	(0.004)	0.111	(0.004)
Dyslipidemia	0.086	(0.003)	0.103	(0.004)	0.119	(0.004)	0.121	(0.004)	0.136	(0.004)

SD denotes standard deviation. Source: The Korea Health Panel survey data (2014–2018).

Seoul metropolitan area showed higher values in the AAPs of experiencing a financial barrier than those living outside (4.7 vs. 3.1%). College graduates had a lower value in the AAP of experiencing a financial barrier than individuals with a lower educational level in both men (2.0 vs. 2.6%) and women (2.7 vs. 3.7%). However, regarding the AAP of experiencing a non-financial barrier, women college graduates showed a higher value than women with a lower educational level (10.6 vs. 9.3%).

Job-holders had a higher value in the AAP of experiencing a non-financial barrier in both men and women compared to the jobless category (in men, 9.6% having a blue-collar job, 8.6% having a white-collar job, and 5.9% in the jobless category; in women, 11.7% having a white-collar job, 11.6% having a blue-collar job, and 7.8% in the jobless category). The AAP of experiencing a financial barrier in individuals having a white-collar job exhibited a lower value than the jobless category in both men (1.9 vs. 2.7%) and women (2.9 vs. 3.7%). When household income was considered, the AAP of experiencing a financial barrier decreased with increasing household income in both men and women (the AAPs for individuals belonging to the lowest quintile, the medium category, and the highest quintile were 5.0, 1.8, and 0.6% in men, respectively, and 6.3, 2.5, and 0.7% in women, respectively). Compared to individuals covered by the NHI programme, those covered by the MCA programme showed higher values in the AAP of experiencing a non-financial barrier in men (8.2 vs. 11.0%) and in the AAPs of experiencing both a non-financial barrier (9.5 vs. 11.8%) and a financial barrier (3.5 vs. 4.2%) in women.

Individuals having a functional limitation, relative to individuals with no functional limitation, exhibited an exceedingly higher value in the AAP of experiencing a non-financial barrier in both men (17.8 vs. 7.8%) and women (17.4

TABLE 2 | Sample characteristics and their descriptive statistics for each year among women.

Characteristics	2014 (n = 7,849)		2015 (n = 7,507)		2016 (n = 7,275)		2017 (n = 7,244)		2018 (n = 7,217)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Barrier to healthcare	0.141	(0.004)	0.150	(0.004)	0.123	(0.004)	0.115	(0.004)	0.130	(0.004)
Non-financial barrier	0.103	(0.003)	0.106	(0.004)	0.086	(0.003)	0.084	(0.003)	0.102	(0.004)
Financial barrier	0.038	(0.002)	0.044	(0.002)	0.037	(0.002)	0.031	(0.002)	0.028	(0.002)
Sociodemographics										
Age (years)	52.343	(0.198)	53.024	(0.205)	53.718	(0.210)	54.217	(0.213)	54.643	(0.216)
Non-married	0.347	(0.005)	0.355	(0.006)	0.366	(0.006)	0.373	(0.006)	0.383	(0.006)
Seoul metropolitan area	0.377	(0.005)	0.373	(0.006)	0.372	(0.006)	0.373	(0.006)	0.372	(0.006)
College or higher	0.263	(0.005)	0.264	(0.005)	0.267	(0.005)	0.276	(0.005)	0.285	(0.005)
Occupation										
No job	0.505	(0.006)	0.525	(0.006)	0.510	(0.006)	0.503	(0.006)	0.487	(0.006)
Blue-collar job	0.330	(0.005)	0.305	(0.005)	0.316	(0.005)	0.321	(0.005)	0.332	(0.006)
White-collar job	0.165	(0.004)	0.170	(0.004)	0.174	(0.004)	0.176	(0.004)	0.180	(0.005)
Household income										
Lowest quintile	0.226	(0.005)	0.222	(0.005)	0.227	(0.005)	0.229	(0.005)	0.231	(0.005)
Medium	0.586	(0.006)	0.589	(0.006)	0.584	(0.006)	0.588	(0.006)	0.586	(0.006)
Highest quintile	0.189	(0.004)	0.189	(0.005)	0.189	(0.005)	0.183	(0.005)	0.183	(0.005)
Medical care aid	0.037	(0.002)	0.038	(0.002)	0.040	(0.002)	0.037	(0.002)	0.036	(0.002)
Private health insurance	0.683	(0.005)	0.712	(0.005)	0.725	(0.005)	0.737	(0.005)	0.748	(0.005)
Physical and health conditions										
Functional limitation	0.065	(0.003)	0.092	(0.003)	0.079	(0.003)	0.069	(0.003)	0.073	(0.003)
Current smoker	0.027	(0.002)	0.021	(0.002)	0.022	(0.002)	0.023	(0.002)	0.021	(0.002)
Alcohol consumer	0.523	(0.006)	0.548	(0.006)	0.545	(0.006)	0.543	(0.006)	0.548	(0.006)
Active routine of physical exercise activity	0.360	(0.005)	0.372	(0.006)	0.360	(0.006)	0.343	(0.006)	0.310	(0.005)
Obese	0.214	(0.005)	0.217	(0.005)	0.219	(0.005)	0.230	(0.005)	0.228	(0.005)
Poor self-assessed health	0.187	(0.004)	0.173	(0.004)	0.181	(0.005)	0.186	(0.005)	0.185	(0.005)
Number of chronic diseases										
None	0.334	(0.005)	0.326	(0.005)	0.321	(0.005)	0.341	(0.006)	0.330	(0.006)
One to three	0.416	(0.006)	0.419	(0.006)	0.410	(0.006)	0.408	(0.006)	0.400	(0.006)
Four or more	0.250	(0.005)	0.254	(0.005)	0.269	(0.005)	0.250	(0.005)	0.270	(0.005)
Hypertension	0.251	(0.005)	0.260	(0.005)	0.267	(0.005)	0.264	(0.005)	0.268	(0.005)
Diabetes mellitus	0.092	(0.003)	0.096	(0.003)	0.101	(0.004)	0.099	(0.004)	0.103	(0.004)
Dyslipidemia	0.124	(0.004)	0.149	(0.004)	0.170	(0.004)	0.172	(0.004)	0.191	(0.005)

SD denotes standard deviation. Source: The Korea Health Panel survey data (2014–2018).

vs. 9.0%) as well as a higher value in the AAP of experiencing a financial barrier in both men (3.7 vs. 2.3%) and women (4.9 vs. 3.3%). The AAPs of experiencing both non-financial and financial barriers were higher in current smokers than in current non-smokers in both men and women (for experiencing a non-financial barrier, 9.6 vs. 7.5% in men and 12.5 vs. 9.5% in women; and for experiencing a financial barrier, 2.9 vs. 2.3% in men and 5.4 vs. 3.5% in women).

Individuals who reported that their health was poor exhibited higher values in the AAPs of experiencing both non-financial and financial barriers compared to individuals reporting that their health was not poor in both men and women (for a non-financial barrier, 13.5 vs. 7.7% in men and 14.6 vs. 8.6% in women; for a financial barrier, 4.5 vs. 2.0% in men and 5.8 vs. 2.6% in women).

Individuals having one to three chronic diseases had a higher value in the AAP of experiencing a non-financial barrier than individuals having no chronic disease only in men (7.8 vs. 9.1%). However, the AAP of experiencing a financial barrier seemed to increase with the number of chronic diseases in both men and women (for no chronic disease, one to three chronic diseases and four and more chronic diseases, 1.7, 2.7, and 2.8% in men, respectively, and 2.0, 3.5, and 4.3% in women, respectively).

DISCUSSION

Differences in the Percentage of People Experiencing Each Type of Barrier to Healthcare Between European Countries and Korea

Based on the results of the present study concerning 37 European countries and Korea, an average of 5.6% of individuals reported

TABLE 3 | The average adjusted probabilities of experiencing non-financial or financial barriers that led to unmet healthcare needs.

Characteristics	Men (n = 31,838)			Women (n = 37,092)		
	Non-financial barrier (N)	Financial barrier (F)	Barrier ($N + F$)	Non-financial barrier (N)	Financial barrier (F)	Barrier ($N + F$)
All	8.3***	2.5***	10.8	9.6***	3.6***	13.2
Married (*R*)	8.6	2.3	10.9	9.3	3.0	12.3
Non-married	7.5**	3.1***	10.6	10.1**	4.4***	14.6
The other areas (*R*)	8.0	2.1	10.1	9.4	3.1	12.5
Seoul metropolitan area	8.7**	3.4***	12.1	9.9	4.7***	14.6
Lower than college (*R*)	8.3	2.6	11.0	9.3	3.7	13.0
College or higher	8.3	2.0***	10.2	10.6***	2.7***	13.3
No job (*R*)	5.9	2.7	8.6	7.8	3.7	11.5
Blue-collar job	9.6***	2.4	12.0	11.6***	3.6	15.2
White-collar job	8.6***	1.9**	10.5	11.7***	2.9*	14.7
Household income, lowest quintile (*R*)	8.7	5.0	13.7	9.4	6.3	15.7
Household income, medium	8.4	1.8***	10.2	9.9	2.5***	12.5
Household income, highest quintile	7.9	0.6***	8.5	9.4	0.7***	10.1
National health insurance (*R*)	8.2	2.5	10.7	9.5	3.5	13.1
Medical care aid	11.0**	2.8	13.8	11.8**	4.2**	16.0
Private health insurance, no (*R*)	8.0	2.7	10.7	9.4	3.9	13.3
Private health insurance, yes	8.4	2.3**	10.7	9.7	3.4**	13.1
Functional limitation, no (*R*)	7.8	2.3	10.1	9.0	3.3	12.3
Functional limitation, yes	17.8***	3.7***	21.5	17.4***	4.9***	22.3
Current smoker, no (*R*)	7.5	2.3	9.8	9.5	3.5	13.1
Current smoker, yes	9.6***	2.9***	12.4	12.5***	5.4***	17.8
Alcohol consumer, no (*R*)	7.8	2.5	10.3	8.8	3.6	12.4
Alcohol consumer, yes	8.4	2.5	10.9	10.4***	3.6	14.0
Active routine of physical exercise activity, no (*R*)	8.6	2.5	11.0	9.9	3.6	13.5
Active routine of physical exercise activity, yes	7.9**	2.6	10.5	9.0***	3.6	12.6
Obese, no (*R*)	8.3	2.5	10.8	9.5	3.5	13.1
Obese, yes	8.4	2.4	10.7	9.8	3.8	13.6
Poor self-assessed health, no (*R*)	7.7	2.0	9.6	8.6	2.6	11.2
Bad self-assessed health, yes	13.5***	4.5***	17.9	14.6***	5.8***	20.4
Number of chronic diseases, none (*R*)	7.8	1.7	9.5	9.7	2.0	11.7
One to three chronic diseases	9.1***	2.7***	11.8	10.2	3.5***	13.7
Four or more chronic diseases	7.4	2.8***	10.2	8.9	4.3***	13.2
Hypertension, no (*R*)	8.4	2.7	11.1	9.9	3.8	13.7
Hypertension, yes	7.9	2.2***	10.1	8.8**	3.4**	12.2
Diabetes mellitus, no (*R*)	8.3	2.5	10.8	9.7	3.7	13.4
Diabetes mellitus, yes	8.0	2.4	10.4	9.0	3.3*	12.2
Dyslipidemia, no (*R*)	8.4	2.5	10.9	9.7	3.6	13.4
Dyslipidemia, yes	7.3***	2.4	9.6	9.1	3.5	12.6

Results of an average marginal effects analysis. R denotes reference category.
****$p < 0.01$.*
***$p < 0.05$.*
**$p < 0.1$.*
Source: The Korea Health Panel survey data (2014–2018).

not receiving a medical examination or treatment that they needed in the past 12 months due to either a non-financial barrier (3.8%) or a financial barrier (1.8%). The findings indicate that the percentage of people experiencing a non-financial barrier comprised ∼70% of the percentage of people experiencing a barrier that led to unmet healthcare needs and was more than twice as high as that of people experiencing a financial barrier. Individuals seemed not to be able to obtain timely and adequate healthcare when they needed it more often due to a non-financial barrier than a financial barrier in Korea and in most European

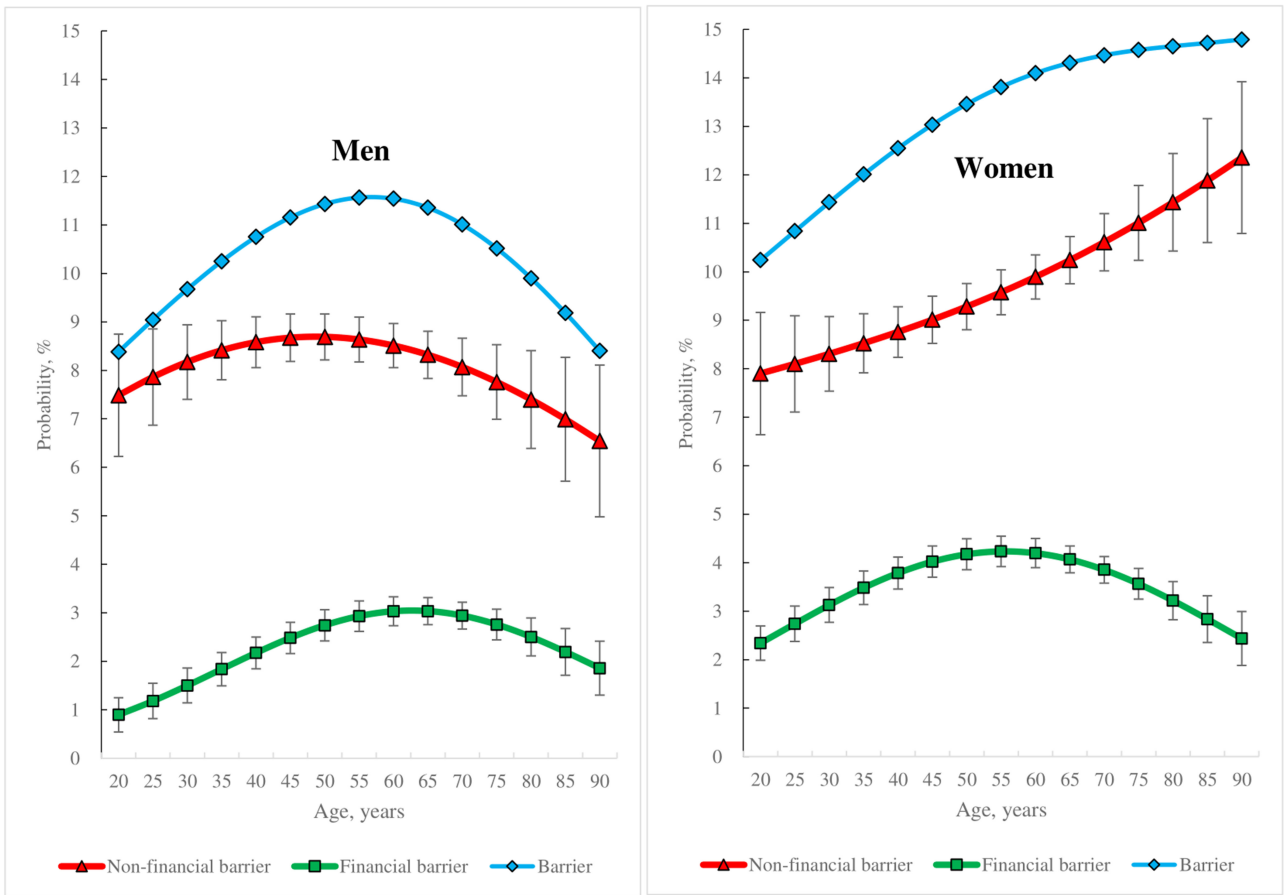

FIGURE 2 | Gender-specific differences in the average adjusted probabilities of experiencing non-financial or financial barriers that led to unmet healthcare needs across different age groups and the 95% confidence intervals.

countries, except for Albania, Belgium, Cyprus, Greece, Italy, and Kosovo.

Compared to individuals in the European countries, individuals' access to necessary healthcare in Korea seemed to be more severely hampered by a high prevalence of non-financial barriers. Based on the study results, the percentage of people experiencing a non-financial barrier (9.6%) was ∼4 times higher than that of experiencing a financial barrier (2.5%). Therefore, it is necessary for policy-makers in Korea to reform the nation's healthcare system to address these non-financial barriers along with concurrent efforts to reduce financial barriers.

To examine the specific barriers to healthcare that led to unmet healthcare needs in Korea, the present study conducted a further estimation of the prevalence rates of each specific barrier using domain analysis with survey weights. The results showed that in 2018, for adults aged 19 years and above, the percentage of individuals who experienced a barrier leading to unmet healthcare needs was 11.7% [standard error (SE) = 0.3], the percentage of individuals who experienced a non-financial barrier was 9.5% (SE = 0.3), and the percentage of individuals who experienced a financial barrier was 2.1% (SE = 0.1). Concerning a non-financial barrier, the highest rate of prevalence was shown in terms of: "7) I had no time to visit a healthcare facility" (4.7%, SE = 0.2), followed by "5) I felt my symptom was not severe" (3.4%, SE = 0.2), and "1) Financial reasons (burden of medical expenditure)" (2.1%, SE = 0.1). These three barriers (10.2%) accounted for most (87.2%) of the barriers to healthcare (11.7%) in Korea (detailed results can be provided on request).

To compare the percentage of people experiencing each barrier to healthcare between the European countries and Korea, the present study further calculated the average value of each barrier in 37 European countries in 2018 using data from the EUROSTAT database. The results showed that the most severe barrier to healthcare for individuals in European countries was a financial barrier, as demonstrated through the following factors identified by respondents: "too expensive" (1.7%), followed by "waiting list" (1.3%), and "wanted to wait and see if the problem got better on its own" (0.8%). These three barriers (3.3%) accounted for most (71.7%) of the barriers to healthcare (5.3%) in the European countries.

Based on the above results, Korea's healthcare system would appear to require differing policies to be implemented compared with the European countries to provide its population with timely and adequate healthcare facilities. Reforms needed in Korea would include: (1) helping busy individuals receive healthcare when they need it, (2) assisting individuals to make a quick decision if their health problem is serious enough to require them to see a physician, and (3) aiding individuals who cannot afford to pay out-of-pocket to address their health issues.

Differences Between the Characteristics Associated With Non-financial Barriers and Those Associated With Financial Barriers in Korea

Identifying the specific characteristics of individuals that are associated with their experience of non-financial and financial barriers is pivotal for healthcare policy-makers. Using this information, the Korean government could identify priority targets to reduce barriers to healthcare.

Previous studies have documented that women experience more unmet healthcare needs than men (21, 22). This study also considered the gender dimension and found that women tended to have higher risks of experiencing non-financial and financial barriers than men. On further analysis of these gender differences in relation to barriers to healthcare needs, this study conducted a calculation using the results displayed in **Table 3** and **Figure 2**, in which the AAP in men was distinguished from the AAP in women and the excess values for the AAP of experiencing each barrier in women relative to men were obtained in terms of percentage points. Based on the results, for non-financial barriers, the largest excess values of the AAP were shown in individuals aged 90 years (5.8% points), followed by individuals aged 85 years (4.9% points), and individuals aged 80 years (4.0% points). For financial barriers, the largest excess values of the AAP were exhibited in current smokers (2.5% points), followed by individuals aged 25, 30, 35, and 40 years (1.6% points for all four age groups, respectively). This finding suggests that age is an important characteristic in explaining gender differences in the risk of experiencing each barrier after adjusting the other characteristics. Specifically, to reduce the risk of experiencing each barrier in women relative to men, it is recommended that the Korean government prioritise the healthcare needs of women aged 80 years and above to help address their non-financial barriers, and the needs of women aged 40 years and under to help address their financial barriers.

Previous studies have shown a decrease in unmet healthcare needs with increasing age (23), mainly because older individuals care more about their health conditions and visit a physician more often (24). Several studies on barriers to healthcare have shown that system barriers, including financial barriers, increase with age (25), whereas personal factors, indicated through comments such as: "I had no time to visit a healthcare facility", decrease with age (25–28). However, based on the present study's findings using panel data and stratifying the analysis by gender, the association between age and the risk of experiencing a barrier leading to unmet healthcare needs differed between genders in Korea, as shown in **Figure 2**. In men, the risk of experiencing a barrier changed with age, shown by the bell curve, with the risk of experiencing a non-financial and a financial barrier also exhibiting this pattern; but in women, while the risk of experiencing a barrier increased at a diminishing rate with age, the risk of experiencing a financial barrier changed in a bell curve shape with age, and the risk of experiencing a non-financial barrier rose at an increasing rate with age. In addition, the present study found that individuals of a particular age group, that is, men ∼60 years old and women ∼55 years old, had the highest risk of experiencing a financial barrier among all the age groups. The age groups with the highest risk of experiencing a non-financial barrier comprised men aged between 45 and 50 years and women aged 90 years and above. These findings suggest that healthcare policies to protect individuals from both non-financial and financial barriers to healthcare should be customised across age groups and between genders in Korea.

While the influence of residential area on access to healthcare depends on how a rural area is defined (29), previous studies have reported that individuals in rural areas generally tend to have a higher rate of unmet healthcare needs due to poor roads leading to healthcare facilities and sparsely located facilities (27, 30). However, the current study shows that both men and women living in the Seoul metropolitan area were exposed to a greater risk of a financial barrier after adjusting for other characteristics than those living outside this area. This finding may be related to the fact that healthcare providers are highly concentrated in the Seoul metropolitan area, which may intensify competition-driven physician-induced demand (31, 32). It may be postulated that that these healthcare providers offer high-quality and high-price healthcare services not covered by the NHI programme or that they are likely to advise individuals to visit them more often, which many individuals in the Seoul metropolitan area cannot afford to pay for. Future research needs to explore whether an increased risk of experiencing a financial barrier to healthcare in the Seoul metropolitan area arises from a higher burden of co-payments for healthcare services that are not covered by the NHI programme or from more frequent visits to healthcare facilities that are covered by the NHI programme. Regarding non-financial barriers, the study found that the risk of experiencing a non-financial barrier was higher in women living in the Seoul metropolitan area than in those living outside. It might be the case that compared to women living outside, women living in the Seoul metropolitan area are more likely to face severe time constraints as they often tend to be engaged in jobs in the labour market in addition to traditional duties, such as housekeeping, child-rearing, and caring for parents (33–35).

It has been generally acknowledged that individuals within a lower socioeconomic category face more barriers to healthcare. However, in terms of the relation between education and unmet healthcare needs, past findings are mixed, showing a negative relation in some studies (36) and a positive relation in others (37). The results of the current study indicate that tertiary education negatively correlates with experiencing a financial barrier in men and women. In contrast, tertiary education has a positive relation with experiencing a non-financial barrier only in women. This finding suggests that highly educated women may postpone

medical visits or treatments in Korea, possibly due to time constraints, as described previously. Hence, it is proposed that policies to reduce each type of barrier leading to unmet healthcare needs need to be designed differently based on education level and gender.

Household income has long been considered a major risk factor for unmet healthcare needs, and an increasing number of studies have recommended policy action for minimising financial barriers to improve access to healthcare (27, 36, 38). However, the results of this study show that a higher level of household income reduces the risk of experiencing a financial barrier in both men and women but fails to reduce the risk of experiencing a non-financial barrier in both. This finding suggests that although financial barriers may be minimised through various policies, a considerable number of unmet healthcare needs are very likely to persist due to non-financial barriers, as shown in **Figure 2**. When job status is considered, this study found that jobless individuals, such as housekeepers, students, the unemployed, and the retired are exposed to a higher risk of facing a financial barrier but a lower risk of a non-financial barrier, when compared with job holders in the labour market. Based on this finding, a pertinent suggestion would be that policies for maximising access to necessary healthcare should be customised to distinguish between the jobless category and job holders. Recent studies have found that jobless women are exposed to an increased risk of mental health issues, and recommend well-designed policy options to cater to their needs (39, 40).

Various studies have shown that disability worsens the ability to access healthcare services (41–43). Individuals with disabilities often report that their healthcare needs are not attended to and that they feel abandoned (44). Women with disabilities experience additional barriers in accessing healthcare services more often than their male counterparts (22, 45). In one study, disabled individuals in the UK reported poorer access to healthcare, with the main barriers being difficulties in transportation, high cost, and long waiting lists (22). The present study found that individuals with a functional limitation exhibited a higher risk of experiencing a financial barrier and a much higher risk of experiencing a non-financial barrier in both men and women, with women being more vulnerable than men in both risk categories, compared to those with no functional limitation. These findings are of concern, given rapid population ageing in Korea and the increase in the number of individuals with a functional limitation (15). As such, an aged population is more likely to experience increased barriers in accessing necessary healthcare. A recent study involving 31 European countries found a considerable variation in the physical accessibility of primary healthcare across these countries, concluding that national healthcare policies should increase the physical accessibility of primary healthcare services to improve access to healthcare for individuals with a disability (46).

Many studies have revealed the positive effects of healthcare on health, which indicates that unmet healthcare needs are likely to be negatively related to self-assessed health (25, 47). Similar to these studies, the present study found that, relative to the individuals who reported that their health was not poor, those who reported that their health was poor had a higher risk of facing non-financial and financial barriers in both men and women. However, it is worth noting that this negative association between the risk of experiencing each type of barrier and self-assessed health may be due to reverse causation. For example, individuals who reported that their health was poor could be considered as being more likely to report that their healthcare needs were not met. As such, future research should investigate the cause-and-effect relationship between subjective unmet healthcare needs and subjective health outcomes.

Identifying Target Groups by Gender to Minimise the Risk of Experiencing Each Type of Barrier in Korea

Identifying target groups by gender can help policy-makers focus effectively on reducing non-financial or financial barriers to healthcare or both. To aid this process and on the basis of the findings (**Table 3**; **Figure 2**), this study first compared the AAP of experiencing a particular barrier between individuals with all the characteristics and all individuals in each gender. Second, this study selected characteristics of individuals that were associated with a higher AAP of experiencing the particular barrier than the AAP for all individuals in the same gender. Third, the selected characteristics of these individuals were divided into three groups comprising characteristics of individuals who would benefit from policy interventions: (1) only reduce a non-financial barrier to healthcare; (2) only reduce a financial barrier to healthcare; and (3) reduce both non-financial and financial barriers to healthcare.

The characteristics of individuals (based on gender) who would benefit from policy interventions to only reduce a non-financial barrier to healthcare were, for men: being married; having a blue-collar job or a white-collar job; living in the Seoul metropolitan area; being in the medium group of household income; being the holder of a private health insurance plan; being an alcohol consumer; engaging in no active, routine physical exercise; being obese; and not having dyslipidaemia. For women, the characteristics were as follows: having a college education or higher; having a blue-collar job or a white-collar job; being in the medium group of household income; being a holder of a private health insurance plan; being an alcohol consumer; engaging in no active, routine physical exercise; having no chronic diseases; having one to three chronic diseases; and having no dyslipidaemia.

Next, the characteristics of individuals (based on gender) who would benefit from policy interventions to only reduce a financial barrier to healthcare, for men, were as follows: being non-married, not having a private health insurance plan; engaging in active, routine physical exercise; and having four or more chronic diseases. For women, the characteristics were as follows: having a lower education level than college; not having a job; being in the lowest quintile of household income; not having a private health insurance plan; and having four or more chronic diseases.

Third, the characteristics of individuals (based on gender) who would benefit from policy interventions to reduce both non-financial and financial barriers to healthcare, for men, were as follows: living in the Seoul metropolitan area; being in the lowest quintile of household income; being an MCA beneficiary; having

a functional limitation; being a current smoker; having poor self-assessed health; having one to three chronic diseases; and having no hypertension. For women, the characteristics were as follows: being non-married; living in the Seoul metropolitan area; being an MCA beneficiary; having a functional limitation; being a current smoker; being obese; having poor self-assessed health; not having hypertension; and not having diabetes mellitus.

More Policy Suggestions

Even if all the financial barriers to healthcare are eliminated, the unequal distribution of healthcare services in terms of non-financial barriers could potentially lead to unequal access to healthcare. Studies on the effect of implementing healthcare reforms in Massachusetts, USA, found that the effects of expanding insurance-based financial coverage on access to healthcare were indeterminate (48–50). Unlike primary care physicians in the USA, those in both Canada and the UK operating within a universal health insurance system have reported that their patients had fewer problems associated with financial barriers to healthcare but greater problems related to non-financial barriers (51).

Therefore, because individuals' access to necessary healthcare may be severely hampered by a high prevalence of non-financial barriers, policy-makers in Korea need to address issues arising in relation to non-financial barriers as well as financial barriers, both at central and regional levels of government. For example, at the central government level, it is recommended to allocate more financial resources towards healthcare and ensure that healthcare personnel are optimally educated and trained, with a special focus on advancing the quality of care, maintaining an appropriate level of cost of care, and taking accountability for providing ready access to healthcare for the whole population. In addition, the present study found that, irrespective of gender, the risk of experiencing a financial barrier to healthcare is the highest in individuals belonging to the lowest quintile of household income and the lowest in individuals belonging to the highest quintile of household income. As Korea's NHI programme is characterised by a high degree of income redistribution (52), the central government needs to more clearly recognise differences in the risk of experiencing a financial barrier to healthcare between wealthier and poorer sections of the population and to create robust policies to address the situation.

At the regional government level, it is recommended that regional administrations create, organise, and coordinate the provision of healthcare facilities in each region and provide necessary healthcare services to each resident in each region proportionately with the use of appropriate mechanisms for reducing the barriers to healthcare. Concerning non-financial barriers to healthcare, individuals with a functional limitation irrespective of gender were found to be at the highest risk, while jobless individuals had the lowest risk. Based on this finding, it is recommended that regional governments implement planning in regional healthcare systems that promotes the possibility of jobless individuals helping individuals with a functional limitation to meet their healthcare needs through cooperation with a healthcare provider (or a provider network).

At both central and regional government levels in Korea, policy-makers should prioritise efforts to address the most common type of non-financial barrier that leads to unmet healthcare needs, that is, the time barrier, demonstrated through comments such as: "I had no time to visit a healthcare facility". This time constraint barrier needs to be reduced for the benefit of working populations with relatively inflexible schedules. One way this could be done would be to set up onsite workplace clinics for workers at medium-scale or large-scale workplaces (53, 54). For workers at small-scale workplaces, the provision of appropriate after-hours healthcare services (55–57), and telehealth services (58–60) could expand their opportunities to receive timely healthcare services.

The second most common type of non-financial barrier identified as leading to unmet healthcare needs in Korea is an information barrier, demonstrated through comments such as: "I felt my symptom was not so serious". This issue could be addressed through policy implementations that increase the number of healthcare providers and that reorganise their roles to ensure the provision of pertinent health information to individuals. It needs to be noted that, although most advanced countries consider primary care as an essential element of universal health coverage (59, 61–65), Korea has long been inattentive to the importance of primary care, as shown through the substantial shortage of primary care physicians (15). Therefore, Korea needs to equip itself with an adequate number of primary care physicians and recognise their indispensable role in the nation's healthcare system through ensuring an appropriate level of training and of remuneration. At the same time, it is recommended that the scope of practise for nurse practitioners and physician assistants be expanded in clinical areas where physicians have long been in short supply (66–69) and that shared medical appointments be encouraged to allow more patients to receive routine primary care (70).

The benefits of regular access to a primary healthcare provider have been documented in numerous studies (71, 72). A recent study on primary healthcare reforms in Canada found that having regular access to a doctor reduced the risk of unmet healthcare needs (25). Encouraging individuals to have a regular primary healthcare provider seems a good way to not only reduce the most prevalent non-financial barriers to healthcare (time and information barriers) through fostering telehealth services or healthcare providers' or social service providers' visits to patients (73, 74), but also to lessen financial barriers through maintaining continuity, comprehensiveness, and coordination of care (75). If regular primary healthcare providers and social service providers combine to form a primary care provider network to cater to the healthcare needs of individuals in each area of a country, it would be possible for individuals to receive timely and adequate healthcare services when they need them. For example, through social services offered by the primary care provider network, individuals with functional limitations could visit a doctor and those socioeconomically disadvantaged would be more likely to be able to overcome financial barriers to healthcare (76–80).

Furthermore, it is recommended that periodic health surveys at both central and regional government levels be implemented to clarify the full range of healthcare challenges and the prevalence

rates of all types of barriers to healthcare, with the relevant factors identified and addressed more effectively. It is strongly recommended that Korea, which has much to learn from the universal health insurance systems operating in European countries, collaborates with the European Union to minimise barriers to healthcare by conducting health surveys informed by approaches adopted in those countries and formulating effective healthcare policies thereafter.

Strengths

To the best of the author's knowledge, this is the first study to identify gender-specific characteristics associated with non-financial and financial barriers to healthcare and quantify the effects of these characteristics, using a nationally representative longitudinal dataset, panel multinomial logit model analysis with time-varying covariates, and the average margins effects method. This study is also the first to compare non-financial and financial barriers to healthcare in Korea with those in many European countries using EUROSTAT statistics and a nationally representative dataset of Korea. This study highlights that, even though policy-makers in most countries have been striving to reduce financial barriers to healthcare and help individuals meet their healthcare needs, the often-ignored non-financial barriers to healthcare need to be considered to ensure effective healthcare. As for the generalisability of the research findings, the method used in the present study can be applied to other socio-cultural and national settings in which a universal health insurance system operates.

Limitations

This study has some limitations. First, concerning the subjective unmet needs in the EU-SILC survey, the question only refers to unmet needs for a medical examination or a doctor consultation in Czechia, Slovenia, and Spain, and it refers to unmet needs for "severe" illnesses in Germany. This might have resulted in lower rates of unmet needs compared with other countries, most of which refer to both a medical examination and treatment (81).

Second, as the KHP survey was not based on clinical assessment, self-reported data, such as unmet needs and their reasons, might have involved recall bias, while self-reported height and weight data may have resulted in measurement errors. However, self-reported data have been recognised as very useful in analysis despite the lack of physicians' assessment data because individuals are often more aware of their healthcare needs even though they may not know the names of diseases and treatment methods as accurately as physicians; and because individuals can provide more precise responses as to why their healthcare needs were not met. Such self-reported data have been used in several studies on unmet healthcare needs in the USA (82, 83), Canada (23, 25), Europe (28, 84, 85), Asia (27, 86), and Africa (87).

Third, the KHP survey only asked respondents about one major reason for unmet healthcare needs in the last 12 months. Consequently, it was not possible to identify barriers that the respondents were able to overcome that allowed them to access healthcare. Future studies might seek to identify these types of barrier, which would be beneficial in research and for policy development by revealing how individuals succeed in overcoming barriers to healthcare. Moreover, because the survey sought information concerning one major reason for unmet healthcare needs, it was not possible to rank the relative importance of barriers that led to unmet healthcare needs. If data on the relative importance of barriers became available, researchers could conduct a more in-depth investigation including changes in the relative importance of barriers to healthcare over a lifetime.

Fourth, given the lack of related information, the present study could not consider other potential characteristics, such as social capital and social support (24, 88), and consumers' emotional satisfaction towards healthcare services (89). Future research needs to investigate whether these characteristics might be significant in determining the risk of barriers to healthcare in Korea.

Fifth, this study used a panel-data mixed multinomial logit model, which, irrespective of its various advantages, assumes that survey weights must be the same for all observations of a case. Therefore, this study could not apply survey weights for the main part of analysis because survey weights for this study's sample differ across individual people and across years. However, the results remain important in that this study did not intend to make statistics computed from the data more representative of the population but intended to reveal the importance of non-financial barriers to healthcare relative to financial barriers to healthcare.

Finally, although it was beyond the scope of this study, it would be of great interest to incorporate characteristics, such as ethnicity or immigrant status, into this type of analysis (26, 38). However, the KHP survey dataset does not include such information.

CONCLUSIONS

Although financial barriers that lead to unmet healthcare needs have long been recognised as a pivotal risk factor in healthcare access, many individuals have experienced unmet healthcare needs due to a variety of non-financial barriers (5, 83, 90–93). The present study found notable differences across European countries and Korea in the percentage of people experiencing non-financial and financial barriers that led to unmet healthcare needs. Further, in most countries including Korea, compared to financial barriers, non-financial barriers more often prevent individuals from meeting their healthcare needs. Furthermore, the individual characteristics associated with experiencing non-financial barriers were found to differ from those associated with experiencing financial barriers. These findings indicate that, even after eliminating financial barriers, non-financial barriers could still generate a considerable degree of unmet healthcare needs and disparity among individuals.

Therefore, it is recommended that current universal health insurance systems apply targeted policy instruments to reduce the burden of non-financial barriers to healthcare to achieve effective universal health coverage. This recommendation would benefit countries such as Korea, where people experience unmet healthcare needs more often due to non-financial barriers than financial barriers, and which is facing the challenges of rapid population ageing and an increasingly higher prevalence of functional limitations.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analysed in this study. This data can be found here: data are from the Korea Health Panel survey, which is available to the scientific community with a signed data access agreement from the Korea Institute for Health and Social Affairs and the National Health Insurance Service database (https://www.khp.re.kr:444/eng/main.do).

ETHICS STATEMENT

This study used the secondary data obtained from the KHP survey that is publicly available on the survey website (https://www.khp.re.kr:444/eng/main.do). All the interviewees in the survey were anonymous, and all procedures involving human participants followed the ethical standards of the relevant institutional and National Research Committee and of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Ethical review and approval was not required for the study.

AUTHOR CONTRIBUTIONS

WC conceived and completed the study and accessed and verified the data.

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Sustainability of Nursing Leadership and Its Contributing Factors in a Developing Economy: A Study in Mongolia

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The sustainability of nursing leadership is a very important problem. Every country continually strives to find the best ways to advance in nurse management and patient care services. Nursing leadership is most desirable in the delivery of health care services. Since there is limited information about leadership skills in Mongolia, to solve the problem of the sustainability of nursing leadership, we carried out this study to explore factors contributing to the sustainability of nursing leadership and their correlation relatively to nurse managers in healthcare institutions. A sample of 205 nurse managers from all forms of health facilities participated in this study. The data were analyzed by descriptive, correlation, and multiple linear regression models using SPSS 19 version. The linear combination of the five independent variables was significantly related to the dependent variable (nurse leadership). Both the behavior and problem-solving are significant regressors of the dependent variable. The correlation analysis significance of the independent study variables, two were found to have a significant effect on nursing leadership: behavior and performance of nurses significantly and positively effect nursing leadership. The transformational role and nurse leadership produced a significantly positive Correlation coefficients give a direction of causation in the relationships of variables, and the multiple linear regression analysis says that two of the variables, namely, behavior and problem-solving, positively contribute to nursing leadership, two of the variables namely, work environment and performance nurse manager do not support; however, variable transformational ability majorly contributes to the sustainability of nursing leadership.

Keywords: nurse leadership, work environment, performance, problem-solving, transformational role

INTRODUCTION

The sustainability of nursing leadership is a very important problem. Healthcare is one of the challenging industries that require complex demands, and needs successful recruitment strategies; however, it is quite difficult to select competent professionals and keep them for a longer period of time. As a growing segment of the population ages, each country strives to find the best way to improve its nursing management and patient care system. Nurses play an important role as doctors in the delivery of health care services. Due to the increased demand for nurse managers, the form of leadership is most desirable in the daily working environment of nurses (1–4).

Nurse managers engage in a range of leadership activities in their daily routine that some will naturally adopt an effective leadership style and provide higher leadership roles, while others may find the concept of leadership is difficult to understand or see themselves not so much competent. Nurse leaders should have rational thinking and exceptional communication skills that are measured by the positive influential ability to reach the goals of health care. The key role of nurse managers is to motivate their subordinates to be autonomous in making patient care decisions and perform safe patient care according to the standards of nursing practice (5–7).

Leadership is important in high-quality patient care and facilitating positive staff development in healthcare settings. Effective leadership significantly influences reducing turnover of nurses and increasing job satisfaction in the workplaces (8, 9). According to literature, leaders should be able to work under pressure and take immediate actions to solve problems, and, at the same time, be both taught and learned in the work environment. Nevertheless, leaders must show emotional intelligence to manage their own and others' feelings. In addition, leaders must have a transformational role to influence their own and others' performances that impact problem-solving in the workplace (9, 10).

Nowadays, the leadership role of nurses depends on rapid technological changes, communication style, information transparency, needs of patients, service quality, and compliance with regulations and standards (8). Besides, the nurse manager is a coach, while nurses provide high-quality patient service, stabilize workload and stress, and increase efficiency in the workplaces. Typically, the leadership of nurse managers is developed through specific educational activities by modeling and practicing competencies (11). Nevertheless, cultural differences influence nursing leadership, for instance, in Arabic countries, nurse managers have an integrative leadership role; in spite of it, in western countries, nurse managers prefer to be decentralized (12, 13).

With the notable shift in the healthcare needs of global populations, healthcare institutions across the world face enormous challenges to be more responsive and efficient, a responsibility that cannot be met without ensuring good quality of nursing care. Yet, due to inconsistent economic development, the quality of nursing varies significantly from country to country. In developing countries, such as Mongolia, nurses work, often under difficult circumstances, in health services that are grossly underfunded and are a vailable only to those who can pay (14).

Over the last decades, the health care industry in Mongolia has faced a series of problems, such as low quality in care provision, human resources scarcity, inadequate training, and insufficient ongoing education for nurses and nursing leadership, as well as poor working environments. In spite of that, nurses work hard to facilitate their resources to their job without considering the environment.

In brief, Mongolia is a landlocked developing country, which is between China and Russia, with a population of 3 million, the majority of which live in the capital city. As of 2020, the life expectancy in Mongolia was 69.9 years. By 2012, there were 9,916 registered nurses (see **Table 1**), while this number increased to 10,948 in 2016 (4, 15, 16).

Studies discuss that insufficiency in autocratic nursing leadership is common within hospital settings of Mongolia, which is the main problem of this study (8). According to the literature, the common factors that have a positive effect on nursing leadership are work environment, performance, behavior, problem-solving, and transformational role (18), which are discussed in section Literature Review and Research Hypotheses more in detail. Thus, the purpose of this study is to explore factors that affect nursing leadership in healthcare institutions of Mongolia. We hope that this study will also serve as a catalyst for further exploration of influencing factors on leadership in developing countries. This study provides instruments in helping hospital administrators to meet the needs of long–term employment of nurses in their organizations. A greater understanding of nurse leadership changes people's minds and functions and increases healthcare quality and patient care services in hospitals of Mongolia. This study has a critical implication on Government policies and regulations on how to develop nurse managers in healthcare settings around the country.

The remainder of the paper is organized as follows. Section Literature Review and Research Hypotheses reviews relevant literature and describes the hypotheses to test. Section Methods presents the methodology. Empirical results are reported in section Data Analysis, while section Conclusions and Discussions presents the conclusions of the paper.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

The theoretical foundation of this study is based on leadership theory, management theory, and psychological theory of nurse managers that influence the activities and competence of an individual or a group in efforts to have goals of achievement in a given situation. Leadership theory says that some people are born to be leaders, while, according to management theory, leadership is a position and a skill that can be earned and developed through years of experience (11, 19). According to the psychological theory, naturally, women have lower aggressiveness that restrains women from leadership positions. Nevertheless, gender plays

TABLE 1 | Number of hospital and nurses.

Type of hospitals	Number of health care institution	Number of nurses	Nurse managers
Primary level health care institutions			
1. Soum hospitals, including inter-soum hospitals in 21 aimags of Mongolia	271	1,165	87
2. Family hospital	221	785	41
Sub-Total	492	1,950	128
Secondary level health care institutions			
1. Provincial general hospital of 21 aimags	20	1,725	76
2. District hospitals in 9 districts of Ulaanbaatar	8	258	7
Sub-Total	28	1,983	83
Tertiary level health care institutions			
1. Specialized hospitals in UB	16	1,988	44
2. Regional diagnostic and treatment center	5	1,357	35
Sub-Total	21	3,345	79
Other health care institutions			
1. Private clinics	1,173	1,275	71
2. Hospitals of state agencies (Authority of border patrol, Railway organization)	45	406	24
3. Maternity hospitals	3	115	8
4. Other healthcare institutions	1,119	842	13
Sub-Total	2,340	2,638	116
Total	2,881	9,916	406

The health care system in Mongolia is characterized by three levels: primary level health care institutions consist of family group infirmaries in Ulaanbaatar, the capital city, in aimag centers, and in soum and inter-soum hospitals in provinces. Secondary-level healthcare institutions include district general hospitals in Ulaanbaatar and provincial general hospitals. Tertiary-level hospitals are major specialized hospitals in Ulaanbaatar and 5 regional hospitals. Ministry of Health of Mongolia (17).

an important role in the nursing profession and remained predominantly female (20, 21).

There are a number of definitions and typologies for the leadership role of nurse managers. The majority of studies used the theoretical framework of Hersey and Blanchard's Situational Leadership Model, Kouzes and Posner's Leadership Challenge, Burns' Transformational Leadership, Bass and Avolio's Transformational and Transactional Leadership, McLelland's Theory of Leadership Motivation (22). They found 20 factors that affect the leadership role and categorized the factors into four groups: [1] behaviors and practices; [2] traits and characteristics; [3] context and practice settings; and [4] educational activities.

Other scholars described nurse roles functions as an independent role function, a dependent role function, and an interdependent role function (23), which are similar to the classification of managerial theory (18) as classified into three major roles: [1] interpersonal, derived from authority and status including the role's figurehead, leader, liaison; [2] informational, derived from interpersonal roles, including the role's monitor, disseminator, and spokesman, and [3] decisional, derived from a manager's information, including the roles of entrepreneurs, disturbance handlers, resource allocators, and negotiators.

As stated in the research of Ramey (5), the leadership role prevents turnover and promotes retention, which is economically important for hospitals and healthcare institutions. Koy et al. (9) found that nursing leadership plays an important role in nursing managers' job satisfaction, organizational commitment, and workplace empowerment.

Thus, this study makes a general proposition (see **Figure 1**) that factors, such as work environment, performance, behavior, problem-solving, and transformational role, affect positively nursing leadership.

Work Environment

A nurse's role in the workplace encompasses illness prevention and care, health promotion and disabilities and palliative care, whereas a leader's role of nurses in the workplaces is to create a conducive work environment (23–25). Nurses are required to work overtime, and extra shifts are creating a stressful work environment. Therefore, nurse managers aim at maximizing nursing productivity and minimizing the direct and indirect costs of overtime work. Nursing has an important impact on hospital costs and the rational use of resources and reduced waste that reduce delivery of care cost and enable larger investment in quality (3, 11, 26).

Rajbhandary and Basu (3) identified that improving the work environment has to be identified as one retention strategy, so it is important to identify mechanisms to retain nurses and increase nurse satisfaction while improving the work environment and working conditions. In the healthcare system, a healthy work environment should be created for the appropriate nursing staff level. Nurse managers experience severe psychological stress and a heavy burden at work, which could have conflict in the work environment. A stressful work environment would likely constitute less autonomy, less control, and a lack of respect. Moreover, they create a safe environment for effective

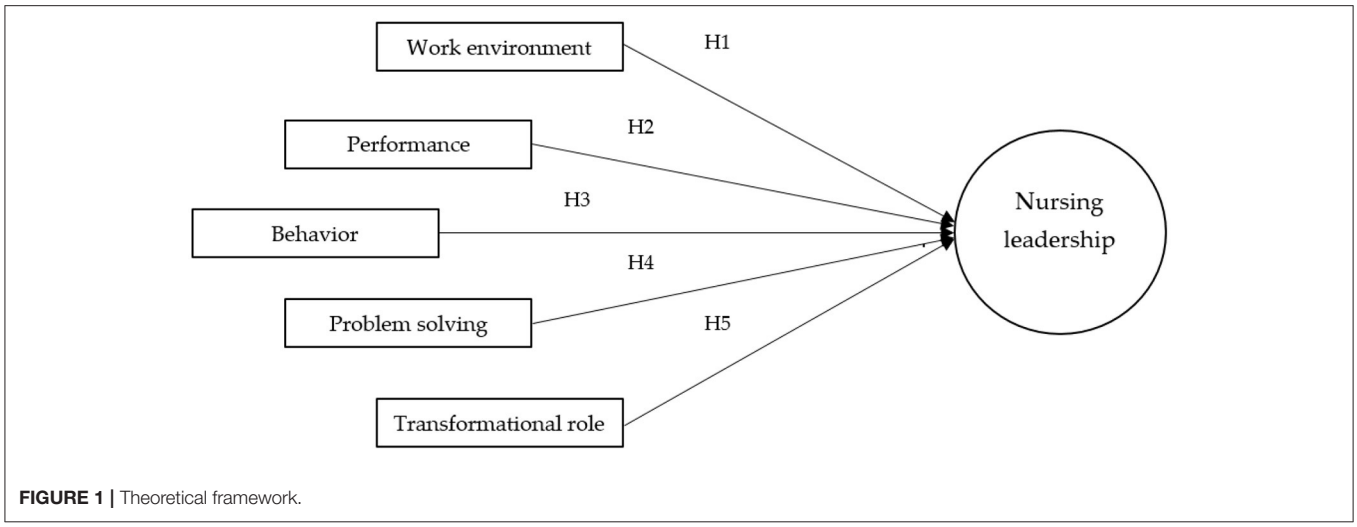

FIGURE 1 | Theoretical framework.

management of the conflict to stimulate personal growth and ensure quality patient care (9, 12, 20, 24).

Many researchers used the Revised Nursing Work Index (NWI –R) and Environment Scale of the Nursing Work index (PES-NWI) to measure factors in the work environment to support professional nursing practice, and explored that leader's role is a critical factor in the work environment (27). Clinical leaders foster a supportive work environment to empower their subordinate nurses in management positions (9). A positive leadership role encourages nurses in managerial positions to involve in a common organizational commitment that contributes to an optimal work environment (9, 28).

Casida (6) found that the leadership role of nurse managers is directly influenced by the nursing unit and organizational culture that is responsive to the external and internal perspectives forward to the hospital goals and vision. A positive work environment does not naturally occur, instead created and fostered by strong nurse leaders their visibility, accessibility, consultation, recognition, and support (27). Thus, the following hypothesis is set to test whether the work environment is positively related to nursing leadership:

Hypothesis 1: Work environment is positively related to nursing leadership.

Performance

The performance of a nurse in a healthcare institution is an interaction between people to work together and help the patients, thereby reducing the power imbalance between the patient and the physician and creating dependency on the part of the patients. Nursing performance is critical to the management of a nursing ward and closely tied to role enhancement of nurse managers and job satisfaction (11, 26, 29).

Health care organizations, including nurse care departments face formidable challenges in improving nurse performance, which is the fundamental aspect to successfully excel in many organizational elements and effectively enhance health care quality to patients. Nurse managers with high performance successfully achieve their responsibility in an organization and have a positive influence on nursing leadership; however, nurse managers with weak performance spent considerable energy, articulating the importance of nursing to the organization (9, 21, 30).

Hypothesis 2: Performance is positively related to nursing leadership.

Behavior

Koy et al. (9) state that demand for care is skyrocketing, and supply for a caregiver is plummeting that behavioral component is essential for nurse managers. Nursing intervention is defined as assisting a patient, significant others, and/or family to improve relationships by clarifying and supplementing specific role behaviors. Some researchers argue that a behavior element has a positive effect on the nurse manager's role based on the leader-member exchange theory. The behavior of nurse managers is most important in staff nurse satisfaction, engaging nurses in the work environment (27).

According to Nilsson et al. (25), role modeling of leadership behaviors by managers, clinical nurse specialists, and other colleagues is developed through a nurse leadership program. Theories of leadership also emphasize positive behaviors are the essential part for leaders. The development of leadership expertise has been described as a process of developing competencies and behaviors over time through education, preceptorship, and mentoring. Supportive interpersonal behavior at work is an important dimension of a nurse manager (11) that managerial support is directly impacted by the attitude and behaviors of the nurse leaders.

Several studies (29) used the Collaborative Behavior Scale created by Stichler (31) to determine the extent of collaboration behaviors that generally exist between nurses and nurse managers. Results of their study show that positive behavior influences positively the leadership role and favorable work

environment. They conclude that bad behavior increases workload, turnover, lack of responsibility. Furthermore, the authors suggest that hospital management should stimulate the autonomy of the nurse managers by creating an environment in which career opportunities are clearly delineated in terms of behavior.

In reality, nurses exhibit diverse behaviors, and most of the nurses do not engage in effective conflict resolution, sharing ideas, understanding each other, and communication about what needs to be done for the patient. Therefore, we developed the third hypothesis to examine whether the behavior is positively related to nursing leadership:

Hypothesis 3: Behavior is positively related to nursing leadership.

Problem-Solving

Problem-solving ability is one of the most important attributes for nurse managers to promote team integration to achieve maximum efficiency. Furukawa and Cunha (8) argue that, in nursing, problem-solving within teamwork emerged in the 1950s in the USA through experience and a solution to the issue of better use of personnel, as leaders develop and learn new skills and they demonstrate and use these skills in practice while setting teamwork as well as teaching others (9, 22, 24).

According to Aiken et al. (7), nursing leadership and problem-solving between groups increased significantly following an intervention and communication. Nurses' daily responsibilities are demonstrated by a critical path, a clinical path, or a care path that is an example of how problem-solving is weaved. To improve clinical problem-solving performance then, it would seem fruitful that nurses should be encouraged to develop a strong nursing leadership and well-structured knowledge base in the context of their discipline.

Hospitals do not provide education regarding problem-solving; thus, nurse managers shall have their own ability to solve a problem. Moreover, the nursing department or unit may develop its own module for nurses. Thus, this study postulates the following proposition to test whether problem-solving has a positive effect on nursing leadership:

Hypothesis 4: Problem-solving ability is positively related to nursing leadership.

Transformational Role

One of the main roles of a nurse manager is to motivate followers and value specified and idealized goals, which are determined by the transformational role. A number of studies used the Leadership Practice Inventory approach to measure nurse managers in perception of leadership abilities to deemphasize that extraordinary nursing leadership composes of transformational roles. Using the method, Krugman and Smith (32) compared outcomes between two units: one with transformational leadership and the other one with conventional management. Their finding shows that nurses with transformational roles have a high rate to be nurse leaders, respected within an institution by departments and physicians.

Registered Nurses' Association (33) reports that support from colleagues with transformational qualities is important for nurse leaders. A transformational leadership ability of individuals broadens and motivates both parties to achieve greater levels of achievement, thereby transforming the work environment; moreover, it could be a great way to generate an optimum decision.

Highly and moderately relevant transformational roles are common among experienced nurses, while low and moderately relevant interpretations were more evident among young or non -experienced nurses (25). Researchers found that the transformational role of nurse managers is positively related to empowerment, and transformational leaders have a clear vision for the future and values in an ongoing dialogue with nurses. Nurse managers empower subordinates by motivating them to share in the vision and make it a reality; thus, they should have a transformational role to some extent. Consequently, the following hypothesis is set to examine whether the transformational role has a positive impact on nursing leadership:

Hypothesis 5: The transformational role is positively related to nursing leadership.

Nursing Leadership

It is evident that leadership in nursing is of supreme importance at this time. The managerial career and nursing leadership are frequently seen as an award, an acknowledgment of a nurse's contribution to an organization and patient care services (8). Casida (6) discusses that a competitive leadership role is crucial for patient satisfaction and must be the survival of any healthcare facility that remains a priority of nurse managers. Nurse managers find themselves facing a challenging global nursing shortage—that the need for health care grows rapidly worldwide.

There are a variety of standards applicable to the practice of nursing leadership. The standards are based on the values of the profession, work environment, nursing actions, and interventions that a nurse implements to achieve desired outcomes in a particular hospital setting. Despite it, the hospital size is considered to be a fundamental feature with important implications for nursing leadership in hospital settings. Furthermore, nursing leadership is higher in bigger hospitals than in small ones (10).

Generally, it is acknowledged that one learns to be a leader by serving as a leader. One is a leader when he or she exercises leadership. Nurses progress throughout their careers as they face new challenges and conflicts in the workplaces. The establishment of criteria for the selection of nurse managers depends not only on years of experience but also on personality and management skills (4, 9, 12).

Nurse managers with positive leadership effects have their own self-interest for a higher purpose and stimulate followers, while those with negative leadership effects avoid leadership responsibilities and take action when issues become serious.

When positive nursing leadership exists within nurse managers, patient satisfaction tends to be high, while turnover of nurse staff becomes low. Nevertheless, leadership policy shall be formulated by the human resources department, involving all management levels.

METHODS

To solve the problem of the sustainability of nursing leadership, the purpose of this study was to examine the relationship between nursing leadership and contributing factors to it, such as work environment, performance, behavior, problem-solving, and transformational role. We used a multifactor questionnaire survey method to collect data. This study has a descriptive and predictive design. Thus, the empirical data examination procedure consists of descriptive statistics, correlation, and multiple linear regression analysis.

Sample and Design

During the study period, a total of 9,916 nurses worked in 2,881 health care settings of Mongolia, of whom 406 were registered nurse managers having worked as nurse managers for at least 1 year (17). On average, a nurse manager supervises 24 nurses. To design the sample, the first step consisted of listing all level health care institutions in Mongolia. These comprised 492 primary-level health care institutions, 28 secondary-level health care institutions, 21 tertiary-level health care institutions, and 2,340 other health care institutions, representing 128, 83, 79, and 116 nurse managers, respectively. Since the target population, 406, is not large, we purposively distributed the coded questionnaire to all nurse managers.

Questionnaires were distributed to the nurse managers of each participating hospital. The response rate achieved in this study was relatively high. All analyses were conducted at the 0.05 significance level. The participants were informed that the findings of this study may not benefit them directly, but, by being part of this study, they contribute to a better understanding of nurse leadership, patient care, and hospital structure of the Mongolian healthcare system. A copy of the summary of findings from the study was submitted to the Ministry of Health of Mongolia for a further policy implication. The coded questionnaire was taken from 205 nurse managers as over 50.4% of the total nurse managers in Mongolia in various hospitals of Ulaanbaatar and provinces. SPSS version 19 was used in data analysis.

The following procedures were employed to study the relationship between the dependent variable, nursing leadership, and the independent variables, including work environment, performance, behavior, problem-solving, and the transformational role. In each hospital, the head of nursing distributed the questionnaires to their nurse managers, and, when completed, they were collected from the nursing unit. The questionnaires were given to their home to respond with their convenience and returned a week later through the head or director nurses.

The response rate achieved in this study was comparatively good in comparison with other studies on nurse managers and leaders. Data collection that started in June 2013 was completed by September 2013. Basic demographic information about gender, age, education level, position level, and years of experience was added to the survey tool for all the participants to investigate how the demographics affect nursing leadership.

Study permission was obtained from seven hospital directors. All the participants had signed on the consent form prior to data collection and their rights to privacy and confidentiality.

Instrument

The following are the seven parts of the survey questionnaire (see **Appendix A**).

1. Demographics include gender, age, education, position, and years of experience.
2. Fundamental features include organizational structure, basic knowledge of "leadership" and policy of particular hospital settings.
3. Work environment represents how nurse manager environment allows making autonomous nursing care decisions to suit patient needs that impact nursing leadership.
4. Performance represents how a nurse manager assesses nurse performance, how to decide to provide training sessions to teach new nursing technologies, develop new medical techniques, improve performance, anticipate and prevent misunderstanding/conflicts, redefine goals, consolidate teamwork for effective nurse leadership.
5. Behavior—how nurse managers enact the behaviors that convey support to staff and impact nursing leadership.
6. Problem-solving—how nurse managers effectively solve problems to be able to decrease the cost of health care and to increase the quality of patient care, and
7. Transformational role—how nurse managers adapt innovativeness of their approaches to the work and impact nursing leadership.

The five factors significantly contribute to nursing leadership that tested for the build, convergent, and distinguishable validity. The questionnaire consisted of a series of items with a five-point Likert scale (5 = strongly agree,..., 1 = strongly disagree) that reflects five factors of nursing leadership.

Fundamental features include the level of hospital size as to whether primary, secondary, tertiary, or other types of healthcare institutions. A few questions were asked from the participants to know nurses' knowledge about leadership and how hospital policy influences career development and nurse leadership. These fundamental questions are to identify an area of focus of nurses, hospitals, and to determine an area that needs attention to strengthen the effectiveness of leadership in the future.

Operational Definitions

- Behavior of leadership is the ability to think critically, ability to solve problems, have respect for people, communicate skillfully, have the tendency to set goals, share vision, and have development of self and others (9).
- A healthcare institution is any hospital, convalescent hospital, health maintenance organization, health clinic, nursing home,

extended care facility, or other institution devoted to the care of a sick, infirm, or aged person (18).

- Leadership is the position or function that organizes and guides a group of people to achieve a common goal and may or may not have any formal authority. The leadership role is building tolerance for ambiguity, setting performance standards for confidence, and holding subordinates accountable to those standards (18).
- Nurse is the protection, promotion, and optimization of health and abilities; prevention of illness and injury alleviation of suffering through the diagnosis and treatment of human responses and advocacy in health care for individuals, families, communities, and populations (33).
- A nurse manager is the nurse with management responsibilities of a nursing unit and requires strong leadership ability, clinical nursing knowledge, and decision–making within organizations employing nurses. The nurse manager does planning, organizing, staffing, directing, and controlling. The nurse manager is a middle manager who has 24-h responsibility for one or more hospitals or clinic units, regardless of the title assigned to that position. This position includes direct supervision of charge and staff nurses on all shifts and accountability for those positions [(4)].
- Performance is the accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed, which is the process of creating a work environment to enable perform best of the nurses' abilities [(25)].
- A problem solver is able to do direct and indirect interventions, delegation, purposeful inaction, consultation, and collaboration with others (4).
- A transformational role is "Four I's" as an idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration (14).
- Work environment includes the surroundings, and conditions of influences that affected performance, role enhancement, and professional relationship in the short and long terms (21).

DATA ANALYSIS

This section presents the demographics, analysis on fundamental features, correlation analysis, and multiple linear regression analysis.

Demographics

This part is about participant demographics. Demographics include gender, age, education, work experience, and position with effects on both nurse retention and nursing leadership. First, descriptive statistics are used to describe the demographics of nurse managers.

Table 2 shows that 96% of the participants were female and only 9 male nurse managers. The data mean that nursing positions are dominated by the female group, which influences the leadership position as stated gender plays an important role in the nursing profession and remained predominantly female.

Table 3 shows that 42% of the sample was aged 41–50 years old, 37.6% of them were 31–40 years old, 11.3% of the participants were 20–30 years old, and 9.3% of them were aged 51–60 years old, respectively.

TABLE 2 | Gender of participants.

		Frequency	%	Valid %	Cumulative %
Valid	Male	9	4.4	4.4	4.4
	Female	196	95.6	95.6	100.0
	Total	205	100.0	100.0	

TABLE 3 | Age of the participants.

		Frequency	%	Valid %	Cumulative %
Valid	20–30 years	23	11.2	11.2	11.2
	31–40 years	77	37.6	37.6	48.8
	41–50 years	86	42.0	42.0	90.7
	51–60 years	19	9.3	9.3	100.0
	Total	205	100.0	100.0	

TABLE 4 | Education of participants.

		Frequency	%	Valid %	Cumulative %
Valid	Associate Diploma	122	59.5	59.5	59.5
	Bachelor	82	40.0	40.0	99.5
	Masters	1	0.5	0.5	100.0
	Total	205	100.0	100.0	

These data show that the majority of nurse managers aged between 31 and 50, which were able to gain work experience, the transition of knowledge, and clinical "know-how" from one generation of nurses to another, are imperative for nurse managers. Nurses with <1 year in the profession are more likely to quit their jobs. Nursing leadership makes older nurses stay in the workforce as long as they want by making a simple adjustment to the work environment.

Table 4 shows that 59.5% of the respondents have an associate diploma education, 40% of participants have a bachelor's degree, and only one nurse has a master's degree. All the nurses were graduated in Mongolia.

Nursing education and the profession have a paralleled opportunity in today's health care system. Unfortunately, the current nursing education is not adequate to meet the needs of the future. Education must develop new partnerships with the community and healthcare institutions. More emphasis and resources must be directed to preparing bachelor's- and master's-level nurses that effective nursing leadership is grounded in the education of nurses in order to achieve successful outcomes.

Table 5 shows that 57% of the nurses are head nurses, 26% of them are registered nurses, about 10% of them are methodologist nurses, and around 6% of the participants are chief nurses.

Leadership myth is associated with the position. Moreover, the values of leadership involve occupying the top position in a hierarchy. A nurse manager is general terminology and divided into several positions, such as a director nurse of the nurse

TABLE 5 | Position of participants.

		Frequency	%	Valid %	Cumulative %
Valid	Head nurse	118	57.6	57.6	57.6
	Nurse	54	26.3	26.3	83.9
	Director nurse	12	5.9	5.9	89.8
	Methodologist nurse	21	10.2	10.2	100.0
	Total	205	100.0	100.0	

TABLE 6 | Years of experience of the participants.

		Frequency	%	Valid %	Cumulative %
Valid	0–10 years	34	16.6	16.6	16.6
	11–20 years	67	32.7	32.7	49.3
	21–30 years	88	42.9	42.9	92.2
	31–40 years	16	7.8	7.8	100.0
	Total	205	100.0	100.0	

department; head nurses are senior nurses in a nurse unit or nurse department, and methodologist nurses are trainers of nurse staffs, who are supervised by the director of hospital settings, respectively. Nurses are former nurse managers; however, they currently hold the position of a nurse.

Table 6 shows that approximately 43% of the participants have 21–30 years of work experience, around 33% of them have 11–20 years of work experience, 16.6% of them have 0–10 years of work experience, and 7.8% of them have 31–40 years of work experiences. Data support the relationship between characteristics of the nurse manager workforce and the nurse leadership, which means nurses with longer work experiences are significantly more satisfied than their less-experienced colleagues with most of the facets of their work (34).

Our data show that between 11 and 30 years of work experience affects nurse managers' positions. Nurses with <10 years of work experience or more than 30 years of work experience do not hold a nurse manager position.

Analysis of Fundamental Features

The study took place at public and private hospitals in the capital city, Ulaanbaatar, and other provinces of Mongolia. The nursing population was diverse, including large hospitals and small healthcare settings. Fifty-one nurse managers are from primary-level hospitals as 24.9% of total participants, 72 nurse managers are from secondary-level hospitals as 35.1% of the total participants and 40 nurse managers are from tertiary hospitals as 19.5% of the total participants, and 42 nurse managers are from other healthcare institutions as 20.5% of the total participants.

The primary hospitals require having 4–20 nurse staff, and one head nurse supervises other nurses, but it does not have a director nurse or a methodologist nurse. Every secondary and tertiary hospital must have a nurse department consisting of one nurse director, two to five methodologist nurses, and around 20 heads in order to manage 250 nurse staff. Other hospital settings, such as healthcare departments in 21 provinces and Ulaanbaatar city, must have at least one nurse manager, either in the position of a director nurse or head nurse.

In addition, we investigated whether nurse managers have knowledge about "leadership"; hence, first questions were "Do you know the word "Leadership?" About 157 nurse managers or 76.58% of the total participants know about it; unfortunately, 48 nurse managers or 23.41% of the total participants do not know about the term "leadership."

Also, some policy-related questions were asked and analyzed as follows. First, "Do hospital policies and procedures have to support the leadership of nurse managers?" About 118 nurse managers or 57.5% of the total participants answered "Yes," 38 or 18.5% answered "No," and 49 nurse managers or 23.9% gave an answer of "Do not know." Second, "Does a nurse manager influence mission and decision-making of general administration issues of the organization?" About 161 nurse managers or 78% of the total participants answered "Yes," 33 or 16% answered "No," and 11 nurse managers or 5.3% gave an answer of "Do not know." Third, "What level of leadership responsibility does nurse manager need?" About 161 nurse managers or 78.5% said "High," 33 nurse managers or 16% said "Medium," and 11 nurse managers or 5.5% of the total participants said "Low."

These fundamental questions are considered to know nurse managers' complaints and suggestions about leadership in the nursing department and hospital settings. Managers who talk to their staff on a regular basis are more informed and have less difficulty when situations occur and increase job satisfaction of nurses, furthermore effects to nursing leadership. Nurses should participate in the policy arena and the decision-making procedure and be engaged in health care reform-related implementation efforts. Increasing the involvement of nurses in high-level leadership contributes to a more stable workforce and, in turn, positively impacts patient quality and safety and transparency and accountability of hospital settings structure.

Correlation Analysis

The relationship between the dependent variable as nursing leadership and five independent variables as work environment, performance, behavior, problem-solving, and transformational role was examined using correlation analysis. Significance was tested at the alpha $= 0.05$ level. Correlation studies are appropriate when there is a need to clarify the relationship, and little or no previous research has been undertaken. Possible relationships were examined using Pearson correlation coefficients shown in **Table 7**.

In terms of the independent study variables, two were found to have a significant effect on nursing leadership: behavior and performance of nurses significantly ($p < 0.05$) to nursing leadership positively. The transformational role moderately ($p < 0.05$) intercorrelated with nursing leadership. However, the work environment and performance were found not to be strongly related to nursing leadership when entered with the other independent variables.

Table 7 shows the results of a Pearson correlation coefficients; nurse leadership ($n = 205$), informed that there was a strong

TABLE 7 | Pearson correlation.

		WE Ave	P Ave	B Ave	PS Ave	TR Ave	NL Ave
WE Ave	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	205					
P Ave	Pearson Correlation	0.143	1				
	Sig. (2-tailed)	0.040					
	N	205	205				
B Ave	Pearson Correlation	0.052	0.121	1			
	Sig. (2-tailed)	0.458	0.084				
	N	205	205	205			
PS Ave	Pearson Correlation	0.030	0.261	0.269	1		
	Sig. (2-tailed)	0.672	0.000	0.000			
	N	205	205	205	205		
TR Ave	Pearson Correlation	−0.015	0.185	0.143	0.159	1	
	Sig. (2-tailed)	0.836	0.008	0.041	0.022		
	N	205	205	205	205	205	
NL Ave	Pearson Correlation	0.047	0.092	0.904	0.367	0.159	1
	Sig. (2-tailed)	0.505	0.189	0.000	0.000	0.023	
	N	205	205	205	205	205	205

WE, work environment; P, performance; B, behavior; PS, problem-solving; TR, transformational role; NL, nurse leadership.

correlation r (205) = 0.90, $p = 0.000$ between the behavior and nurse leadership and r = 0.36, $p = 0.000$ between problem-solving and nurse leadership. Also, the transformational role and nurse leadership produced a positive correlation r = 0.159, $p = 0.023$. However, there is no relationship between performance and nurse leadership r = 0.092, $p = 0.189$, and between work environment and nurse leadership r = 0.047, $p = 0.505$.

The results suggested that successful nurse leadership is based on behavior and problem-solving. This opens the floodgates to nurse leadership development, as opposed to simple psychometric assessment that sorts those with leadership potential from those who will never have the chance. Leaders must be taught how to adapt and change constantly to keep up. Also, problem-solving is the most crucial and common thinking process used in nursing that requires various mind actions. This enables them to more accurately represent the nature of the clinical problem and to deal with the problem less in sequential terms in order to override clinical concepts. Thus, the findings support Hypotheses 3 and 4.

The majority of nurse managers are female, and the female leaders scored higher than the male leaders on all transformational roles, because it provides them with a means of overcoming the dilemma of the role and ability to meet the requirement of their leadership role. Therefore, this study supports Hypothesis 5 that the transformational role positively affects nursing leadership.

The work environment and performance are outcome variables that are determined to be mediated by the workload of nurses (3); however, the findings of this study do not support Hypotheses 1 and 2 that variables significantly low contributes to nursing leadership at the hospital level. These results show that, in Mongolia, nursing leadership is strongly correlated with behavior, problem-solving, and transformational roles, and nurses' performances and work environment must be improved to create a professional practice environment for nurse managers.

Multiple Linear Regression Analysis

Inferential statistics, including R-square, regression, and multiple linear regression analysis, are used to test the validity of the set hypotheses. Multiple linear regression analysis determines whether nurse leadership perceives work environment, performance, behavior, problem-solving, and transformational role. The linear combination of the five independent variables was significantly related to the dependent variable (nurse leadership), R squared = 0.83, adjusted R squared = 0.83, or 83% of the total variance in the dependent variable.

Table 8 contains the ANOVA and shows the factors that contribute to nursing leadership. The analysis shows that there is a difference with an F score of 5, 199 = 204.81 and significance (0.000) well-beyond the alpha < 0.05 standard.

The multiple linear regression analyses showed that behavior and problem-solving positively contribute to nursing leadership. But work environment, performance, and transformational roles do not contribute to nursing leadership. The level of statistical significance was set *a priori* at = 0.05. **Table 9** shows that the model analysis included the five independent variables of the work environment, performance, behavior, problem-solving and transformational ability. The behavior ($t = 29.058$, $p < 0.05$) and problem-solving ($t = 4.693$, $p < 0.05$) are emerged as a significant

TABLE 8 | Multiple linear regressions for a single set of predictors: a model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
Model Summary					
1	0.915	0.837	0.833		0.3007438
Sum of squares		**df**	**Mean square**	**F**	**Sig.**
ANOVAb					
Regression	92.622	5	18.524	204.810	0.000
Residual	17.999	199	0.090		
Total	110.621	204			

TABLE 9 | Multiple linear regressions for a single set of predictors: coefficients.

	Unstandardized coefficients		Standardized coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
Coefficients					
(Constant)	−0.015	0.219		−0.067	0.947
Work environment	0.006	0.031	0.006	0.192	0.848
Performance	−0.104	0.057	−0.056	−1.836	0.068
Behavior	1.017	0.035	0.869	29.058	0.000
Problem-solving	0.155	0.033	0.144	4.693	0.000
Transformational role	0.025	0.033	0.022	0.750	0.454

coefficient of the dependent variable. No other variables in the model were significant.

There is, therefore, a need to develop a work environment in a hospital setting and enhance performance and encourage transformational roles in order to strengthen the effectiveness of nursing leadership.

The results from the regression equation for the standardized variables were as follows: Predicted work environment score = 0.006 + (−0.104) (performance) + 1.017 (behavior) + 0.155 (problem solvency) + 0.025 (transformational ability) (**Table 9**). The findings provide support for the hypotheses (H3 and H4). These findings answer Research Questions 1 and 2 positively. The 0.000 significance level is less than the level of significance for the test of (0.05). However, the findings do not support Hypotheses 1 and 2, and weak support Hypothesis 5. Behavior was determined to be the strongest predictor of the five variables, and work environment was the weakest predictor of nursing leadership.

Nurse managers must have positive behavior and capable problem-solvers because their profession requires a high level of cognitive reasoning and discretionary decision-making that supports Hypotheses 3 and 4 as behavior and problem-solving contribute to nursing leadership. The transformational role is more focused on processes that motivate followers to perform to their full potential by influencing change and providing a sense of direction for nurse managers. Therefore, this study found that the transformational role slightly contributes to the nursing leadership as finding supports Hypothesis 5.

Minimizing nurse staff workload and enhancing nurse staff job satisfaction should be consistent with retaining nurse leaders in the profession. Unfortunately, this study does not support Hypothesis 1 that the work environment does not contribute to nursing leadership. The nurse manager must assess and improve nurse staff's performance, decide to provide training sessions to teach nursing technologies, and consolidate teamwork. But this study does not support Hypothesis 2 that performance does not contribute to nursing leadership.

CONCLUSIONS AND DISCUSSIONS

To solve the problem of the sustainability of nursing leadership, the purpose of this study is to examine the factors that contribute to nurse leadership in hospital settings in Mongolia. This section discusses the findings in relation to the theoretical framework, stated limitations, and presented suggestions and concluding remarks on the further implication of research.

This study is the first research in the literature to assess nursing leadership in Mongolia. Correlation coefficients give the direction of causation in the relationships of variables. According to the results of multiple linear regression analysis, two of the variables, namely, behavior and problem-solving, have strong positive influence on nursing leadership. Nonetheless, work environment and the transformational role do not have significant impact on nursing leadership. Finally, performance has a weak significant influence on nursing leadership.

This study is essential to develop nursing practice, increase the reputation of nurses, and motivate nurses to work in hospital settings for independent decision-making of patient care. Leadership is an observable, learnable set of practices with the desire and persistence to lead—to make difference—that can substantially improve nurse abilities.

The realities of a global society, expanding technologies, and an increasingly diverse population require nurses to master complex information, to coordinate a variety of care experiences, to use technology for health care delivery and evaluation of nursing outcomes, and to assist clients with managing an increasingly complex system of care, which wholly requires to have nursing leadership.

Nursing leadership promotes harmonious interaction between persons and their environment, strengthens the wholeness of an individual, and redirects human and environmental patterns or organization to achieve maximum health. The nursing leadership congress is designed to help nurses become catalysts, and it provides an opportunity to share practical experiences in solving many problems in the health care industry. It focuses mainly on practical experience rather than a theoretical approach. By postulating new factors and relationships and confirming the relevance of leadership factors and their relationships, the study has opened up new horizons for other researchers to investigate more deeply and precisely.

Discussion

Whereas correlation coefficients give the direction of causation in the relationships of variables, the multiple linear regression analysis attempts to explore the relationship between independent and dependent variables. Hypothesis tests were performed to answer the following research question as "How do specific factors (work environment, performance, behavior, problem-solving and transformational role) contribute to nursing leadership in Mongolia?"

The finding of this study says that two of the variables, namely, behavior and problem-solving, positively contribute to nursing leadership and nurses' perceptions of their leader's effectiveness. This means that this study supports two out of the five hypotheses and does not support three hypotheses. The results suggest that an individual behavior and characteristics (problem-solving ability and the transformational role) strongly reflect leadership. In contrast, the reflection of external variables depends on the profession and specialty, as nurses have a high workload; therefore, work environment and performance do not contribute to the nursing leadership.

The nurse department consists of nurses with different types of behaviors, but individual behavior affects the outcome of the nurse leadership. Registered Nurses' Association (33)'s guideline states that the individual behavior of a leader is important, but, also, the culture, climate, and values of organizations are essential to building the behavior of an individual. Since nursing research is not common in Mongolia, it is necessary to explore the way how behavior influences nursing leadership and, in turn, how the behavior of the nurse leadership influences the organizational outcome.

What Are the Multiple Correlations Between the Predictors (Work Environment, Performance, Behavior, Problem-Solving, and Transformational Ability) and the Nursing Leadership?

The multiple regression performed in this study indicated 83% of the variance in nursing leadership was accounted for by the linear combinations of work environment, performance, behavior, problem-solving, and the transformational role. Therefore, it is important to explore variable factors to impact nursing leadership in hospital settings in Mongolia.

The results in this study revealed a positive correlation existed between the dependent variable, nursing leadership, and three independent variables, behavior, problem-solving, and the transformational role. Behavior reflected the strongest correlation, followed by perceived problem-solving and the transformational role of nursing leadership. This means that nurse leaders should accurately anticipate and prevent misunderstanding and conflicts, redefine the goals of nurse managers, develop new medical techniques, and facilitate desirable strategic decision-making.

Registered Nurses' Association (33) identified that there is a growing understanding of the relationship between nurses' work environment, patients' outcomes, and healthcare institutions' performances. However, our study did not confirm that the work environment influences nurse leadership. Moreover, there is some research on the direct impact of the work environment on developing and sustaining nursing leadership. Nurse manager turnover is usually associated with a range of negative outcomes, including training new nurses, increased workload, and the salary range.

This research suggests that gender roles are higher from their management identity as nurse managers in hospital settings. For those who evaluate the competence and effectiveness of nursing leadership in hospital settings that are mostly female, the data suggest that females may be more effective leaders since females are more likely to practice a transformational role. This is a very important implication in order to develop a policy framework for health care settings.

Why Do We Need to Study Factors Contributing to the Sustainability of Nursing Leadership?

When we know the factors that contribute to nursing leadership, healthcare institutions are able to develop leadership styles among nurses in the nursing department. The study increases the effectiveness of current nurse managers and guides the identification of future nurse leaders.

Currently, in Mongolian hospitals, almost more than 50 percent of nurse managers' performances spent for administrative work include making a list of all the prescription drugs, counting the number of beds and linens in a hospital, and monitoring shift change of nurse staffs. Therefore, very few percentages of performances are spent on hospital care. Thus, performance was not contributed to the nurse leader in the Mongolian case. In the future, it must change the nurse manager's role that enables high performance for quality care of patients and hospital care.

Moreover, nurse managers experience a higher workload than ever before due to several reasons, although the work environment does not support nurse leadership. The reasons are, first, hospitals do not have online patient registration; therefore, the nurse managers fill out all registration forms by hand, and, hence, they spend most of their working hours in the workplace. Second, there is no consolidated database of nurse

performance within hospitals, compared to the physicians. For instance, hospitals have an integrated database for all physicians; however, neither nurse managers nor nurses have an integrated database. Third, the high workload of nurse managers does not allow training other nurse staff due to shortage of time. Finally, there is a lack of technology, including the internet environment and patient care resources.

The specialty nursing expertise is generally obtained on the job, also through nursing programs to attract new graduate nurses and motivate them further in nursing leadership. In Mongolia, around 1,000 nurses graduate from the National Medical University and its three branches, and private three universities per year. Nursing leadership programs must be offered through undergraduate and graduate education in formal and informal ways. Unfortunately, currently, nursing leadership programs are offered neither by universities nor hospitals. High school graduates are less likely to major by the nurse due to low reputation and low career development. Moreover, promoting higher education to nurses of all educational levels is critical to developing nurse leadership in hospital settings. Hence, another main reason that why the work environment and performance of nurse managers do not support our hypotheses.

How Does Nurses' Role Function Transfer to a Leadership Role in the Hospital Care Delivery System?

Nurse managers' autonomy over decisions affects the work at the unit level, patient care services, and health care institutions' commitment. When nurse leadership is high among nurses, nurse managers feel empowered and influential not only in their current role but also regarding impacts on nursing staff.

Leadership is rewarding and important for building succession, and it is a significant level of commitment to a job (18). But, in the Mongolian case, it is controversial as nurses are at the same level as kindergarten teachers and elementary school teachers; unfortunately, their salary range is lower than theirs. A nurse manager earns only one percent higher salary than nurses; however, less-experienced nurse managers have the same salary range as nurses. Therefore, the performances of nurse managers that are weak, do not motivate them to be leaders. In the last few years, the education level of nurse managers has been increased, and almost 50 percent of nurses have a bachelor's degree. However, the higher education level does not increase salary.

Promotion is not common among nurse managers and nurses that raise a negative impact to nurse performance and nurse leadership. The performance assessment is not clear in hospital settings. The nurse service quality is far away from the international standards; therefore, patients have more complaints on nurse performance, which directly affects nursing leadership. Quality of care is based on confidence and competence, which nurse leaders need support now more than ever.

Physicians and doctors do not recognize the nurse leadership role in patient care service and do not have the legal environment to support the nurse manager's performance and work environment.

Is Nursing Leadership Essential for a Hospital? If Yes, How?

The nurse staff is working longer hours and taking an increased patient assignment. Moreover, job satisfaction highly reflects nurse turnover. Therefore, involving nurse staff at a high level in policy and procedure development will score high on the retention scale and motivate nurse leadership among nurse managers in hospital settings. Moreover, strengthening nursing leadership is particularly critical not only in nursing and medicine but also in society.

Head nurses and director nurses include the members of management of a hospital; indeed, they must be involved in decision-making for patient care and policy development of an organizational structure. Unfortunately, nurse managers have a weak nurse leadership role, which cannot reflect strong policy development in a whole organizational setting.

Overall, these results suggest an important role of nurse leadership in strengthening hospital development and patient care services in hospital settings. The nursing unit must set behavioral standards, problem-solving approaches, and transformational roles among nurses that most positively influence the nursing leadership. On the other hand, the external variables, as work environment and performance, have to reflect the demanding role of today's nurse managers at the surface level of a hospital.

Limitations

The data were gathered using a self-report questionnaire, like the majority of earlier studies, and no objective measures were used. Self-report data might be contaminated by common method variance because five independent variables and dependent variables are based upon one source of information. Nevertheless, this study has stated that leadership has a strong and positive impact regardless of whether outcomes are measured subjectively or objectively.

Future studies need to identify the work environment and performance of nurses in the hospital settings in regard to nursing populations.

Suggestions

Health care organizations must invest in educational programs to develop leadership competencies in the workplaces to enhance their roles. Accordingly, the Ministry of Health of Mongolia must organize fruitful leadership programs in that nurses and new graduates should be encouraged to develop a strong and well-structured knowledge base in the context of their discipline. The curriculum should make an explicit reference to the international experience base and further development of nurses.

Nurse managers must have the higher professional expertise to sustain nursing leadership comparing nurse staff; however, there are no criteria between nurse managers and nurse staff to compare the effectiveness of leadership roles. An online database of nurses and nurse managers must be developed, and promotional activities are vital for effective nursing leadership.

Recently, the educational level of nurses has been increased, but there are no differences in terms of reference between position levels of nurses. The key recommendation

is for the reinvention of nursing education and work environments to address and appeal to the needs and values of a new generation of nurses and enhance the quality of patient care.

Effective nursing practice, education, research, and leadership are grounded in the complexity of human relationships and, therefore, require systematic and careful thinking in order to achieve successful outcomes of nurse performance. A hospital organizational structure must allow having a voice in policymaking for nursing service and patient care. We need a stronger model for developing and grooming nurse leaders. The nurse career model must include differential salary ranges between nurses and nurse managers that positively impact nursing leadership.

Currently, the basic techniques in hospitals are very old, and they must change the techniques in a complex way and renovate the hospital buildings, which can impact the work environment and enhance patient care services. Unfortunately, due to financial shortage, Government is not able to support hospitals, which has negative reflects on nursing leadership. The supply of hospital equipment and linens is not sufficient for hospital settings; therefore, we have widely recognized the quality of supply apart from product quality that strengths the work environment of nurses and, moreover, impacts the nursing leadership.

The policy of hospitals has greater uncertainty and ambiguity; therefore, in the forthcoming years, we will likely see greater revision and practical approaches to promote nursing leadership. Moreover, it is necessary to collectively determine the purpose of nursing leadership and to make changes in our healthcare systems that positively impact patient care services. This guiding purpose will help us determine what we are likely to do, and where we are likely to go from here. Our paper applies descriptive and correlation analysis and employs multiple linear regression models to examine nurse management and patient care services. Extensions of our paper include using our approach to examine food waste reduction (35, 36), network analysis (37), carbon emissions (38), procurement system (39), and many others. Readers may read Wong (40) for other areas in that academics and practitioners could apply the approach used in our paper for their studies. This paper studies the sustainability of nursing leadership; scholars can apply the approach used in this paper to study the sustainability of herding behavior ((41)), portfolio selection (42), organizational climate and work style (43), supply chains (44), health insurance (45), and many others.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for this study in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BW, DD, and M-UB: conceptualization. BW: methodology. DD: data curation and writing—original draft. BW and DD: formal analysis. W-KW: supervision. M-UB and OS: writing—review and editing and funding acquisition. W-KW and M-UB: project administration. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Satisfaction as a Mediator and Its Interaction With Adherence to Labor Analgesia Protocols: A Cross-Sectional Survey of Chinese Medical Personnel

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Background: Although the Chinese promotion of labor analgesia began in 2018 to improve maternal health, high-quality medical care is difficult to provide to pregnant women when medical staff cannot implement standard labor analgesia procedures. This study aims to examine medical personnel's adherence to labor analgesia protocols and to explore the relationships among adherence, satisfaction, and other factors.

Methods: The data were from a national cross-sectional dataset ($N = 13{,}944$) of the 2020 Chinese Labor Analgesia Pilot Evaluation Project. Mediating and moderating effects analyses were used to examine the role of satisfaction as a mediator between support measures and adherence.

Results: There were differences in adherence between different types of medical personnel. Support measures and satisfaction had a positive association with adherence to labor analgesia protocols. Satisfaction had a significant mediating and moderating effect on the relationship between support measures and adherence to labor analgesia standards. Moderating effects of professional titles and attitudes were also observed.

Conclusion: Primary health care policies worth considering include comprehensive incentives for medical institutions to improve the use of labor analgesia by medical personnel. It is also worth considering providing more training opportunities for the staff in anesthesiology departments.

Keywords: adherence, labor analgesia, personnel medical, maternal health, China

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INTRODUCTION

Maternal health influences the quality of maternal life, the birth of healthy babies, and the stability of society; thus, it is a global concern (1). Health policies in many countries have made significant progress in improving maternal health (2, 3). The United Nations Sustainable Development Goals (SDGs) proposed accelerating the improvement of maternal health. Maternal health was also a focus of the Global Strategy for Women's, Children's, and Adolescent's Health 2016–2030 led by the WHO. However, in 2020, the global maternal mortality rate was 12/100,000,

and the rate was 16.9/100,000 in China (4). Most maternal deaths in developing countries could be prevented if women received timely care during childbirth such as labor analgesia (5). The situation in developing countries is of great concern.

Developing countries have many problems threatening maternal health, while developed countries have successfully reduced maternal deaths by up to 80% through adequate funding, highly qualified personnel, and advanced technology (6). Labor analgesia technology has been shown to effectively promote maternal health (7). There is a disparity between developing and developed countries regarding the prevalence of labor analgesia. The rate of labor analgesia use in developed countries reached above 80% at the beginning of the twenty-first century (8–11). To improve maternal health, many developing countries are promoting labor analgesia (12, 13). However, only a few medical institutions offer adequate pain treatment during childbirth in China, and the rate of labor analgesia was only approximately 10% in 2017 (14). Labor analgesia has just begun to be used as an effective intervention to relieve labor pain in developing countries, and there are many issues that need to be addressed. To motivate further development of labor analgesia, the National Health Commission of China (NHCC) issued the Developing Labor Analgesia Pilot Work in 2018, and 913 hospitals were included in the first pilot in 2019.

A review of the available literature showed that standardized labor analgesia was of great significance for reducing the prevalence of cesarean section, improving the quality of life after labor (15, 16), and meet women's needs for painless labor (17). The committee of labor analgesia experts of the Chinese Medical Doctor Association compiled *the Clinical Standardized Management Path for Labor Analgesia in China*, which stated that an entire labor analgesia service should include promotion, professional operation, record keeping, and follow-up services (18). However, labor analgesia in China is still in the developing stage, and a large number of medical personnel are still learning basic skills. Irregularities may unavoidably occur during the implementation of labor analgesia. Consequently, determining medical personnel's adherence to standard labor analgesia plays an essential role in improving maternal health. In addition, the evidence suggests that women who chose labor analgesia are affected by the information provided by medical personnel and the quality of the labor analgesia (19–21). Adherence to labor analgesia protocols by medical personnel is essential for both maternal health and the well-being of society. Thus, this study aims to examine the factors related to the administration of labor analgesia, which offers insights to identify target groups, provides information for improving adherence to labor analgesia protocols, and provides implications for other developing countries facing similar issues.

LITERATURE REVIEW

Adherence to Labor Analgesia Protocols and Support Measures

Labor analgesia is crucial for pregnant women to live healthy life (7). Previous studies have identified implementing standardized labor analgesia has contributed to reducing the prevalence of cesarean section and improving pregnant women's physical and mental health (22). However, low-quality labor analgesia may cause serious complications (23); thus, it is important for medical personnel to adhere to analgesia measures. Adherence to labor analgesia protocols is also an important indicator in evaluating the progress and effectiveness of labor analgesia policies (24).

Since the promotion of labor analgesia in China, the influence of support measures on adherence to labor analgesia has been examined rarely. Lack of incentives and unavailability of equipment or personnel will influence labor analgesia adherence (25). Medical personnel often have negative attitudes to labor analgesia due to the scarcity of knowledge (26). It has been reported that incentives reduce the gap between medical personnel's knowledge and clinical practice with a large gain in efficiency (27). Added incentives for labor analgesia implementers could increase medical personnel's enthusiasm and improve the quality of service (28).

In addition, evidence has shown that one of the factors that affect labor analgesia in public hospitals is the lack of medical personnel and detailed charging items that is related to pain relief (29). Related arrangements for labor analgesia consist of four components—adequate personnel, adequate equipment, reasonable medical reimbursement, and charging items (18). Previous research has found that the better the arrangements are, the higher the rate and quality of labor analgesia (30). Based on the discussion above, this study is aimed to evaluate the relationship between support measures on labor analgesia.

Satisfaction With the Implementation of Labor Analgesia

Support measures are probably to have positive effects on departmental collaboration satisfaction and consequently labor analgesia adherence, but the mechanism by which satisfaction relates to the relationship between labor analgesia adherence and support measures has not been specified in the literature. The existing evidence points to relevant perspectives in understanding this relationship. Existing evidence provides work satisfaction is closely related to the quality of medical services (31). Medical personnel with high work satisfaction are more likely to provide high-quality services. Meanwhile, work-related factors have a significant effect on work satisfaction (32). Labor analgesia can only be conducted with multidisciplinary cooperation (33). Specifically, anesthesiologists need to understand the whole process of labor and delivery, and obstetricians need to know the key points and operational techniques of labor analgesia, while midwives spend the longest time with women in labor (34). Highly intensive cooperation can result in timely and correct treatment to ensure maternal safety and guarantee the therapeutic effectiveness of maternal analgesia (35). Numerous studies have demonstrated the positive effects of adequate personnel and reasonable policies on the teamwork of medical personnel (36–38).

Professional development satisfaction exerts a powerful effect on improving the professional skill level of medical personnel (39). Since the NHCC implemented labor analgesia in 2018,

medical institutions have implemented incentive measures that attract medical personnel by promoting them to professional positions. Adopting incentives was an excellent policy for those with lower-level professional titles (24, 40), but the incentive effect is limited to experts with senior professional titles. This is because seniors prefer to provide more professional guidance rather than practice labor analgesia (41). In addition, willingness is an indicator of satisfaction (42), and refers to whether medical personnel voluntarily participate in labor analgesia. Medical personnel are more willing to participate in labor analgesia when they are satisfied with the incentives and related arrangements (43). Meanwhile, medical personnel may be more inclined to use labor analgesia because there are fewer side effects and more effective pain treatment than previously reported (44).

So far, no studies have yet evaluated the role of satisfaction in mediating the relationship between support measures and labor analgesia adherence. Based on the discussion above, this study proposes a conceptual framework, as shown in **Figure 1**, in which support measures affect satisfaction with professional development and departmental collaboration and willingness affect adherence to labor analgesia. standards; that is, departmental collaboration satisfaction, professional development satisfaction, and willingness play mediating roles between support measures and adherence to labor analgesia protocols.

METHODS

Data

The Chinese Association of Anesthesiologists surveyed to evaluate the progress and effectiveness of the Chinese national labor analgesia pilot programme with the help of provincial health administrations in 2020. All 913 pilot hospitals were invited to complete the related information in the system for the labor analgesia programme. The cluster sampling method was used for the investigation. All medical personnel in anesthesiology, obstetrics, and midwifery in each pilot hospital were invited to participate in the online questionnaire survey, which was developed by the team from Huazhong University of Science and Technology. Oral consent was obtained from all participants. A total of 13,944 questionnaires were sent out and 12,614 valid questionnaires were collected; the validity rate was 90.46%.

Variables

Adherence to labor analgesia protocols was related to the support measures of the medical institution. As **Table 1** shows, total adherence was selected as the dependent variable. Adherence comprised training for medical personnel and prenatal teaching for pregnant women and their family members. It also included four operative preparations: regular preoperative visits and records, adaptation training in the labor analgesia puncture position before labor, monitoring and recording throughout the administration of analgesia, and routine postoperative follow-up and recording after labor. The individual choices in the questionnaire were classified as Yes (1) and No (0). According to these six conditions, adherence to labor analgesia protocols was scored from 0 to 6 points.

Medical institutions' support measures were selected as the independent variable, including added incentives and related arrangements. Added incentives were graded on a scale of 1–5 to indicate "fairly unsatisfactory" to "fairly satisfactory". According to the Clinical Standardized Management Path for Labor Analgesia, this study created a continuous variable, related arrangement, by adding up adequate staffing sufficient equipment, reasonable health insurance reimbursement, and charging entries, which was scored from 1 to 20 points. According to the availability of the relevant information in the database, the following variables were defined to explore the effect of the mediators and moderators: gender, age, length of service,

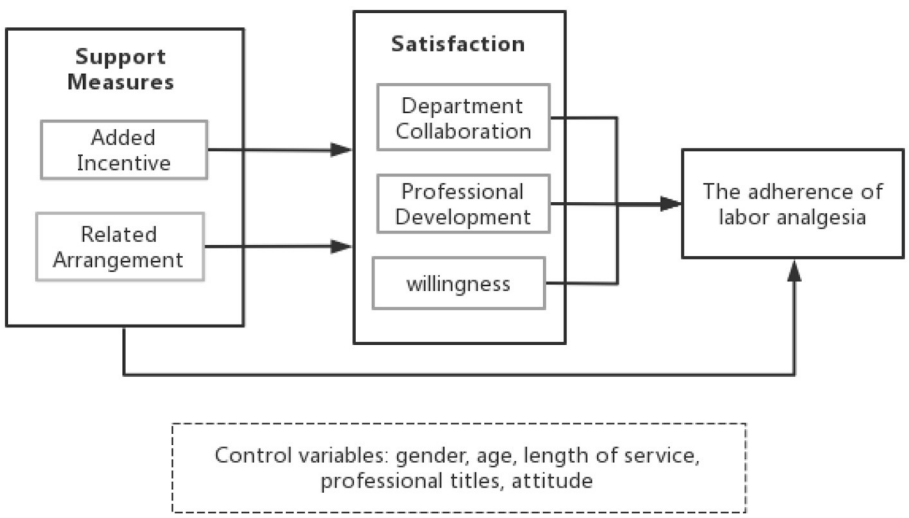

FIGURE 1 | Conceptual framework.

TABLE 1 | Dependent variables and assignments.

Variables	Assignments
Dependent variable	
Added incentives	1 = fairly unsatisfactory; 2 = unsatisfactory; 3 = general; 4 = satisfactory; 5 = fairly satisfactory
Related arrangement	Continuous variable (1–20)
Satisfaction	
Department collaboration	1 = fairly unsatisfactory; 2 = unsatisfactory; 3 = general; 4 = satisfactory; 5 = fairly satisfactory
Professional development	1 = fairly unsatisfactory; 2 = unsatisfactory; 3 = general; 4 = satisfactory; 5 = fairly satisfactory
Willingness	0 = no; 1 = yes
Personal factors	
Gender	1 = man; 2 = woman
Age	Continuous variable
Length of service	1 = 0–9 years; 2 = 10–19 years; 3 = 20–29 years; 4 = over 30 years
Professional titles	1 = primary and others; 2 = middle; 3 = vice-senior; 4 = Senior
Attitude	1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree

department, occupation, professional title, and attitude. Among them, the length of service indicated the years that the medical staff had worked in the medical institutions. Attitudes referred to the medical personnel's beliefs about whether labor analgesia is valuable.

Data Analysis

The data analysis consisted of analysis of variance, correlation analysis, mediating effect analysis, and moderating effect analysis. Analysis of variance was used to test the differences in adherence between different groups. Afterward, the Pearson correlation coefficient was used to estimate potential relations between the factors. Finally, mediating effect analysis was carried out to explore the relations between labor analgesia adherence and potential factors based on Baron's three-step method (45). The criteria for mediating effects were as follows: There was statistical significance between the independent variable and the dependent variable and between the independent and mediator variables. Then, the mediator in the regression model that included the independent variable and mediator was statistically significant (46). Similarly to the proposed methods (47), the moderating effect was tested by adding an interaction variable to the regression analysis to test both models. The first model contained potential variables and dependent variables (Model 1) and the second also included an interaction between the two variables (Model 2). And the interaction in Model 2 should be statistically significant when there are moderating effects. The data analysis was performed by SPSS 26.0. The results were regarded as significant when the p-value was <0.05.

RESULTS

Adherence to Labor Analgesia Protocols

A total of 12,614 medical personnel participated in this survey. As shown in **Figure 2**, 71.7% of the medical personnel had the highest possible scores for adherence, and medical personnel with low to medium scores (≤ 4) accounted for 11.6% of the total.

The Difference in Adherence to Labor Analgesia Protocols

As **Table 2** shows, the adherence scores were different among the subgroups with different genders, ages, lengths of service, departments, occupations, professional titles, and attitudes. Female medical staff aged over 48 years or with more than 30 years of working experience had a higher rate of adherence. In addition, midwives and obstetricians with senior professional titles and positive attitudes had better labor analgesia adherence. More details are shown in **Table 2**.

Correlation Analysis Between Labor Analgesia Adherence and Other Factors

As **Table 3** illustrates, added incentives and related arrangements were positively correlated with adherence. Correspondingly, department collaboration satisfaction, professional development satisfaction, willingness, and gender were related to adherence and support measures. In addition, a positive attitude was also observed as having a similar correlation with adherence and support measures.

Multiple Linear Regression Analysis of Labor Analgesia Adherence

The continuous variables were entered into the multiple linear regression model. The results are shown in **Table 4**. The multiple linear regression analysis showed the association of added incentives and satisfaction with adherence to labor analgesia policies. However, a correlation between the length of service and professional titles was not found in the model.

Mediating Effects of Satisfaction on Labor Analgesia Adherence

The estimates derived from the regression model were used to test the conceptual framework. As shown in **Table 5**, added incentives and related measures had a significant effect on adherence to labor analgesia protocols. Regarding the mediators, the results showed that professional development, department collaboration, and willingness had significant mediating effects on the effect of support measures on adherence to labor analgesia protocols. A significant relationship between support measures and professional development was observed. The correlation coefficient between added incentives and adherence decreased significantly from 0.121 to 0.025 after professional development entered into the regression model. A similar association was seen in analyses of related arrangements.

Similarly, department collaboration and willingness mediated the effect of support measures on adherence. The correlation coefficient between added incentives and adherence decreased from 0.121 to 0.090 when willingness was entered into the

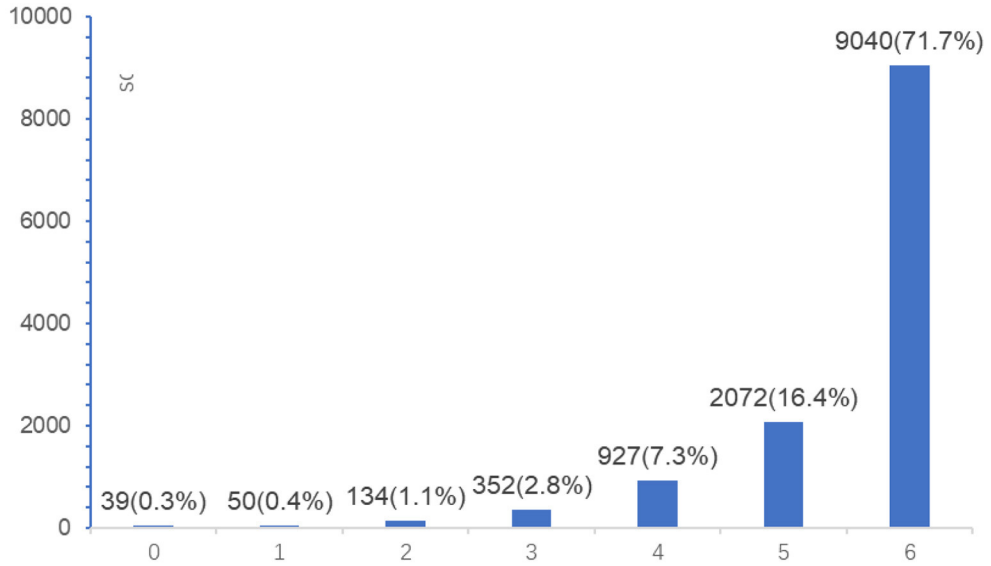

FIGURE 2 | Adherence to labor analgesia protocols among medical personnel.

regression model. In addition, age and length of service positively mediated the relationship between support measures and adherence. A partial mediating effect of professional titles on the relationship between added incentives and adherence was observed.

Moderating Effects of Satisfaction on Labor Analgesia Adherence

As shown in **Table 6**, Model 1 and Model 2 were developed to estimate the associations among added incentives, professional titles, and the interaction between added incentives and professional titles on adherence. A positive correlation between added incentives and professional titles was observed. The correlation coefficient between added incentives and adherence decreased slightly from 0.121 to 0.109 when professional titles and the interaction between added incentives and professional titles were entered into the regression model. As a result, professional titles moderated the relationship between added incentives and adherence. Likewise, department collaboration moderated the relationship between related arrangements and adherence in Model 3 and Model 4. Attitude had a similar moderating effect in Model 5.

DISCUSSION

Standardized labor analgesia has been recognized as an effective method of promoting safe delivery for pregnant women (48). This study investigated the current situation and associated factors with adherence to labor analgesia protocols by Chinese medical personnel and examined the mediating and moderating effects on satisfaction with adherence. These results are in agreement with a recent study indicating that incentives and related arrangements lead to the improvement of adherence to labor analgesia protocols (49).

The policy, organization, and workforce of labor analgesia need to be further strengthened. Evidence indicates that although the Chinese government strongly supports the development of childbirth analgesia at the national level, it is still in the early stage of implementation, and time is required for further coverage to be developed (18). Based on the medical problems above, it is suggested that the government devote adequate resources and financial support to expand coverage of labor analgesia. In this study, high-scoring medical personnel accounted for 88.1% of the total, but importantly, anesthesiologists and anesthesia nurses had a low level of adherence. A possible explanation is that there is a severe shortage of anesthesiologists (47). There are only 0.5 anesthesiologists per 10,000 people in China, which is far short of the international standard of approximately 2.5 anesthesiologists per 10,000 people (18). However, these trained anesthesiologists are functionally important for improving the level of obstetric anesthesia. The difficulty of obstetric anesthesia and the shortage of staff might contribute to the low adherence to labor analgesia protocols. Thus, medical colleges or associations are suggested to increase anesthesia specialty to expand the scope of anesthesia students and provide more staff training in anesthesiology departments.

Comprehensive incentive measures are conducive to improving satisfaction with labor analgesia in medical personnel. As mentioned above, professional development and willingness played mediating roles in the relationship between supporting measures and adherence (23, 50). This may be explained by the fact that professional development is an important way to develop professional skills and income, which are more attractive to young people with more junior professional titles (40). In addition, comprehensive incentives are likely to improve medical personnel's willingness, which is significantly associated with good knowledge and adherence to labor analgesia standards (39).

TABLE 2 | Descriptive statistics.

Variables	*N*	The scores of adherence of labor analgesia *N* (%)							*F*	*P*
		0	1	2	3	4	5	6		
Gender									11.549	<0.001
Man	1,994	10 (0.5)	13 (0.7)	35 (1.8)	81 (4.1)	203 (10.2)	340 (17.1)	1,312 (65.8)		
Woman	10,620	29 (0.3)	37 (0.3)	99 (0.9)	271 (2.6)	724 (6.8)	1,732 (16.3)	7,728 (72.8)		
Age									3.415	0.002
18–27 years old	2,202	12 (0.5)	5 (0.2)	10 (0.5)	42 (1.9)	191 (8.7)	369 (16.8)	1,573 (71.4)		
28–37 years old	6,138	20 (0.3)	30 (0.5)	72 (1.2)	191 (3.1)	452 (7.4)	1,007 (16.4)	4,366 (71.1)		
38–47 years old	2,985	6 (0.2)	8 (0.3)	42 (1.4)	74 (2.5)	201 (6.7)	511 (17.1)	2,143 (71.8)		
over 48 years old	1,289	1 (0.1)	7 (0.5)	10 (0.8)	45 (3.5)	83 (6.4)	185 (14.4)	958 (74.3)		
Length of service									3.082	0.005
0–9 years	6,247	25 (0.4)	26 (0.4)	57 (0.9)	167 (2.7)	487 (7.8)	1,080 (17.3)	4,405 (70.5)		
10–19 years	3,790	9 (0.2)	10 (0.3)	43 (1.1)	108 (2.8)	276 (7.3)	594 (15.7)	2,750 (72.6)		
20–29 years	1,889	4 (0.2)	12 (0.6)	33 (1.7)	54 (2.9)	126 (6.7)	299 (15.8)	1,361 (72.0)		
over 30 years	686	1 (0.1)	2 (0.3)	1 (0.1)	23 (3.4)	38 (5.5)	99 (14.4)	522 (76.1)		
Department									39.506	<0.001
Operating room	333	3 (0.9)	5 (1.5)	2 (0.6)	9 (2.7)	57 (17.1)	37 (11.1)	220 (66.1)		
Obstetrics (delivery room)	4,681	5 (0.1)	10 (0.2)	27 (0.6)	86 (1.8)	210 (4.5)	688 (14.7)	3,655 (78.1)		
Obstetrics (non-delivery room)	3,768	15 (0.4)	10 (0.3)	31 (0.8)	77 (2.0)	240 (6.4)	633 (16.8)	2,762 (73.3)		
Anesthesiology	3,671	16 (0.4)	25 (0.7)	71 (1.9)	175 (4.8)	395 (10.8)	682 (18.6)	2,307 (62.8)		
Others	161	0 (0)	0 (0)	3 (1.9)	5 (3.1)	25 (15.5)	32 (19.9)	96 (59.6)		
Occupation									15.397	<0.001
Anesthesiologist	3,415	10 (0.3)	22 (0.6)	63 (1.8)	162 (4.7)	347 (10.2)	631 (18.5)	2,180 (63.8)		
Anesthesia nurse	416	8 (1.9)	4 (1.0)	9 (2.2)	17 (4.1)	64 (15.4)	68 (16.3)	246 (59.1)		
Obstetrician	3,619	6 (0.2)	8 (0.2)	19 (0.5)	52 (1.4)	176 (4.9)	613 (16.9)	2,745 (75.8)		
Midwife	3,740	1 (0.0)	8 (0.2)	25 (0.7)	73 (2.0)	156 (4.2)	515 (13.8)	2,962 (79.2)		
Obstetric nurse	1,093	12 (1.1)	3 (0.3)	15 (1.4)	35 (3.2)	106 (9.7)	190 (17.4)	732 (67.0)		
Others	331	2 (0.6)	5 (1.5)	3 (0.9)	13 (3.9)	78 (23.6)	55 (16.6)	175 (52.9)		
Professional titles									2.428	0.024
Primary and others	5,962	27 (0.5)	21 (0.4)	46 (0.8)	138 (2.3)	465 (7.8)	1,000 (16.8)	4,265 (71.5)		
Middle	4,290	9 (0.2)	22 (0.5)	63 (1.5)	150 (3.5)	297 (6.9)	681 (15.9)	3,068 (71.5)		
Vice-senior	1,775	2 (0.1)	6 (0.3)	20 (1.1)	47 (2.6)	128 (7.2)	288 (16.2)	1,284 (72.3)		
Senior	587	1 (0.2)	1 (0.2)	5 (0.9)	17 (2.9)	37 (6.3)	103 (17.5)	423 (72.1)		
Attitude									184.123	<0.001
Strongly disagree	17	0 (0)	1 (5.9)	1 (5.9)	3 (17.6)	1 (5.9)	3 (17.6)	8 (47.6)		
Disagree	18	0 (0)	1 (5.6)	1 (5.6)	3 (16.7)	3 (16.7)	2 (11.1)	8 (44.4)		
Neutral	342	5 (1.5)	11 (3.2)	17 (5.0)	32 (9.4)	45 (13.2)	77 (22.5)	155 (45.3)		
Agree	2,414	8 (0.3)	16 (0.7)	38 (1.6)	104 (4.3)	268 (11.1)	504 (20.9)	1,476 (61.1)		
Strongly agree	9,823	26 (0.3)	21 (0.2)	77 (0.8)	210 (2.1)	610 (6.2)	1,486 (15.1)	7,393 (75.3)		

Comprehensive incentives leading to a sustained improvement in adherence in terms of labor analgesia are expected. These findings suggest that medical institutions should adopt individual incentive measures to improve medical personnel's enthusiasm for the use of labor analgesia in addition to the national-level promotion plan. These insights can help to contribute to the ongoing policy and incentives toward improving adherence to labor analgesia policies, thus addressing pregnant women's needs in the future.

To improve adherence to labor analgesia protocols, capacity-building programmes for medical institutions are recommended to enhance department collaboration and change medical personnel's attitudes. The level of departmental collaboration is an essential way to strengthen doctors' medical skills, which

TABLE 3 | Correlations of variables.

Variables	1	2	3	4	5	6	7	8	9	10	11
1 adherence	-										
2 Added incentives	0.164**	-									
3 Related arrangement	0.289**	0.564**	-								
4 Department collaboration	0.313**	0.445**	0.690**	-							
5 Professional development	0.343**	0.549**	0.706**	0.738**	-						
6 Willingness	0.273**	0.167**	0.260**	0.280**	0.313**	-					
7 Gender	0.071**	0.038**	0.151**	0.103**	0.101**	0.085**	-				
8 Age	0.010	−0.052**	−0.087**	−0.081**	−0.092**	−0.007	−0.119**	-			
9 Length of service	0.018*	−0.025**	−0.050**	−0.047**	−0.062**	0.004	−0.064**	0.833**	-		
10 Professional titles	0.004	−0.038**	−0.103**	−0.086**	−0.091**	−0.013	−0.126**	0.738**	0.730**	-	
11 Attitude	−0.181**	−0.248**	−0.401**	−0.445**	−0.546**	−0.210**	−0.010	0.006	0.009	−0.021*	-

*$p < 0.05$; **$p < 0.01$.

TABLE 4 | Multiple linear regression analysis.

	Unstandardized coefficients		Standardized coefficients	T	β^1 (95%CI)
	β^1	S.E.	β^2		
Constant	2.792***	0.094		29.556	2.607 to 2.977
Supporting measures					
Added incentives	0.039***	0.008	0.053	5.141	0.024 to 0.054
Related arrangement	0.018***	0.004	0.061	4.715	0.011 to 0.026
Satisfaction					
Department collaboration	0.103***	0.015	0.087	6.724	0.073 to 0.133
Professional development	0.069***	0.005	0.203	15.202	0.060 to 0.077
Willingness	0.716***	0.037	0.168	19.390	0.644 to 0.788
Confounding factors					
Age	0.007***	0.002	0.067	3.082	0.003 to 0.012
Length of service	−0.039***	0.020	−0.038	−1.942	−0.079 to 0.001
Professional titles	0.026***	0.014	0.024	1.802	−0.002 to 0.055
Department	−0.071***	0.009	−0.069	−7.951	−0.088 to 0.053

***$P < 0.001$.

suggests the significance of cooperation between medical teams for treatment (43, 51). In addition, medical personnel's attitudes toward labor analgesia deserve more attention. It was found that the attitude of professionals is significantly related to labor analgesia. Some medical personnel believe that labor analgesia affects pregnant women's health and thus reduces their use of labor analgesia (39). Increasing the risk of illness and delaying delivery are common reasons why medical personnel are unwilling to provide labor analgesia (52). However, the National Association of Obstetricians and Gynecologists (ACOG) passed a series of clinical trials and proved that labor analgesia is unrelated to the incremental maternal prevalence (53, 54). This misunderstanding may be the cause of low adherence (55). Therefore, strengthening training for the target group and enhancing interdepartmental cooperation are suggested for improving low adherence among certain groups, such as anesthesiologists and anesthesia nurses. Meanwhile, labor analgesia in China is currently concentrated mainly in specialty hospitals. It is recommended that general hospitals improve their ability to provide labor analgesia services by preparing specific internal protocols and arranging adequate training for the involved personnel.

LIMITATION

Some limitations of this study need to be mentioned. First, this study used a cross-sectional survey. It therefore could not determine the long-term status of the adherence to labor analgesia protocols in Chinese medical personnel. A cross-sectional study has limited ability to infer causality and the potential for reverse causation. In addition, retrospective self-assessment may lead to bias, and medical personnel may miss some specific details during the investigation process. In addition, this survey was conducted through a web-based questionnaire, and the quality of the investigation process was difficult to control.

TABLE 5 | Results of mediating effects.

IV	M	DV	IV-DV	IV-M	(IV+M)-DV	
					IV	M
			β [95%CI]			
AI	Professional development	Adherence	0.121*** [0.109 to 0.134]	1.232*** [1.199 to 1.265]	0.025*** [0.004 to 0.047]	0.119*** [0.112 to 0.125]
AI	Willingness	Adherence	0.121*** [0.109 to 0.134]	0.029*** [0.026 to 0.032]	0.090*** [0.078 to 0.102]	1.077*** [1.005 to 1.149]
AI	Department collaboration	Adherence	0.121*** [0.109 to 0.134]	0.277*** [0.268 to 0.287]	0.023*** [0.009 to 0.037]	0.353*** [0.332 to 0.375]
AI	Age	Adherence	0.121*** [0.109 to 0.134]	−0.036*** [−0.047 to 0.024]	0.122*** [0.109 to 0.134]	0.020* [0.001 to 0.038]
AI	Length of service	Adherence	0.121*** [0.109 to 0.134]	−0.018** [−0.031 to 0.006]	0.121*** [0.109 to 0.134]	0.023* [0.005 to 0.040]
AI	Professional titles	Adherence	0.121*** [0.109 to 0.134]	−0.026*** [−0.038 to 0.014]	0.121*** [0.109 to 0.134]	0.011 [−0.008 to 0.029]
AI	Attitude	Adherence	0.121*** [0.109 to 0.134]	0.102*** [0.095 to 0.109]	0.094*** [0.081 to 0.107]	0.268*** [0.237 to 0.300]
RA	Professional development	Adherence	0.086*** [0.071 to 0.114]	0.640*** [0.629 to 0.651]	0.027*** [0.021 to 0.034]	0.091*** [0.084 to 0.099]
RA	Willingness	Adherence	0.086*** [0.071 to 0.114]	0.018*** [0.017 to 0.019]	0.069*** [0.064 to 0.074]	0.905*** [0.833 to 0.977]
RA	Department collaboration	Adherence	0.086*** [0.071 to 0.114]	0.173*** [0.170 to 0.177]	0.041*** [0.034 to 0.048]	0.257*** [0.230 to 0.284]
RA	Age	Adherence	0.086*** [0.071 to 0.114]	−0.024* [−0.029 to 0.019]	0.087*** [0.082 to 0.092]	0.038*** [0.020 to 0.056]
RA	Length of service	Adherence	0.086*** [0.071 to 0.114]	−0.014** [−0.019 to 0.009]	0.088*** [0.081 to 0.091]	0.033*** [0.016 to 0.050]
RA	Professional titles	Adherence	0.086*** [0.071 to 0.114]	−0.028** [−0.033 to 0.024]	0.087*** [0.082 to 0.092]	0.036*** [0.018 to 0.054]

β, *unstandardized coefficient; IV, independent variable; M, mediator; DV, dependent variable; AI, added incentive; RA, related arrangement. *P < 0.05; **P < 0.01; ***P < 0.001.*

TABLE 6 | Results of moderating effects.

Variable	M1	M2	M3	M4	M5	M6
	β [95%CI]					
Added incentive	0.121*** [0.109 to 0.134]	0.109*** [0.008 to 0.139]				
Related arrangement			0.041*** [0.034 to 0.048]	0.120*** [0.097 to 0.143]	0.086*** [0.071 to 0.114]	0.172*** [0.129 to 0.216]
Professional titles	0.011 [0.008 to 0.029]	0.007 [0.005 to 0.013]				
Department collaboration			0.257 [0.230 to 0.284]	0.540*** [0.456 to 0.623]		
Attitude					0.140*** [0.107 to 0.172]	0.421*** [0.291 to 0.550]
Interaction						
Added incentive*professional titles		−0.015** [−0.074 to 0.044]				
Related arrangement*department collaboration				0.019*** [0.013 to 0.024]		
Related arrangement*attitude						0.020*** [0.011 to 0.029]

β, *unstandardized coefficient. *P < 0.05; **P < 0.01; ***P < 0.001.*

CONCLUSION

This study aimed to investigate the current situation and associated factors with the adherence to labor analgesia protocols by Chinese medical personnel. The results show that willingness had direct and indirect beneficial effects on adherence to labor analgesia protocols. Satisfaction played an important role in the improvement of labor analgesia. The government should continue to reinforce the promotion of labor analgesia to continue to improve the proportion of financial support. More training opportunities should be provided for more anesthesiologists and anesthesia nurses to enhance knowledge about labor analgesia knowledge. More capacity-building programmes should be launched to improve interdepartmental collaboration. An effective incentive mechanism needs to be designed to attract more medical staff, especially skilled personnel, to participate in labor analgesia work.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

DL: analyzed the data and wrote the original draft preparation. CLo, SL, YX, FC, RZ, and ST: gave the critical feedback. All authors: conceptualization and data collection. All authors contributed to the article and approved the submitted version.

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Analysis of Spatio-Temporal Characteristics of Urban Economic Resilience and Influencing Factors in Guangdong-Hong Kong-Macao Greater Bay Area

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Due to the changes in the domestic and international economic situation in the post-pandemic era, the economic development of the Guangdong-Hong Kong-Macao Greater Bay Area has become unstable in many aspects. The paper adopted the Pressure-State-Response (PSR) model to build a regional economic resilience evaluation system from the perspective of public health emergencies. Then, the spatial and temporal evolution of the economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area and the influencing factors were explored by using entropy weight method, GIS and gray correlation method. The conclusions show that: (1) Temporally, the economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area has generally increased from 2010 to 2021, and is divided into three main stages: rapid development, adjustment to fluctuations and stable development. (2) Spatially, the overall pattern of economic resilience in the Guangdong-Hong Kong-Macao Greater Bay Area is high in the middle and south and low in the northwest, and shows a "stochastic—equalized—polarized" pattern of transformation. (3) In terms of influencing factors, economic status and economic response are the main dimensions affecting the resilience level of the economic system in the Guangdong-Hong Kong-Macao region. The level of scientific research and innovation, medical governance, government regulation and the rationalization of the industrial system are the key factors.

Keywords: economic resilience, public health emergencies, PSR model, Guangdong-Hong Kong-Macao Greater Bay Area, spatial and temporal evolution

INTRODUCTION

The COVID-19 epidemic swept the world in 2020, which caused a number of problems including disruption of international trade, price fluctuations, increased unemployment, and increased pressure on government spending on health care, thereby impacting the economic stability of countries. The intensification of globalization has made the world economy a mutually integrated

organic whole, but at the same time, the economic development of cities and regions is inevitably influenced by the external environment. With the increasingly frequent flow of products, resources, and human resources between countries, the threat of global epidemics will be a problem that cities and regions must deal with in their economic development, and economic resilience has also become a strategic issue that countries must pay attention to in their economic development (1). Economic resilience is the ability of an economic system to recover from shocks and disruptions (2), focusing on the ability of the region to resume production, escape from the economic downturn crisis and recover successfully after suffering from external shocks. Located at the frontier of the coastal opening area in China, the Guangdong-Hong Kong-Macao Greater Bay Area is one of the most active and open areas in China for foreign trade, as well as a strategic place for China to enhance the innovation and competitiveness of the national economy. The cultivation of its economic resilience is of great significance for the healthy and stable development of China's regional economy. In addition, because of the high openness of the Guangdong-Hong Kong-Macao Greater Bay Area, it is more vulnerable to the influence of the external environment than other regions, and the study of its economic resilience also provides a valuable reference for other cities and regions. In this paper, urban economic resilience in the Guangdong-Hong Kong-Macao Greater Bay Area is studied from the perspective of public health emergencies, and the evaluation system of urban economic resilience is improved and the related influencing factors are examined.

Numerous studies have shown that population health and infectious diseases are strongly associated with regional economic growth. In earlier years, Bloom et al. (3) found a significant positive effect of population health on macroeconomic growth by studying the micro effects of health on wage levels; the outbreak of international public health emergencies can have a significant impact on the global economy, leading to significant declines in urban industrial output and GDP (4), declines in the real estate sector, market price fluctuations (5) and global economic contraction (6). Especially in the case of outbreaks of infectious diseases such as SARS and the COVID-19 epidemic, "lockdown" and "quarantines" are required for cities. Deb et al. (7) found that these measures would result in a loss of 15% of the monthly average industrial output by looking at daily economic data. At the same time, many scholars have conducted a series of studies on how to deal with and reduce the economic impact of such public health emergencies. In particular, after the outbreak of the COVID-19 epidemic, scholars in many countries have actively explored ways to reduce the impact of the epidemic on urban economies from the perspectives of government public investment decisions (4), policy orientation (8) and medical resource availability (9). Chinese scholars such as Li (10), Liu and Li (11), and Qin and Liu (12) have used resilience theory to analyze the resilience of economic systems in cities and regions from the perspectives of regional economic linkages, industrial structures and knowledge innovation capacity (13). The COVID-19 epidemic has enabled scholars to ponder over economic resilience in a more comprehensive way.

Regional economic resilience refers to a region's economic resilience to resist market competition or environmental shocks and recover its growth path (14), which is mainly composed of four processes: vulnerability, resistance, stability, and resilience (15). Economic resilience can better explain the process of self-regulation and change of economic systems under external conditions. However, due to the inherent complexity and geographical variability of economic systems, there is no unified system of indicators to assess them. At present, the research on regional economic resilience mainly includes two aspects: influencing factors and resilience evaluation. Studies on the influencing factors range from the impact of national environment (16), policies and institutions (17), regional linkages (18), industrial structure and multiculturalism (19) on resilience. Most scholars have evaluated the structure of the regional economic system and its vulnerability and resilience to the crisis, the degree of recovery from the recession, and the redevelopment and renewal capacity of the economic system after the shock (20), with the resilience and recovery capacity being the most emphasized research points (21). Therefore, regional economic resilience measurement methods can be broadly divided into two categories: one is to measure a core variable as a reflection of economic resilience. Zhu (22) analyzed China's economic resilience and dynamism through Purchasing Managers' Index (PMI), and concluded that the key to economic development is to drive domestic demand with investment and consumption, to pull back the economic function with the service industry, to drive exports with the policy of stabilizing foreign trade and foreign capital, and to promote the transformation and upgrading of the manufacturing industry with new dynamic energy. The other is to establish a system of comprehensive indexes for assessment. Hu Xiaohui and other Chinese scholars believe that regional economic resilience should contain three characteristics: complex adaptability, non-equilibrium and dynamic evolution. They also deduced four connotations from the characteristics, including resilience, recovery capacity, reorganization capacity and renewal capacity (23). Cai Jianming (24) sorted out the conceptual differences in ecological resilience, engineering resilience, economic resilience and social resilience. Xu Yuanyuan concluded that uncorrelated diversity and innovation are the core of a region's economic resilience level by building a regression analysis model. Meanwhile, she chose the spatio-temporal bifixed Durbin model and concluded that science and technology, transportation development, and fixed asset investment have strong direct effects on regional economic resilience (25). Shao and Zhu (26) found that regions and cities with high level of development and strong professional production capacity suffered more drastic economic shocks from the epidemic, but these places could display stronger resilience with close regional connectivity and information technology.

In summary, the current analysis of economic resilience is mainly carried out from two aspects, namely, capital market and regional industrial structure, to explain and analyze the laws and influencing factors of economic resilience, but there are still some shortcomings in research perspectives and research methods. Although the current evaluation system of economic

resilience theory is richly constructed, most of the studies focus on the impact of natural disasters or financial crises on the region, and the analysis of the close correlation between public health emergencies and the economy is not enough. At the same time, the dynamic pattern and influencing factors of economic resilience can be further analyzed. Therefore, this paper adopts the Pressure-State-Response (PSR) model to build a regional economic resilience evaluation system. Moreover, the entropy power method, GIS and gray correlation method are combined to explore the spatial and temporal evolution and influencing factors of the economic resilience of Guangdong-Hong Kong-Macao Greater Bay Area, so as to provide suggestions for the economic transformation and upgrading of the Guangdong-Hong Kong-Macao Greater Bay Area under the post-pandemic era.

RESEARCH METHODOLOGY AND DATA SOURCES

Theoretical Framework

The PSR model was originally proposed by Canadian statisticians David and Tony to address ecological and environmental issues (27). It reveals a direct chain of interactions between the influencing factors, the system, and human activities, and emphasizes the intrinsic mechanism of frequent material and energy cycles between the system and human activities (28). Economic resilience is the ability of a system to adapt, resist, recover and develop in response to external disturbances. In the system, it first experiences risky shocks, then keeps itself stable after the shocks, and finally transforms the crisis into an opportunity to achieve the innovative development. Therefore, strong economic resilience can be seen as a spiral upward process in which economic systems continuously adapt to risks and recover and strengthen themselves. The resilience of the regional economic system from the perspective of public health also has such process property, which means that the region will experience the dynamic process of "stabilization, shock and re-stabilization" after the outbreak and disturbance of public health emergencies and under the stimulus input.

At present, most of the processes of economic resilience evaluation still decompose the regional system into parallel vertical subsystems such as industrial structure, technology level and economic scale, but the positive and negative feedback processes between the front-end and the regional subject are still less emphasized. If the PSR model is used, it is possible to describe more accurately the process properties of the economic resilience of the system by using the logical thinking of mutual regulation of the region from the subject system and the stress risk input to the system and the three-way feedback of the system's own state changes.

Therefore, based on the above understanding, the economic system process can be divided into three stages: riskiness before the shock, stability and resistance during the shock, and resilience and evolutionary power after the shock, which correspond to the three process elements of "pressure-state-response" in the PSR model, respectively. In this study, three dimensions of

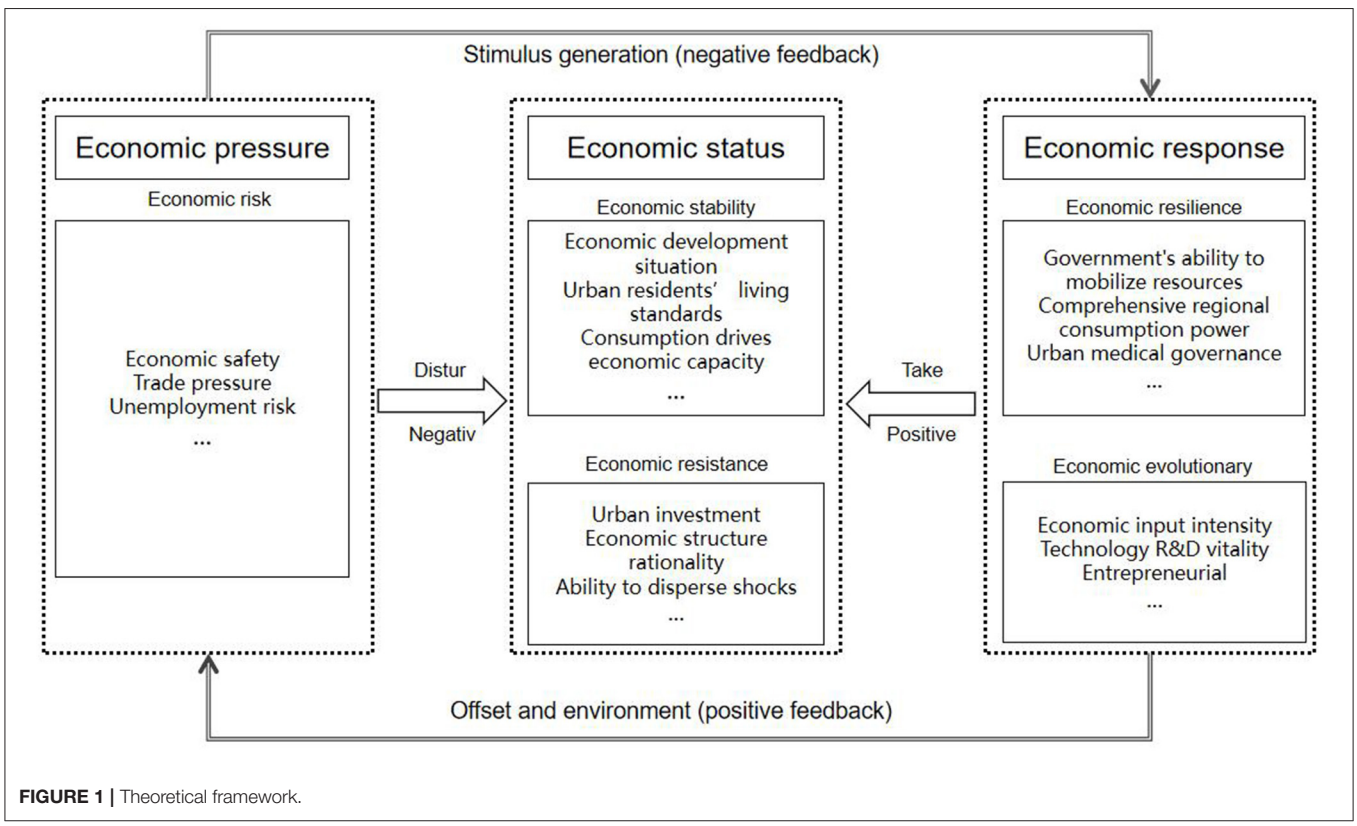

FIGURE 1 | Theoretical framework.

the resilience process are proposed for the regional economic system to cope with the disturbance, namely, economic pressure, economic status, and economic response as shown in **Figure 1**.

Economic pressure refers to the pressure on the system during the outbreak of public health emergencies and its aftermath, and is characterized by its own potential riskiness. It can be interpreted as the low exposure of the system to the risk of public health emergencies and its negative effects, reflecting the external disturbances and endogenous perturbation dynamics of the regional economic system. Economic vulnerability can be used as a measure of the relative loss value of the regional economy, usually manifested as employment decline, trade pressure, and financial risk, that is, risk vulnerability (29).

Economic status refers to the stability of the system's own structure and its resistance to disturbances, while it is constantly changing in the process of negative effect of "pressure" and positive feedback of "response." Economic status consists of economic stability and economic resistance. Economic stability can spontaneously maintain the ability of its own structural system to function as an internal stabilizer; economic resistance refers to the ability of the regional economic system to withstand shocks. It usually operates in the form of consumption level, economic base, industrial structure and capital input.

Economic response refers to the ability of the subjects of the urban economic system to respond and take actions in response to disturbances, reflecting the ability of the subjects of the regional economic system to deal with risks, learn from shocks and disturbances and optimize their own organizational structure. Economic recovery capacity means that the speed and extent of recovery from shocks can be achieved through rapid and diversified response measures. Economic evolutionary power is the ability to renew and reorganize internal structures and functions, generating new development models and paths for the purpose of strengthening the development of economic agents.

Assessment System

For the connotation of economic resilience, Martin proposed four dimensions of regional economic vulnerability, resistance, stability, and resilience to break down the operation process of economic resilience. Zeng (30) also constructed a comprehensive index system of regional economic resilience from three different dimensions of evolutionary power, resistance and resilience. Zhang (31) analyzed the four aspects of regional economic stability, regional economic diversity, regional economic innovation capacity, and regional economic vitality. Based on this, an index system of economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area is constructed from three dimensions of economic pressure, economic status and economic response, as shown in **Table 1**.

Entropy Method

In order to eliminate the influence caused by data units and subjective determination of index weights, this paper adopts the extreme value entropy method to dimensionlessly process and assign weights to the selected indexes. The greater the index dispersion, the greater the entropy value, and the greater the effective information reflected. It means that the greater the influence on the evaluation, the more significant the weight is. On the contrary, the smaller the index dispersion, the smaller the influence and the smaller the weight (32, 33). The specific formula is shown as follows:

(1) Building the original matrix

Build the matrix of n (year/city) * m (index). Let the value of the jth index for the ith year (city) be X_{ij}.

(2) Standardizing the data

Assuming that the evaluation index X_j is a positive index or negative index, the following can be derived:

$$\begin{aligned} &\textit{Positive index}: \ X_{ij}{}^{*} = \frac{Xij - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \\ &\textit{Negative index}: \ X_{ij}{}^{*} = \frac{\max\{X_j\} - Xij}{\max\{X_j\} - \min\{X_j\}} \end{aligned} \tag{1}$$

If the evaluation index X_j is a suitability index, the following can be derived:

$$\begin{aligned} X_{ij}{}^{*} &= 2\frac{\max\{X_j\} - Xij}{\max\{X_j\} - \min\{X_j\}} (\overline{X_j} - Xij < \max\{X_j\}) \\ X_{ij}{}^{*} &= 0(Xij \geq \max\{X_j\} \, Xij \leq \min\{X_j\}) \\ X_{ij}{}^{*} &= 2\frac{Xij - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} (\min\{X_j\} < Xij < \overline{X_j}) \end{aligned} \tag{2}$$

(3) Calculate the ratio $P_{ij}$of the ith city/year to the jth index

$$P_{ij} = \frac{X_{ij}{}^{*}}{\sum_{i=1}^{n} X_{ij}{}^{*}} \tag{3}$$

(4) Calculate the entropy value e_j of the jth index

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n \sum_{ij} e_j} P_{ij} \ln \tag{4}$$

(5) Calculate the co-efficient of variation d_j of the jth index

$$d_j = 1 - e_j \tag{5}$$

(6) Calculate the weight w_j of the jth index

$$w_j = \frac{d_i}{\sum_{j=1}^{m} d_i} (j = 1, 2, ..., m) \tag{6}$$

Gray Correlation Analysis

Based on the data samples, the gray correlation analysis uses the geometric similarity between the parent sequence and the signature sequence to identify the closeness of the association, and obtains the gray correlation between the parent sequence and each signature sequence. The greater the correlation, the closer the relationship between the signature sequence and the parent sequence, and vice versa. The formula is as follows:

$$\zeta i(j) = \frac{\overset{\min\min}{i \ \ j} \left|Q_i - x'_i(j)\right| + \rho^* \overset{\max\max}{i \ \ j} \left|Q_i - x'_i(j)\right|}{\left|Q_i - x'_i(j)\right| + \rho^* \overset{\max\max}{i \ \ j} \left|Q_i - x'_i(j)\right|}, (i = 1, 2, ..., n) \tag{7}$$

TABLE 1 | Table of regional economic resilience indexes.

System level	Criterion level	Index level	Index definitions	Nature	Index calculation	Weight
Economic pressure	Economic risk	X_1 foreign trade dependence (%)	Urban trade pressure	–	Total import and export trade/GDP	0.0539
		X_2 urban registered unemployment rate (%)	Urban unemployment risk	–	Number of unemployed persons/(number of employed persons + number of unemployed persons)	0.0310
		X_3 loan-to-deposit ratio (%)	Economic security	*	Ending balance of various loans/Ending balance of various deposits	0.0792
Economic status	Economic stability	X_4 ratio of total retail sales of consumer goods to GDP (%)	The ability of consumption to drive economic growth	+	Total retail sales of social consumer goods/GDP	0.0468
		X_5 urban per capita disposable income(yuan)	Living standard of urban residents	+	Total urban income/resident population	0.0418
		X_6 local GDP (in 10,000 yuan)	Economic development status	+	Yearbook statistics	0.0550
	Economic resistance	X_7 ratio of tertiary industry output to GDP (%)	Reasonable degree of economic structure	+	Tertiary industry output/GDP	0.0700
		X_8 ratio of fixed asset investment to GDP (%)	The level of urban investment	+	Fixed asset investment/GDP	0.0628
		X_9 industrial value added (in 100,000,000 yuan)	Industrial situation	+	Yearbook statistics	0.0620
		X_{10} diversification of industrial structure	Ability of the city to disperse economic shocks	+	Diversification index (DIV)	0.0702
Economic response	Economic recovery capacity	X_{11} general public budget revenue (in 10,000 yuan)	Government's ability to mobilize resources	+	Yearbook statistics	0.0494
		X_{12} ratio of health expenditure to fiscal expenditure	Scale of government funding for epidemic prevention	+	Health spending/financial spending	0.0455
		X_{13} number of hospitals	Urban medical governance capacity	+		0.0496
		X_{14} number of public health personnel per 10,000 people		+	(Number of health workers/resident population) *10000	0.0384
		X_{15} number of hospital beds per 10,000 people		+	(Number of beds/resident population) *10000	0.0469
	Economic evolutionary power	X_{16} number of patent applications per 10,000 people (in piece)	Technology R&D vitality	+	Patent Statistics	0.0645
		X_{17} ratio of R&D expenditure to total GDP (%)	Economic investment intensity	+	R&D expenditure/GDP	0.0464
		X_{18} number of patents granted per 10,000 employed population (in piece)	Entrepreneurial innovation spirit	+	Number of patents granted / Total number of employed persons	0.0866

*+ is a positive index, − is a negative index, and * is a moderate index.*

where, $\zeta_i(j)$ denotes the gray correlation co-efficient, Q_i denotes the parent sequence, $x_i'(j)$ denotes the signature sequence, ρ denotes the identification co-efficient, with ρ being 0.5. The correlation co-efficient is the correlation value between the signature sequence and the parent sequence at each moment. Due to the multi-valued nature of the correlation co-efficient, it is difficult to make an overall comparison, so the average value of the correlation co-efficients at all moments is used as the value

FIGURE 2 | Overview of the study area. Source: A standard map of the standard map service system of the Ministry of Natural Resources [Review No.: No. GS(2019)4342].

of the correlation between the comparison sequence and the reference sequence. The calculation formula is as follows:

$$r_j = \frac{1}{n}^{*} W_j^{*} \sum_{i=1}^{n} \zeta_i(j), i = 1, 2, ..., n; j = 1, 2, ..., m \qquad (8)$$

where, n denotes the number, W_j denotes the weight. The greater the value of the correlation co-efficient r_j, the higher the impact of the index on the comprehensive resilience level.

Data Source

Located in the south of China, the Guangdong-Hong Kong-Macao Greater Bay Area now covers Guangzhou, Shenzhen, Foshan, Dongguan, Zhuhai, Huizhou, Zhongshan, Jiangmen, Zhaoqing, as well as Hong Kong and Macau as shown in **Figure 2**. The Greater Bay Area is densely populated with an export-oriented economy. Moreover, it has developed comparative and comprehensive advantages in technology, finance, foreign trade, transportation and tourism, and is one of the two major economic engines of China.

The time span of this study is 2010–2019, and the data sources include the fourth national economic census, statistical yearbooks of each region, statistical yearbooks of the Pearl River Delta city cluster, statistical yearbooks of cities in China and national economic statistical bulletins. Since the statistical standards vary from city to city, the number of registered unemployed in Hong Kong and Macau in this study is the unemployed population, the total retail sales of social consumer goods in Hong Kong is the total value of retail sales, and the total retail sales of social consumer goods in Macau is the total sales of retail trade. The total volume of imports and exports in Hong Kong and Macao is the total volume of trade; at the same time, all of them are converted into RMB at the current exchange rate of the year.

TEMPORAL AND SPATIAL EVOLUTION CHARACTERISTICS OF THE GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

Temporal Evolution: Increasing Overall Volatility, With Distinct Characteristics in Phases

The economic data of the Greater Bay Area from 2010 to 2021 are used to construct a matrix of year* index, and the results are shown in **Figure 3**. The economic resilience level of the Greater Bay Area has generally improved, except for a small decline in the regional economic resilience in 2020. It is divided into three main phases by the development trajectory:

First, the period from 2010 to 2013 represents the period of rapid development of the Greater Bay Area. During this period, the Greater Bay Area advocated a model of rapid economic construction, thus maintaining a high rate of economic resilience development, with economic pressure, economic status and economic response all making improvements to varying degrees. After the 2009 H1N1 and 2008 financial crisis, economic pressure, economic status and economic response maintained a dynamic equilibrium relationship that promotes each other. At this time, the economic pressure risk is high, the economic status foundation is weak, and the economic response capability is insufficient. If one of them fails, the whole system will be affected. Therefore, they are developing more in a relatively "conservative" way. In terms of a single index, fixed asset investment and the deposit-to-loan ratio have a short-lived mini-peak, which caters to the massive tides of economic development in the early stages and a huge amount of capital is needed to promote the economic vitality of the Greater Bay Area.

Second, the period from 2013 to 2017 represents the period of fluctuations and adjustment of economic resilience. It is the transition period of industrialization in the Greater

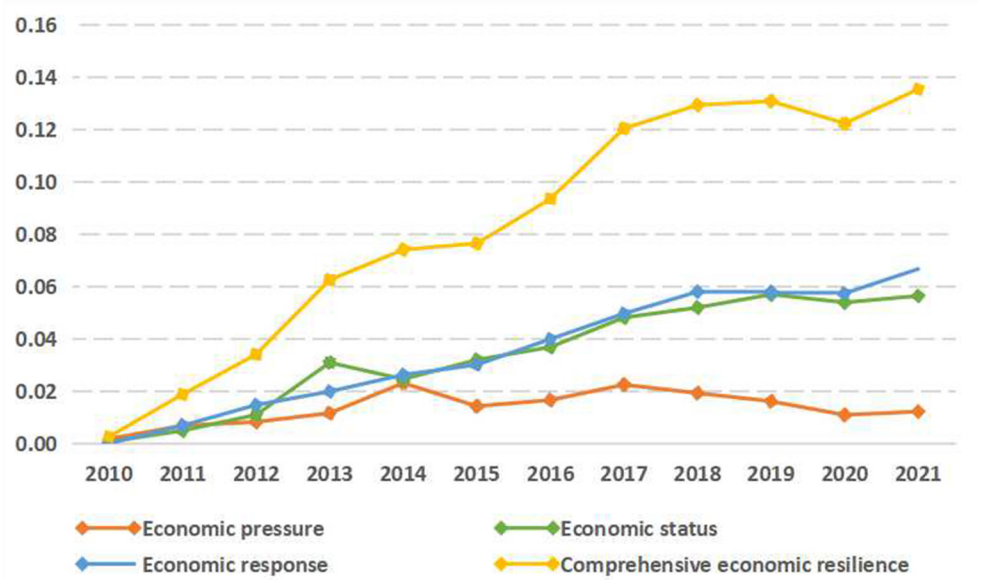

FIGURE 3 | Temporal evolution of the overall economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area.

Bay Area, where economic pressure and economic status underwent rapid changes and adjustments, and then the three converged in 2014, and then became differentiated. Economic pressure, economic status, and economic response became distant from each other, and the economic system of the Greater Bay Area regulated itself mainly in the form of status-response. From a single index, the value added of tertiary industry witnessed explosive growth, the economic structure of the Greater Bay Area was upgraded, entrepreneurship and scientific research vitality emerged in the budding stage of development, and the industrial structure tended to be diversified and intelligent.

Third, the period from 2017 to 2021 represents the period of stable development of economic resilience. At this point, the industrial transformation of the Greater Bay Area matured, from the original high-speed development mode to high-quality development mode, and the industrial structure was gradually adjusted from labor-intensive to knowledge-intensive industries. Economic pressure gradually decreased, while economic status and economic response slowly increased, and the distance between the three gradually expanded, with the economic system in a high-exposure development model. The fall in economic pressure means that the economic system is more likely to face high-risk shocks. However, the economic system is less likely to collapse even after a public health emergency by continuously strengthening the substrate of economic status, increasing the threshold of economic resilience against the maximum risk intensity, and establishing an economic response at the same time. Furthermore, the rapid response and regulation allows the economic system to return to its original stage of development, as exemplified by the COVID-19 epidemic in 2020. The economic resilience of the Greater Bay Area declined briefly when the crisis occurred, but soon rebounded and continued to grow. In terms of a single index, the rapid rise in entrepreneurial innovation and R&D vitality signifies the beginning of a massive renewal of the industrial structure based on technological innovation. The spike in the loan-to-deposit ratio could easily cause a payment crisis in banks, which would spread further to lead to a financial crisis.

A matrix of year* index is constructed from the economic data of 11 cities in the Greater Bay Area of Guangdong-Hong Kong-Macao, and the results are shown in **Figure 4**. The economic resilience of each city in the Greater Bay Area has been improved in general. The average value of the growth rate of the 11 cities is used as the threshold value, and they are classified into two categories: rapid development and slow development:

First, the cities with rapid development include Zhuhai, Foshan, Huizhou, Zhongshan, and Shenzhen. Among them, Zhuhai has the fastest growth in economic resilience in the past 12 years, with an average growth rate of 30.61% as shown in **Figure 5**. Most of the cities in this category are dominated by high-tech manufacturing and other emerging industries, such as Zhuhai (biomedical), Shenzhen (Internet), Foshan (advanced manufacturing), Huizhou, and Zhongshan (electronics);

Second, the cities with slow development include Zhaoqing, Jiangmen, Dongguan, Guangzhou, Macau, and Hong Kong. Among them, Hong Kong is the slowest in building economic resilience, with a rate of 10.95% as shown in **Figure 5**. Most of the cities in this category are highly involved in global economic networks, such as Hong Kong (transit trade and finance), Macau (gaming and finance), Dongguan and Guangzhou (export trade).

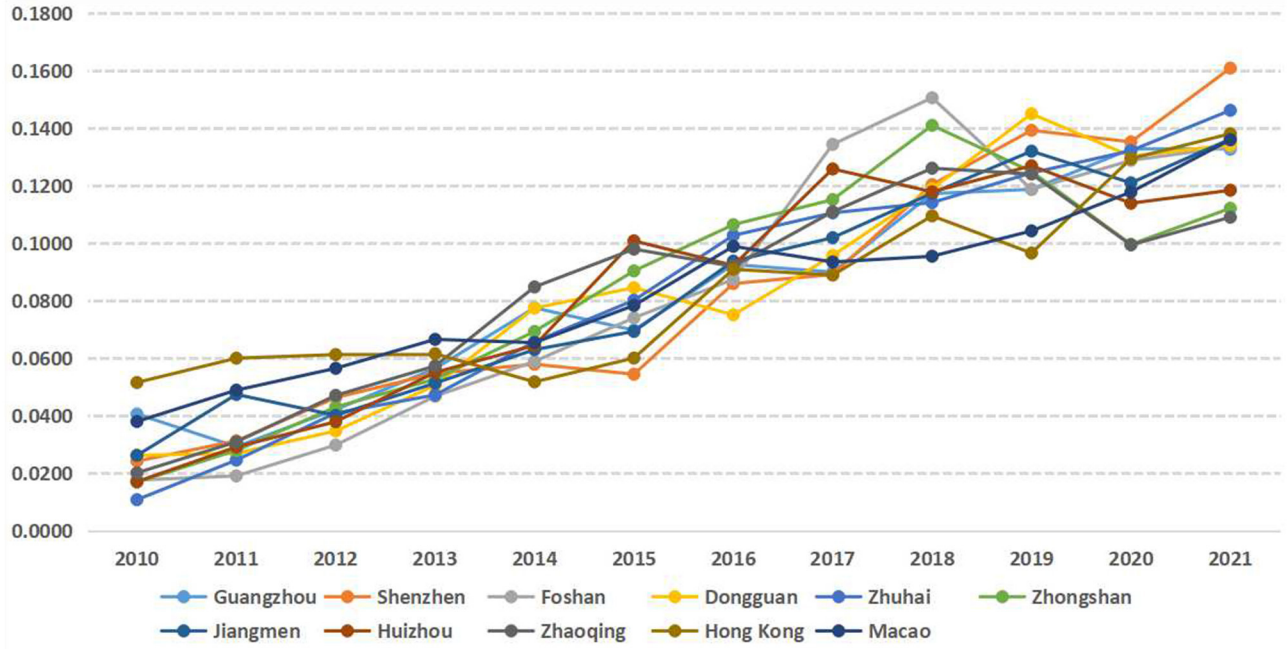

FIGURE 4 | Sequence diagram of economic resilience of cities in the Guangdong-Hong Kong-Macao Greater Bay Area.

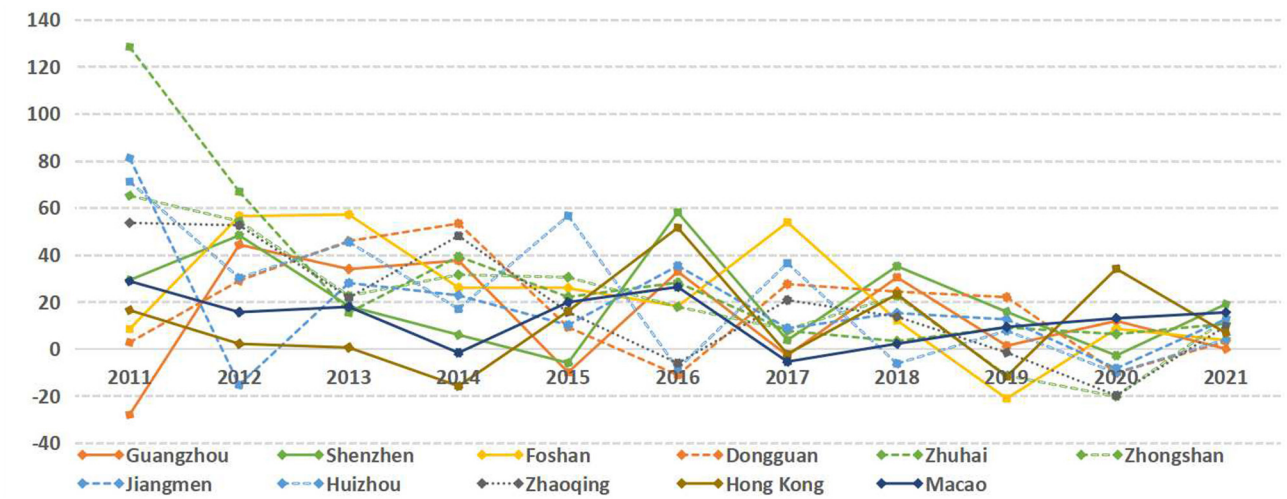

FIGURE 5 | Rate of change in economic resilience of cities in the Guangdong-Hong Kong-Macao Greater Bay Area.

Although cities with high involvement in the global economy facilitate industrial division of labor and economic development to some extent, the flow of goods and population is restricted and the economic system is easily affected when faced with global public health emergencies such as H1N1, H7N9 and the COVID-19 epidemic (34). The other part is due to their weak economic base, such as Jiangmen and Zhaoqing (raw material processing).

Spatial Distribution: A Pattern of High in the Central and Southern Parts and Low in the Periphery, Evolving in a "Stochastic—Equalized—Polarized" Pattern

A matrix of city* index is constructed by counting the panel data of each city in the Guangdong-Hong Kong-Macao Greater

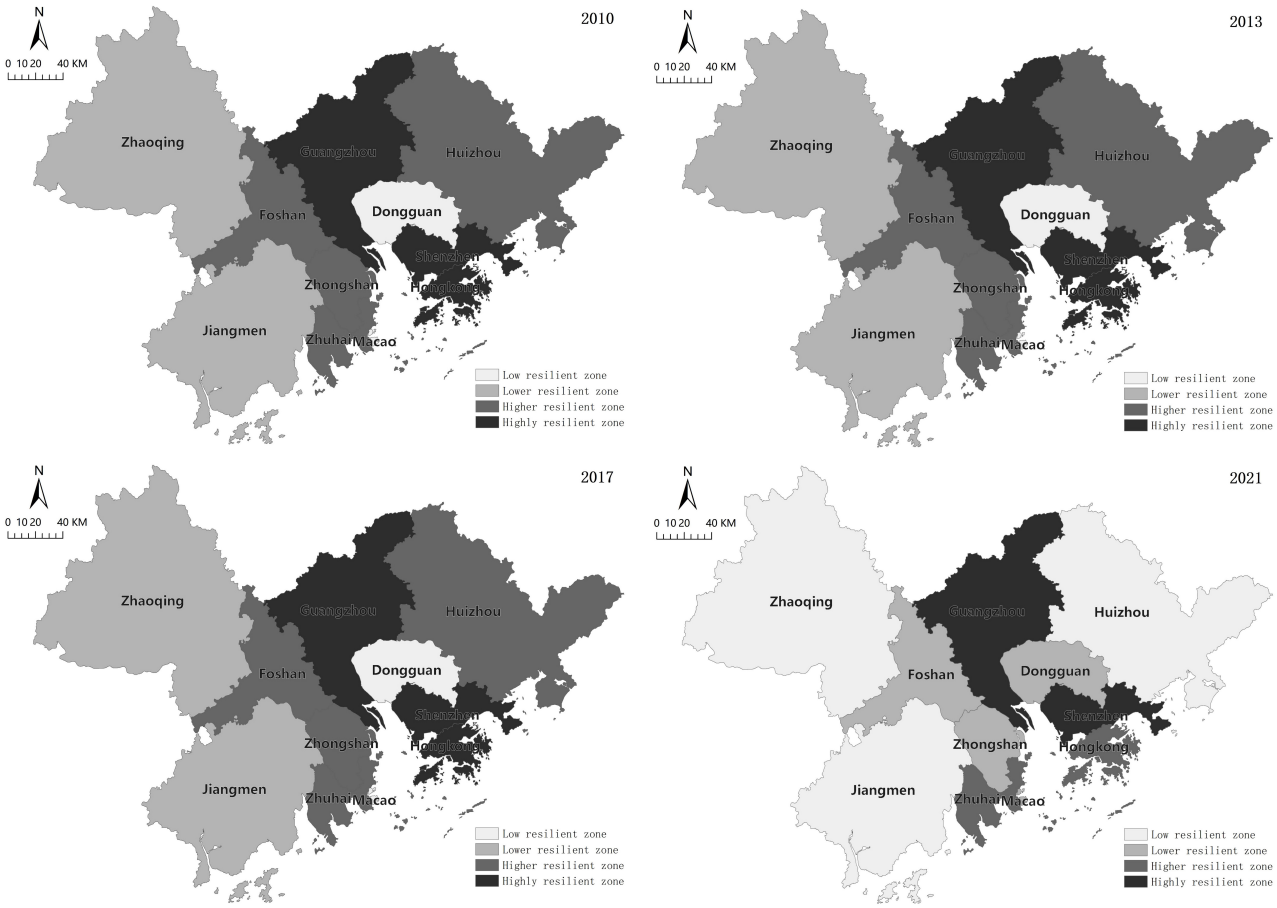

FIGURE 6 | Spatial distribution of economic resilience in the Guangdong-Hong Kong-Macao Greater Bay Area.

Bay Area from 2010 to 2021. Taking the average value of economic resilience of the cities in the Greater Bay Area from 2010 to 2021 as the criterion, four representative nodes were selected in 2010, 2013, 2017 and 2021. With the help of natural breaks classification method in GIS (35), the regional economic resilience is divided into four types: low resilience zone, relatively low resilience zone, relatively high resilience zone and highly resilient zone. As shown in **Figure 6**, the spatial layout characteristics have a large variation in different periods, and its characteristics mainly present a pattern of high in the central and southern parts and low in the periphery, and its distribution shifts along the stochastic—equalized—polarized pattern.

First, the spatial pattern of the high resilience zone is stable. The high resilience zone is mainly concentrated in the first-tier urban areas, roughly in the central and southeastern parts of the Greater Bay Area. Initially, Guangzhou, Shenzhen and Hong Kong were the two poles of resilience, and then Guangzhou and Shenzhen became the two poles. Guangzhou benefits from the advantages of gross domestic product, industrial value added, fiscal revenue and hospitals. Guangzhou, as the capital city of Guangdong Province, can carry out division of labor and cooperation within the provincial cities, promote technology transfer and industrial upgrading, form industrial linkage effects, and optimize industrial structure (36), which can disperse most of the economic shocks and strengthen its economic status resilience. Shenzhen mainly benefits from its gross domestic product, industrial value added and technological R&D emphasis, and changes from a labor-intensive industrial model dependent on Hong Kong to a knowledge-intensive industrial model with independent innovation. As a result, a full set of high-tech industrial chain of "R&D-production" is formed in combination with industrial bases to realize spillover benefits of knowledge economy (37). Its economic resilience is characterized by the flexible economic evolutionary power to consolidate its economic status, so as to quickly update to cope with the next round of economic crisis.

Second, the space with relatively high resilience shifts. Initially distributed in Jiangmen and Zhongshan in the west wing of the Greater Bay Area, it was subsequently shifted to Hong Kong and Zhuhai in the south of the Greater Bay Area. Benefiting from the advantages of fixed asset investment and entrepreneurship, Zhuhai has generated a wave of investment oriented to scientific and technological innovation, and developed toward the scientific and technological innovation center in the west wing of the Greater Bay Area, thus enhancing the resilience and evolutionary power of economic development. As a global

financial center, Hong Kong has a large-scale economy, extensive capital markets, and a well-developed global network, so it has the advantages of gross domestic product, tertiary industry, and per capita disposable income. However, Hong Kong is not backed by local manufacturing industry and is overly dependent on global financial and trade networks, so Hong Kong will be subject to global logistics blockade, trade disruption or order cancellation in case of an economic crisis (38).

Third, the space with relatively low resilience continues to expand. Initially, it was distributed in Dongguan, Foshan, and Zhuhai, which are between high and relatively high resilience values, and then expanded to the peripheral cities of the Greater Bay Area, and finally returned to Dongguan, Foshan, Zhongshan, and Macau. Like Hong Kong, Macau follows a free port economic policy, and as the only gaming financial city in China, Macau is home to a large amount of non-investment capital, resulting in a high per capita income and a developed tertiary industry, but it is at the bottom of the Greater Bay Area in health care and scientific and technological R&D. In addition, Macau is exposed to a high risk due to the excessive lending (93.20% of the loan-to-deposit ratio in 2020). Once the economic crisis strikes, Macau will be subject to a series of economic chain reactions and the credit crisis will be further aggravated. Although Foshan and Zhongshan do not have as many economic advantages as Guangzhou, Shenzhen, and Zhuhai, they both have their distinctive strengths. Foshan has achieved a good balance in terms of the loan to deposit ratio, and the development model of specialized towns in Foshan has been the unique feature of its economy. Nowadays, Foshan has been trying to diversify the risk by transitioning the original specialization model to a non-related diversification model through banking, scientific and technological innovation and financial means (39). In recent years, Zhongshan has introduced a series of policies to encourage scientific and technological innovation, so it has made progress in entrepreneurial innovation, and in the future, it will implement industrial upgrading and adjustment through economic evolutionary power, just like Shenzhen, so as to improve the level of resilience. Dongguan, like Foshan, started with manufacturing industries, but its spatial proximity to Guangzhou and Shenzhen has allowed it to receive economic spillovers from both cities, resulting in a healthy loan to deposit ratio and vibrant entrepreneurship. However, unlike Foshan, Dongguan is mainly oriented to foreign markets and will be exposed to the same trade risks as Hong Kong.

Fourth, the space with low resilience is basically in the periphery, such as Jiangmen, Zhaoqing, and Huizhou. Except for 2017, when Huizhou rose to a relatively low resilience, it has been in low resilience for the rest years, with poor performance of various economic indexes. Huizhou suffers from a lack of capital and a large population outflow from Huizhou, resulting in a serious aging population, sluggish economic development, and slow recovery in times of economic crisis. Jiangmen's industrial structure is still being shifted from agriculture to industry, and its economic resilience is low due to its low per capita income, unstable economic base, and delayed industrial restructuring. Zhaoqing suffers from low fiscal revenues and inadequate health personnel, and its industrial base is weak, making it extremely difficult to respond to public health emergencies if they occur.

TABLE 2 | Gray correlation of criterion levels of economic resilience in the Guangdong-Hong Kong-Macao Greater Bay Area.

Criterion level	Correlation value	Correlation degree
Economic pressure	0.5966	Medium
Economic status	0.6436	High
Economic response	0.6913	High

TABLE 3 | Gray correlation of regional economic pressure resilience in the Guangdong-Hong Kong-Macao Greater Bay Area.

Primary index	Secondary index	Average correlation	Tertiary index	Average correlation
Economic pressure	Economic risk	0.5966	Foreign trade dependence (%)	0.5573
			Urban registered unemployment rate (%)	0.6003
			Loan-to-deposit ratio(%)	0.6323

Influencing Factors: Economic Status and Economic Response as the Key Factors Influencing the Economic Resilience of the Greater Bay Area

The economic resilience value of the Greater Bay Area calculated is used as the parent sequence of the gray correlation analysis, and the other 18 indexes are used as the signature sequence to analyze the fitting effect of the economic resilience with each index, so as to determine its influencing factors. According to **Table 2**, the average correlation between the economic pressure resilience index and the regional economic resilience level is the lowest, while the economic response resilience index is the highest of the three, followed by the economic status resilience index. It shows that the Greater Bay Area is not subject to much fluctuation of pressure between 2010 and 2021. The impact of pressure resilience on the level of economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area is relatively low. Moreover, the resilience level of the economic system of the Greater Bay Area depends largely on the resilience level of the economic status and the resilience level of the economic response of the region.

Low Impact of Economic Pressure Resilience, Not the Goal of Economic Resilience Development in the Greater Bay Area

As shown in **Table 3**, the average correlation of the resilience of economic pressure is 0.5966, which is a medium correlation level. Among them, the correlation co-efficient of the loan-to-deposit ratio is the largest and the correlation co-efficient of foreign trade dependence is the smallest, so the loan-to-deposit ratio is the main factor influencing the economic pressure. From the experience of the development of the greater bay areas worldwide, the development of the capital market has

TABLE 4 | Gray correlation of regional economic status resilience in the Guangdong-Hong Kong-Macao Greater Bay Area.

Primary index	Secondary index	Average correlation	Tertiary index	Average correlation
Economic status	Economic stability	0.6668	Ratio of total retail sales of consumer goods to GDP (%)	0.6014
			Urban per capita disposable income (yuan)	0.6673
			Local GDP (in 10,000 yuan)	0.7315
	Economic resistance	0.6262	Ratio of tertiary industry output to GDP (%)	0.6075
			Ratio of fixed asset investment to GDP (%)	0.5968
			Industrial value added((in 100,000,000 yuan)	0.6872
			Industrial structure diversification	0.6135

an irreplaceable and important role in the construction of the greater bay area. The Guangdong-Hong Kong-Macao Greater Bay Area has an overall high degree of external economic dependence and a high degree of economic export orientation. However, with the advancement of the integrated development of Guangdong-Hong Kong-Macao Greater Bay Area, it has made great achievements in the integration of the commodity market, the factor market and the service market, which has brought into full play the internal linkage and reciprocal development and reduced the degree of external dependence of the economic development to a certain extent. The increase of the loan-to-deposit ratio has brought some risk pressure to the financial market of the Guangdong-Hong Kong-Macao Greater Bay Area. With the outbreak of the COVID-19 epidemic in 2020, the overall loan ratio of the Greater Bay Area already reached 78.69%, which exceeds the normal credit scale of 75% and is prone to financial risks. Therefore, in the complex and changing international environment, the Greater Bay Area needs to develop an innovative path and pattern of financial development and opening, facilitate the interconnection of financial markets and financial infrastructure, enhance the level of financial service innovation, and prevent cross-border financial risks, so as to effectively enhance the efficiency and resilience of economic development.

Economic Status Resilience With the second Largest Correlation, With the Greatest Impact of Economic Stability

As shown in **Table 4**, among the status resilience indexes, economic stability has the highest correlation value, which indicates that the change of status resilience is heavily influenced by economic stability. Stable development is the foundation for improving economic resilience, while livelihood issues, the degree of economic development and the optimization of industrial structure are fundamentals for stabilizing development and improving economic resistance. In terms of single indices, the regional consumption level, regional economic development and regional industrial structure all have a significant positive impact on the economic status resilience of the Greater Bay Area. Among them, Guangdong-Hong Kong-Macao Greater Bay Area has a high per capita disposable income in urban areas (an average of RMB 99,612.84) and a high ratio of total retail sales of consumer goods, and the general public has a high consumption potential and capacity. The scale effect of consumption is gradually highlighted as Guangzhou is pushing forward the development as an international consumption center city and Shenzhen as the international consumption hub of the Greater Bay Area. In the context of the double cycle, the Greater Bay Area is stabilizing consumption by stabilizing the subjects to help stabilize economic growth. At the same time, the Greater Bay Area is also actively promoting economic transformation and industrial structure optimization. The Greater Bay Area is undergoing industrial transformation and upgrading at the current stage. For most of the manufacturing-oriented cities in the Greater Bay Area, industry is the underlying foundation of the economy, while the tertiary industry is the core force of the future dynamic transformation, so it is necessary to vigorously develop advanced manufacturing and high-tech industries. These are of great significance to the economic stability and economic resilience of the Greater Bay Area.

Economic Response Resilience With the Highest Correlation, With Economic Evolutionary Power as the Key Factor

As shown in **Table 5**, among the response resilience indexes, the correlation value of the economic evolutionary power is higher overall, indicating that the Greater Bay Area's economic response resilience is mainly influenced by the economic evolutionary power. In terms of single indexes, the correlation co-efficients of scientific research vitality, entrepreneurial innovation, and government resource mobilization capacity are higher, indicating that the government's ability to manage public health emergencies and technological means in the epidemic also play a crucial role in the socio-economic operation. Scientific and technological innovation is an important regional feature of the Greater Bay Area, and it is essential to jointly build an international scientific and technological innovation center and promote industrial synergy and scientific and technological innovation. In the context of high-quality development, the Greater Bay Area should give full play to the leading role of both entrepreneurship and scientist spirit (40), and encourage more talented people to be involved in building the scientific and technological development pattern of the Greater Bay Area. If economic, social, ecological, demographic, and resource resilience constitute the hard power of urban resilience, then institutional, managerial, and organizational resilience are the soft power of urban resilience (41). As the visible hand, the government plays an indispensable role in resource allocation,

TABLE 5 | Gray correlation of regional economic response resilience in the Guangdong-Hong Kong-Macao Greater Bay Area.

Primary index	Secondary index	Average correlation	Tertiary index	Average correlation
Economic response	Economic recovery capacity	0.6577	General public budget revenue (in 10,000 yuan)	0.7318
			Share of health expenditure in fiscal expenditure	0.6760
			Number of hospitals	0.6213
			Number of public health personnel per 10,000 persons	0.6454
			Number of hospital beds per 10,000 persons	0.6139
	Economic evolutionary power	0.7474	Number of patent applications per 10,000 persons (piece)	0.8392
			Ratio of R&D expenditure to GDP (%)	0.6696
			Number of patents granted per 10,000 employed persons (piece)	0.7335

institutional innovation, and management capacity. In addition, the government is equipped with strong resource integration and grassroots mobilization capabilities in the allocation of public budget, public infrastructure construction, industrial policy, and social welfare, which can effectively enhance economic resilience.

CONCLUSION AND DISCUSSION

Temporally

The economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area continues to grow, with most cities experiencing an increase in their resilience levels. From 2010 to 2021, the economic resilience of the Greater Bay Area has generally improved, mainly divided into three main stages: rapid development, adjustment in fluctuations and stable development. The regional economic structure has been evolving steadily, showing a healthy development of a pressure-state-response pattern, in which the economic resilience indexes regulate, circulate and influence each other. Among them, the pressure resilience increases in the fluctuations, and the external disturbance of the system decreases. The status resilience increases rapidly, and the robustness level of the system continues to grow. The response resilience increases in fluctuations, and the response capacity is constantly enhanced. In the development of resilience of cities within the region, except for Hong Kong and Macau, where the level of resilience is decreasing, there is a steady increase in the resilience of most of the other cities, reflecting the strong resilience of the Greater Bay Area as a whole. However, under the disturbance of changes in the global economic environment and public health emergencies, it is necessary to pay close attention to the dynamics of the Greater Bay Area's economic resilience and its forecast.

Spatially

It develops in an imbalanced way, high in the central and southern parts and low in the northwest. The spatial pattern of the high-resilience areas is stable, mainly concentrated in the first-tier urban areas. Benefiting from the degree of economic development, industrial structure optimization and economic innovation capability, these high-resilience cities play an essential role in enhancing the resilience of the entire Greater Bay Area through economic connectivity. The space with relatively high resilience has shifted, mainly in Jiangmen and Zhongshan in the west wing of the Greater Bay Area, Hong Kong, and Zhuhai in the south of the Greater Bay Area. These cities have a sound industrial base, but have a high economic risk (e.g., Hong Kong), and are vulnerable to the global economic crisis and their economic resilience fluctuates heavily. The space with relatively low resilience continues to expand, such as Dongguan, Foshan, Zhongshan, and Macau. The industrial structure of these areas is relatively homogeneous, which restricts their economic activities and diversified development, so they need to upgrade and adjust their industries, increase the economic evolutionary power, and improve the level of resilience. The space with low resilience is basically in the periphery. These cities have a poor economic foundation, are lagging behind in industrial restructuring, and are slow to recover from economic crises and public health emergencies once they are hit. Therefore, these cities are the priority target for enhancing the economic resilience of the Greater Bay Area.

Influencing Factors

The economic resilience of the Guangdong-Hong Kong-Macao Greater Bay Area is significantly correlated with the economic status and economic response, while it is less correlated with the economic pressure resilience. Economic evolutionary power is the key, with a correlation co-efficient of 0.7474. Economic stability and economic recovery capacity are the main focus, while the changes in economic resistance and economic risk should be paid attention to. As for the subfactors, local GDP, industrial value added and urban per capita income have contributed significantly to the increased economic resilience of the Greater Bay Area, reflecting the importance of regional social and economic development, industrial construction and market consumption. At the same time, the positive effects of general public budget revenue and the number of patents applied or granted per 10,000 persons also indicate that the government's ability to manage public health emergencies and the technological means in the epidemic also play a crucial role in the socio-economic operation. Therefore, the foundation of economic development, industrial structure, government regulation and control capacity, and technological innovation capacity are of vital importance to the economic resilience of the Greater Bay Area, and are also important elements

in the future resilience enhancement path of the Greater Bay Area.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

YZ and BT contributed to the topic selection, development of the framework and writing of the manuscript, and figures and the literature review. ZC contributed to the data analysis, drawings and the tables. HS contributed to the revision of data analysis and drawings. All authors contributed to the article and approved the submitted version.

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Measuring patients' satisfaction toward health tourism in Malaysia through hospital environment, nutritional advice, and perceived value: A study on Chinese exchange students

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Malaysia is a reputed destination for health tourism in the Asia Pacific region for its hospitable nature and good quality of service. Patients' satisfaction has been a key concern in health tourism to maintain the flow of tourists' arrival for medical purposes. By considering the importance of health tourism and patients' satisfaction in Malaysia, this study aimed to examine the influence of hospital environment, nutritional advice, perceived value on patients' satisfaction. This study is cross-sectional in nature and follows a quantitative approach. The researchers used questionnaires as a survey tool to obtain information from the respondents. The sample of this is chosen from Chinese exchange students in Malaysia. Using a systematic random sampling technique, 205 usable responses were selected from the respondents and proceeded with further analysis. The study conducted structural equation modeling using Smart PLS version 3. The results found that hospital environment, nutritional advice, and perceived value significantly influence patients' satisfaction in Malaysia.

KEYWORDS

patients' satisfaction, health tourism, hospital environment, nutritional advice, perceived value

Introduction

Researchers and marketing experts have focused their attention on the relevance of customer satisfaction to a company's long-term survival and growth. If anyone wants to acquire a competitive edge in today's business world, to pay attention to the quality of their services. Increasingly, customer orientation is being applied to the healthcare business. As health is seen as one of the most important human assets, it's not unusual for people to travel for (1). Health is more than just physical wellbeing. A person's physical, mental, and social wellbeing are all included in the term "health" when seen from a

holistic viewpoint instead of only the absence of sickness or illness (2). Tourism is any activity that involves a person visiting or living outside usual surroundings for pleasure, business, or any other reason for less than a year in a row. It might be argued that the term "tourism" encompasses more than only recreational travels, such as commercial and medical trips, as well as travels for pleasure. Travels associated with health services may be either curative (medical) or preventative, or wellness-oriented, depending on the purpose of the trip (3). Traveling from one location to another to get health-related services might be referred to as health tourism under several situations (4). Aside from obtaining health-related treatments, visitors who go on a health-related vacation may also profit from the many tourist attractions they come across. Such considerations have little impact on health tourists' core goal of improving their quality of life via access to medical treatment (5). No single researcher has been able to agree on what exactly constitutes health to tourism. According to Abbas et al. (6), the term encompasses a wide range of activities, including medical care to health assessments to surgery to beauty treatments to rehabilitation to convalescence to leisure and recreation at a particular location. In addition, medical tourism, medical wellness tourism, and wellness tourism are all separate subcategories within the author's overall classification of health tourism. Health tourism encompasses both medical and wellness travel (7). According to Pan et al. (8), an accurate definition of health tourism includes medical and wellness tourism. Health tourism is a fast-growing segment of the tourist industry (9). Low-cost remedial methods, more advanced hi-tech services and products globally trained competent medics and nurses, and amazing healthcare facilities are all factors that encourage health tourists to seek treatment outside their nation. As a result, many countries' tourist businesses, particularly developing countries, see health tourism and associated fields as one of the most profitable segments (10, 11). Medical travel abroad has become more accessible and less expensive due to globalization in the last several decades. Health care delivery is already beginning to cross national borders, further demonstrating that globalization is no longer limited to manufacturing. Many developing countries are now leading destinations for medical tourism, thanks to globalization (12). According to a literature assessment, developing nations are drawing many health tourists. The biggest reason people seek healthcare in developing countries is cost (13). Asia has recently risen to the top of the most popular locations for medical tourists (14).

Figure 1 shows the uprise of Malaysia's market since 2018. It can be seen that it has been continuously rising from 2011 till 2018.

Nutritional advice is based on dietary needs established by published research and clinical guidelines (15). The goal of hospital environments refers to the spatial, physical, and functional design characteristics that healthcare environments should possess to achieve two goals, including lowering the stress level, which can be quite significant for both staff and patients. Malaysia is a key player in health tourism (16). Healthcare tourism brought in RM 588.6 million in 2015 and attracted 859,000 visitors to Malaysia (17). The government's goal of making Malaysia a regional center for medical tourism has made health tourism a top priority (18). However, Malaysia is one of the world's most popular tourist destinations (19). It has yet to establish itself as the region's top destination for health tourism. The government is making significant efforts to boost the country's health tourism business. For Malaysia's healthcare business, identifying the underlying elements that may influence patients' satisfaction with health tourism has arisen as a critical concern. There hasn't been a thorough investigation on its suitability as a health tourist attraction yet. Patients' satisfaction with health tourism in Malaysia has received a cursory look at the aspects that may influence their experience. Health tourism is a multifaceted industry that requires careful consideration of factors such as cost, service quality, motive, destination image, and perceived value (20). Kurgun et al. (21) have recommended that hospital environment, perceived value is important element in tourism industry which ultimately led to satisfaction level. Medical advice is one of the most important aspects contributing to customer satisfaction with health tourism (22). To get a whole picture of how patients feel about health tourism, it's necessary to consider these factors. According to a study of the literature, it has been found that few studies have assessed the simultaneous influence of these variables on patients' satisfaction with health tourism. Consequently, by considering the importance of health tourism and patients' satisfaction in Malaysia, the current research was designed to examine the influence of hospital environment, nutritional advice, perceived value on patients' satisfaction.

Literature review

Hospital environment and patients' satisfaction

There are two types of quality in health care: technical (or result) and functional (or process) (23). Functional quality focuses on how the service is delivered to customers rather than what they get. As a result, a patient's quality of care is measured by the correctness of their diagnosis and treatments and how the care is given to them (24). But Dewa et al. (25) argue that quality is not described in terms of clinical quality but rather service delivery quality in health care. It is important for a hospital to not simply concentrate on clinical outcomes. It can count on the work being of the highest quality and would go to a hospital if they can't rely on the doctors to provide them with top-notch care. Instead, the focus should be on giving high-quality service, aside from special medical treatment. The focus should be paid to establishing proper interaction between staff and patients,

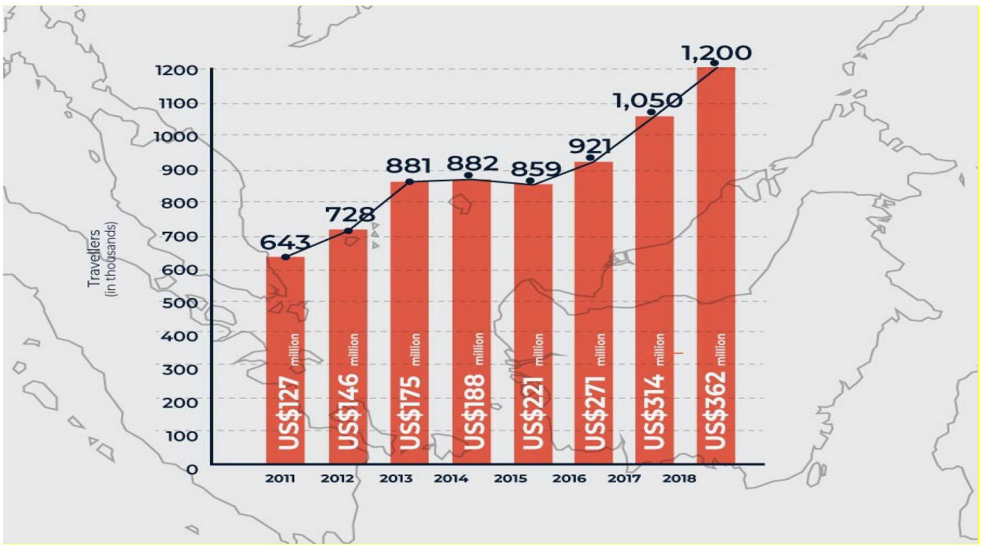

FIGURE 1
Health Tourism Market in Malaysia. Source: The Malaysia Healthcare Travel Council (MHTC), 2019.

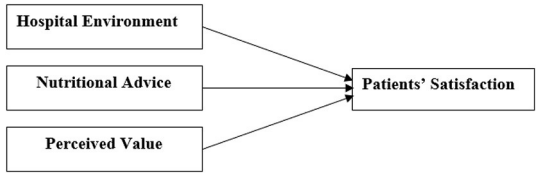

FIGURE 2
Research framework.

or in general, connecting with patients (26). From the patient's standpoint, service quality involves the impression of medical treatment and physical facilities and relationships with both medical and nursing staff members.

Based on above literature, this following hypothesis can be posed as:

H1: Hospital environment is positively related with Patients' satisfaction

Nutritional advice with patients' satisfaction

People's post-consumption evaluation of a product or service may be characterized as satisfaction (27). In tourism, visitors' emotional states are often linked to their feelings of pleasure, and it is widely assumed that visiting the place of their choosing would result in a feeling of contentment (28). As a result, customer satisfaction is comparable to the joy travelers have after visiting a certain location. When visitors' expectations for service are compared to the service they get, contentment results from this comparison (29). Tourists are considered happy if the service they get is in line with what they had hoped. The link between patients' expectations of healthcare providers' services and the service given by healthcare organizations may be regarded as a measure of patient satisfaction. In this case, patients are deemed pleased when the healthcare treatment they get meets or exceeds their expected outcomes. According to an existing research study, several characteristics of health tourism satisfaction may be attributed to it. One of the crucial factors in health tourism is the cost of treatment (30). The degree to which visitors are motivated has also been linked to their level of satisfaction (31, 32). Patients are also satisfied with the destination's image (33). It is for healthcare institutions to meet visitors' needs without delivering high-quality service and value (34, 35). The following hypothesis can be posed as:

H2: Nutritional advice is positively related with patients' satisfaction

Perceived value and patients' satisfaction

To effectively use relationship-based marketing in the tourist industry, a company's perceived worth must be considered (36). Individuals' decision-making is influenced by this, too, to some extent (37). It's all about comparing the product's or service's

value to its price that makes up the concept of perceived value (38). In this way, contentment is closely associated with it since it is believed to occur when people think they have achieved a good value. For the most part, perceived value is made up of two factors: first and primarily, the benefits that one receives, which can be in the form of social as well as economic, and secondly, sacrifices, which include the price one must pay for a given product or service and the time it takes one to acquire the service or product (39). Study after study has found that perceived value is a crucial predictor of customer satisfaction. Adly (40) claimed that perceived value is an important factor in customer satisfaction. In addition, the impact of perceived value on visitor satisfaction has been expanded. Numerous studies in tourism have shown that customer satisfaction is closely linked to a destination's perceived value (41, 42). Patients' pleasure was also shown to be influenced by perceived value (43, 44).

The following hypothesis can be posed as:

H3: Perceived value is positively related with patients' satisfaction

Methodology

By considering the importance of health tourism and patients' satisfaction in Malaysia, the current research was designed to examine the influence of hospital environment, nutritional advice, perceived value on patients' satisfaction. This study is cross-sectional and followed a quantitative approach to examine the influence of hospital environment, nutritional advice, perceived value on patients' satisfaction. A cross-sectional study usually involves measuring all variables for all cases within a short period and once only. The researchers used structured questionnaires as a survey tool to obtain information from the respondents. The sample of this is chosen Chinese exchange students in Malaysia. To collect the data, the researchers used a systematic random sampling technique. Two hundred and five usable responses were collected from the respondents and proceeded for further analysis. The initial analysis was conducted using SPSS version 23, and structural equation modeling was conducted using Smart PLS version 3.

Measurement of the study

One-to-seven-point Likert scales have been used to measure responses (1) Strongly disagree, (2) Disagree, (3) Somewhat disagree (4) No opinion/Neutral (5) Somewhat agree, (6) Agree, (5) Strongly Agree. The measurement of this study adopted from previous studies. For patients' satisfaction was measured using four items from Antreas and Opoulos (45). The items include "I am satisfied with staying in this hospital." Hospital environment was measured using a three items construct adopted from Markovic et al. (46). The items include "Available and clear information at the hospital." A five items construct used to measure nutritional advice adopted by Yildiz and Erdogmus (47). The items include "The nutritional advice provided to me is useful." Perceived value was using six items construct adopted from Sweeney and Soutar (48). The items include "Performing service in the promised time." These items further tested and validated by Petrick (49).

TABLE 1 Construct validity and reliability.

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Hospital environment	0.865	0.917	0.786
Nutritional advice	0.916	0.937	0.750
Patients' satisfaction	0.871	0.912	0.721
Perceived value	0.881	0.909	0.628

Data analyses and hypotheses results

The researchers examined the data using PLS-SEM to assess Hospital Environment, Nutritional Advice, Patients' Satisfaction, and Perceived Value. We report results using a significance level at $p < 0.01$ and $p < 0.001$.

In terms of content validity, a variety of operational aspects were evaluated using pre-existing research and multiple-item measurements. Both confirmatory and exploratory factor analyses confirm the factorability of the variables. An example of this is depicted in Figure 2. One item had a loading above 0.60, and the rest exceeded the recommended 0.70 loading. Table 1 lists all the constructs, and the Cronbach alpha for each is $\geq$0.70.

Furthermore, the overall reliability of the composite was above the standard. The average variance extracted was checked to ensure convergent validity and found that every variable was more significant than or equal to the recommended value of 0.50 (see Table 1). As a result, all of the variables point to the validity and dependability of the contents of the questionnaire.

Figure 3 shows the factor loading of individual items and confirms the confirmatory factor analysis. To evaluate the mdoe, the discriminant validity of the 4-variables is used in the study, Heterotrait-and Monotrait (HTMT) analysis was performed.

The result of confirmatory factor analysis shown in Table 2 supports the empirical evidence of the distinctiveness of the variables. No correlation exceeds the limit of maintaining an HTMT value of 0.85. Thus, all the study variables ensured the discriminant validity for further analysis.

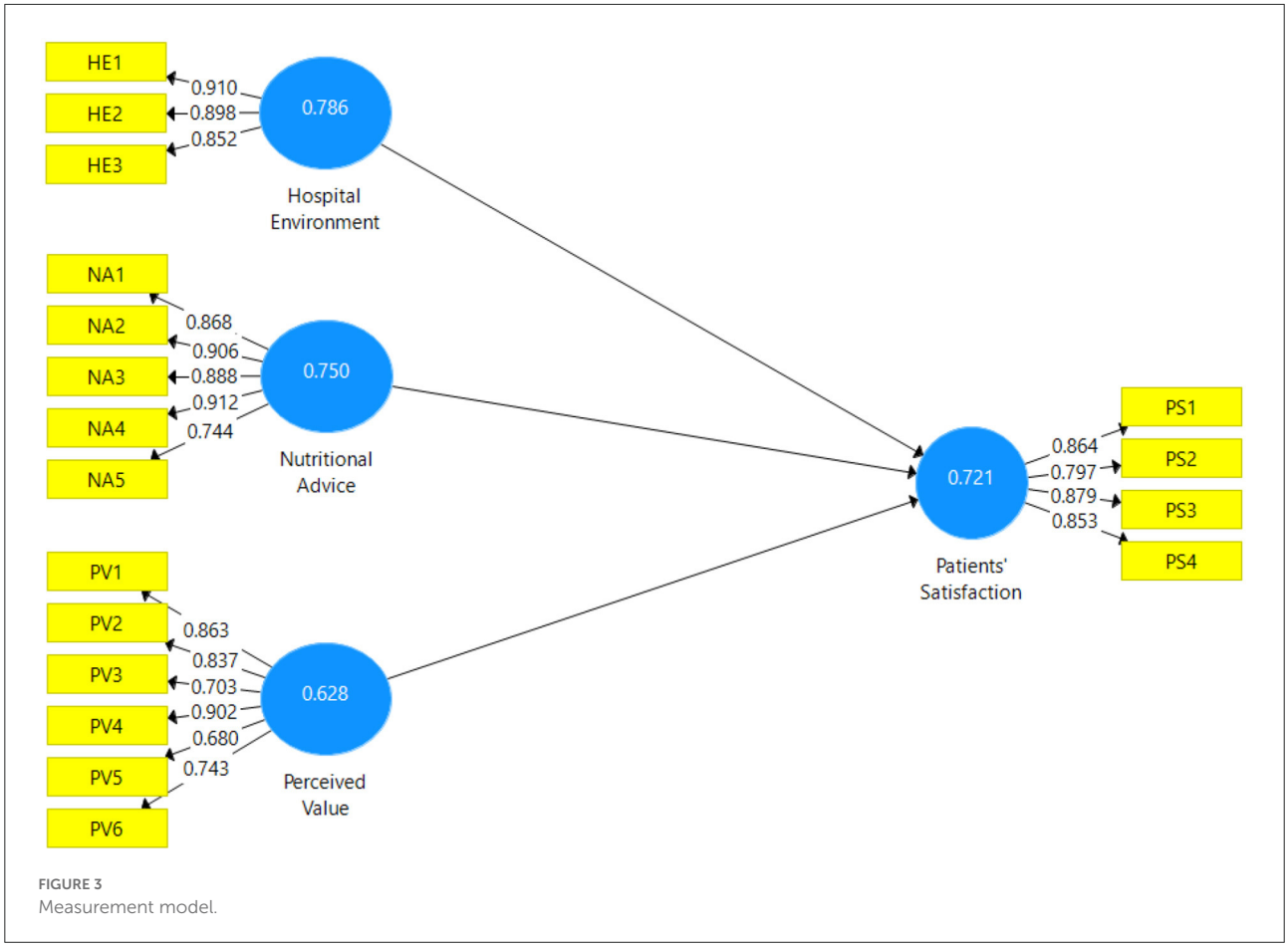

FIGURE 3
Measurement model.

Structural equation modeling

In Smart-PLS, two models are used to examine the effects of independent variables on the dependent variable: the measurement model and the structural model. These include constructing validity and reliability that have already been discussed in detail. R square is also shown in the structural modeling equation for the ability of independent variables to predict the outcomes of their underlying dependent variables. The three variables chosen to have an R-Squared Value of 0.111, indicating a connection between the hospital environment, nutritional advice, and satisfaction. As a further measure of model fit, the SRMR (statistical correlation coefficient) was calculated, which was found to be 0.07.

As demonstrated in Table 3, the hospital environment ($\beta = 0.221$, $T = 3.918$, $P = 0.000$), nutritional advice ($\beta = 0.158$, $T = 2.828$, $P = 0.005$), and perceived value ($\beta = 0.119$, $T = 2.301$, $P = 0.022$) all have a significant influence on patient satisfaction. Hospital environment features have the greatest impact on patient satisfaction. Nutritional advice has a significant positive influence on patient satisfaction. Nutritional advice has a positive effect on patient satisfaction, as does perceived value have a positive effect on patient satisfaction. As a result, all hypotheses are supported.

TABLE 2 Discriminant validity (HTMT).

	Hospital environment	Nutritional advice	Patients' satisfaction	Perceived value
Hospital environment				
Nutritional advice	0.131			
Patients' satisfaction	0.290	0.239		
Perceived value	0.184	0.369	0.229	

Discussion and conclusion

The results found that the hospital environment, nutritional advice, and perceived value significantly influence patients'

TABLE 3 The Direct effects of HRM practices on operational performance.

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1: Hospital environment -> patients' satisfaction	0.221	0.225	0.056	3.918	0.000
H2: Nutritional advice -> patients' satisfaction	0.158	0.160	0.056	2.828	0.005
H3: Perceived value -> patients' satisfaction	0.119	0.126	0.052	2.301	0.022

satisfaction in Malaysia. The results suggest that the responsible stakeholders maintain health tourism in Malaysia by good health care service, hospital environment, appropriate nutritional advice from the doctors, and perceived value of the medical service which is aligned with previous study of Johari and Ong (50). It further concludes that, in terms of service quality, majority of the patients are satisfied with the current services offered by the Malaysian hospitals.

Lam (51) and Manaf (52) found that, it is crucial to keep and attract more medical tourists by providing high-quality service, such as delivering accurate information to patients, up-to-date information services, and patients' awareness of the worth of the money they spent on their treatments. In order to attract and retain medical tourists, the Malaysian government needs to identify the many needs that they can aggressively promote them as a key medical tourism player in order to satisfy their customers' needs (53, 54).

Furthermore, it is necessary to publicize medical success stories and the services they provide in order to attract more overseas patients (55, 56). The findings of this study make it abundantly evident that the competitiveness of a destination is a significant consideration for medical tourists. General tourists and medical tourists are not motivated by the same things (57, 58). Tourists go on vacation to have fun, relax, or take in the sights, and this is known as general tourism.

Contributions of the study

The theoretical and practical implications of this research are enormous. For the theoretical growth of tourism, this study provides a structured relationship between many components of Malaysian medical tourism and the development of the business. For those working in the hospitality and medical industries, this study can serve as an example for how a positive image of the location, high-quality service, and attentive staff influence customers' perceptions and attitudes toward medical tourism opportunities in Malaysia.

In addition to that, there are practical consequences and suggestions for speciality hospital management based on the findings of this study. People value cleanliness and neatness, professionalism of the employees, their attitude toward patients, and dependability of service delivery more than anything else. Specialized hospitals need to strengthen their non-medical services, including hospitality, sports and leisure, entertainment, and social activities, to acquire a competitive edge in the health tourism industry. They should also match customer expectations based on market trends. That's why specialist hospitals and medical spas need to better grasp the value of extra services they offer to increase their quality. There are several problems with the study that might affect the findings. The research tool is the two most important considerations. Hospital/health services, hotels, and travel/leisure are the three main components of medical tourism. As a result, governments who participate in this developing business might benefit significantly from appealing policies and effective marketing tactics. To do this, host governments must implement a legislative framework that is appealing to consumers throughout the globe. Consumers must be encouraged to go to the host nations to obtain the treatment they seek. Different approaches need to be developed for each because of the uneven participation of the private and public sectors in Malaysia's health tourism industry.

Limitations and future study recommendation

A small sample size but a representative sample was used for the analysis. The model for evaluating service quality should be evaluated on a more significant sample in the future study, which would enable the application of sophisticated statistical approaches. Patients' expectations and satisfaction could also be analyzed to see statistical significance variations between persons in a healthcare facility due to an injury or recovery and those who utilize medical services to enhance their wellbeing. Further studies should examine the variations in perceived and expected efficiency between non-profit and for-profit medical institutions between private and public-owned facilities and between the perspectives of patients and service providers. New

items and questions on the significance of specific characteristics for patients might be added to the study instrument.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

LL: conceptualizing the idea, introduction, and supervision. NR: literature review. AP: data collection, data analysis, and conclusion. WB: data collection. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Benefit-to-harm ratio and cost-effectiveness of government-recommended gastric cancer screening in China: A modeling study

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Objective: Current guidelines recommend the gastric cancer risk score scale (GCRSS) for screening in gastric cancer (GC) high-risk populations in China. This study aimed to estimate the clinical benefits, harms, cost, and cost-effectiveness of the GCRSS screening strategy from a Chinese healthcare system perspective.

Materials and methods: Using a microsimulation model, we evaluated 7 screening scenarios of the GCRSS with varying starting ages. We simulated 100,000 individuals from the age of 20 for each screening scenario. The main outcomes included GC incidence reduction, number of cause-specific deaths, costs, quality-adjusted life year (QALY), incremental cost-effectiveness ratio (ICER), and benefit-to-harm ratio. Deterministic and probabilistic sensitivity analyses were done to explore the robustness of model findings.

Results: Screening with the GCRSS strategy at the age of 40 years (40-GCRSS) provided the greatest reduction of GC incidence by 70.6%, with 7,374 GC deaths averted per 100,000 individuals and the lowest benefit-to-harm ratio of 0.392. Compared with no screening or previous less costly strategy, at a willingness-to-pay (WTP) threshold of $37,655 per QALY, the 40-GCRSS strategy was cost-effective, with ICERs of $12,586 and $29,115 per QALY, respectively. Results were robust across univariate and probabilistic sensitivity analyses. The 40-GCRSS strategy showed a 0.856 probability of being cost-effective at a $37,655 per QALY WTP threshold.

Conclusions: The findings suggest that the GCRSS strategy is effective and cost-effective in reducing the GC disease burden in China from a Chinese healthcare system perspective. Screening from the age of 40 would be the optimal strategy.

KEYWORDS

gastric cancer, screening, endoscopy, cost-effectiveness, modeling, benefit-to-harm ratio

Introduction

Gastric cancer (GC) remains a common gastrointestinal tumor in China, threatening human health (1). There are over 670 thousand new diagnosed cases and about 500 thousand dead cases every year in China, which accounts for around 42 and 45% of the world, respectively (2, 3). At present, reducing the morbidity and mortality of GC is a major public health problem that needs to be solved (4, 5).

The prognosis of GC depends on the timing of detection and treatment, and prognosis of the advanced-stage detection is poor. In China, nearly 90% of GC patients were detected at an advanced stage (6). Although the endoscopic examination is an effective GC screening approach, even in developed countries with a high incidence rate of GC, such as Japan and Korea, it is impossible to screen GC for the whole population (7, 8). Only screening high-risk individuals of GC may be an effective and feasible method to reduce the disease burden of GC in China.

According to China's guidelines for diagnosis and treatment of GC, *Helicobacter pylori* (Hp) infection and gastric mucosal atrophy are important factors for identifying GC high-risk groups (9). Hp was classified as a class I carcinogen of GC by the International Agency for Research on Cancer as early as 1994 (10), which is the principal etiologic factor for the development of non-cardia GC, with an estimate of 75% of all the non-cardia GCs related to Hp infection (11, 12). Fortunately, Hp is considered to be a controllable environmental factor (13), and its eradication would effectively reduce the incidence of GC (14). Gastric atrophy and intestinal metaplasia of gastric mucosa are the most common conditions leading to the development of GC (15, 16), whereas serum pepsinogen (PG) and gastrin-17 (G-17) levels are usually used as biomarkers for the gastric mucosal atrophy status (17). The "serology biopsy" has proved to be useful in the screening for GC high-risk populations who experience gastric mucosal atrophy, which is defined as the combined detection of Hp antibody, PG, and G-17 (18).

The combination of non-invasive serological screening and endoscopy is helpful to improve the effect of GC screening (19). Therefore, the GC risk score scale (GCRSS) based on the serological indicators of Hp infection and atrophy was developed and recommended by the National Health Commission of China in 2022 as a screening strategy for GC in high-risk populations (20). Understanding the trade-offs in lifetime benefits, harm, and cost between current guidelines and alternative screening strategies is necessary to be integrated into dialogues on cancer control policy. The objective of our study was to assess the clinical benefits, harm, cost, and cost-effectiveness of the GCRSS screening strategy from a Chinese healthcare system perspective.

Materials and methods

Overview

A previously developed microsimulation model was adapted to evaluate the GCRSS strategy, in which 100,000 individuals were simulated from the age of 20 for each GC screening scenario (21). Because of the lack of data on the willingness-to-pay (WTP) of China, we assumed that the WTP threshold was equal to three times the per capita gross domestic product (GDP) in China, according to the World Health Organization cost-effectiveness definition (22). An incremental cost-effectiveness ratio (ICER) <one time the per capita GDP was defined as highly cost-effective; 1 to 3 times the per capita GDP was defined as cost-effective; and an ICER >three times the per capita GDP was defined as not cost-effective. In 2021, the per capita GDP in China was $12,552 (23).

The primary outcomes were GC incidence reduction, number of GC deaths averted, number of endoscopies, number of cause-specific deaths, costs, life years, and quality-adjusted life years (QALYs). We calculated the ICER by the difference in costs divided by the difference in QALYs. Moreover, the benefit-to-harm ratio was measured, which was defined as the ratio of screening complication-related events to GC deaths prevented.

The model was implemented using TreeAge Pro 2022 software (version 2022 R1.1; https://www.treeage.com), and additional statistical analyses were performed in R software (version 4.1.3; http://www.r-project.org).

Modeling

We simulated the natural history of GC by constructing a model with 15 health states (Figure 1). The model adopted a 1-year cycle length and a lifetime horizon. Through several precancerous lesion states, individuals can progress to more advanced precancerous lesions and eventually invasive GC. In the absence of screening, we assumed that individuals were diagnosed only when developing clinical symptoms. The screening was performed to diagnose the precancerous and preclinical patients. After the intervention of screening strategies, the GC natural history would be altered due to the detection or treatment of precancerous lesions or preclinical cancer.

We considered the impact of individual risk profiles on disease progression, such as Hp infection and smoking behavior, which were the two most powerful risk factors for GC (10, 24–26). We assumed that Hp infection and smoking would increase the risk of progression to atrophy and dysplasia, respectively. Individuals entered the model from the age of 20 and were assigned Hp infection status and

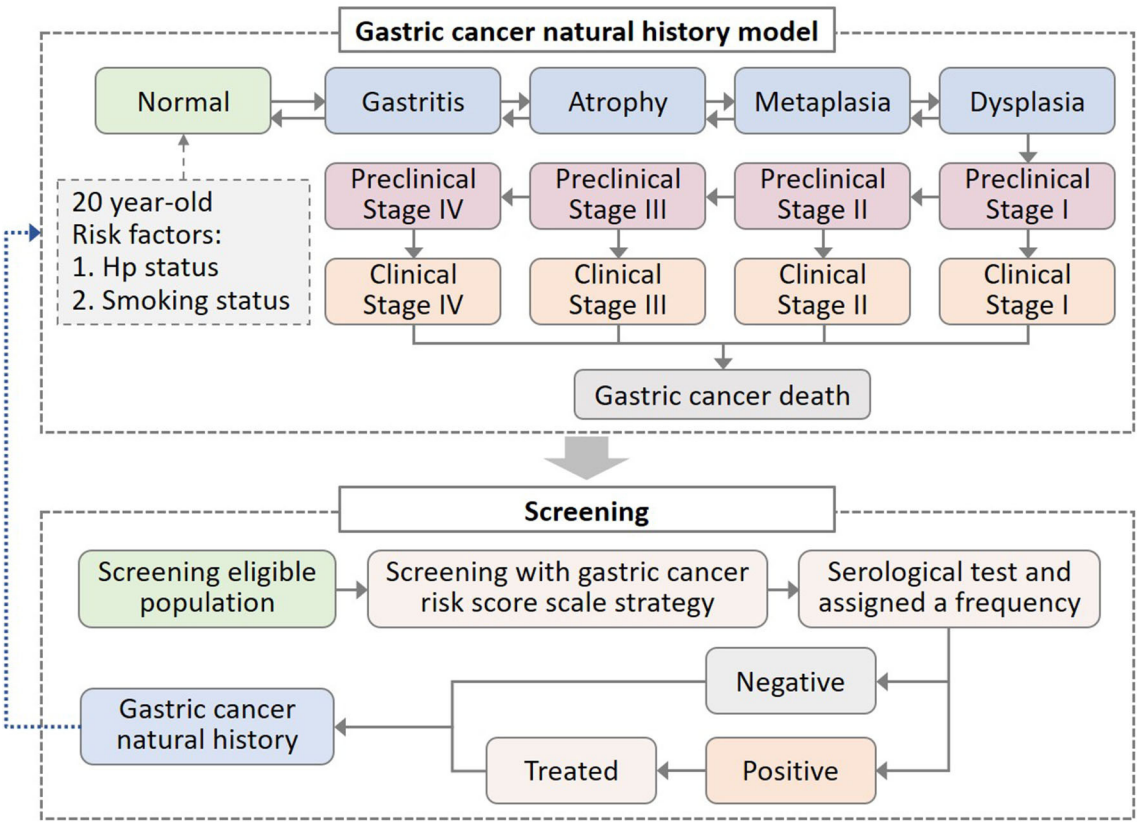

FIGURE 1
Decision-making model of gastric cancer (GC) natural history and screening intervention. In the natural history model of GC, all healthy states suffered background mortality, while clinical gastric cancer states suffered additional GC mortality. Hp, *Helicobacter pylori*.

smoking behavior (Figure 1). Based on epidemiologic data, we applied 67% Hp prevalence and 64 and 34% smoking rate in men and women, respectively (27, 28). According to the smoking intensity, current smokers were further divided into <10 cigarettes per day and ≥10 cigarettes per day (29, 30).

Due to a paucity of progression rates data for the potential biological process from normal to GC, our model was calibrated to epidemiological data of precancerous lesions prevalence, GC incidence, and GC stage-specific proportion (31–33), to obtain these parameter sets of transition probabilities (more details were described in the Supplementary materials). We extracted background mortality that was specific for age and sex from Chinese life tables, and derived stage-specific GC mortality from a published follow-up study (34, 35). We validated the model using data not used in the calibration. Our model outcomes showed that the relative risk of GC incidence associated with Hp infection positive (4.3) and smoking (1.8) was matched with published estimates (95% *CI*, 2.7–7.2 and 1.5–1.8, respectively) (26, 36).

Strategies

Compared with no screening, we evaluated seven strategies of the GCRSS with varying starting ages, such as 40, 45, 50, 55, 60, 65, and 70 years. For all the strategies, individuals were screened for the first time at the corresponding starting screening age. The target population for the GCRSS screening strategy was the GC high-risk population, who aged 40 years or older with one of the following conditions (residing in high-incidence areas, Hp infection, previous precancerous diseases, a positive family history of GC, regular intake of high-salt diet, smoking, and heavy alcohol drinking, etc.) (37).

The GCRSS strategy stratified individuals according to the serological detection results of serum PG, G-17, and Hp, followed by different scheduling endoscopy accordingly (37). The tested individuals were divided into four GC risk levels with stepwise increased GC risk: level A, Hp (−) and atrophy (−); level B, Hp (+) and atrophy (−); level C, Hp (+) and atrophy (+); and level D, Hp (−) and atrophy (+) (Supplementary Figure S3). Individuals with level A were retested for the Hp and atrophy

TABLE 1 Clinical and cost-effectiveness outcomes.

Strategy	No screening	40-GCRSS	45-GCRSS	50-GCRSS	55-GCRSS	60-GCRSS	65-GCRSS	70-GCRSS
GC incidence reduction[a], %	NA	70.6	67.2	62.1	56.0	33.0	21.9	15.4
GC deaths averted[b]	NA	7,374	6,997	6,495	5,848	3,639	2,208	1,416
Life-years[c]	56.060	56.855	56.827	56.707	56.625	56.336	56.152	56.110
Number of endoscopies[b]	NA	1,01,8390	8,81,227	7,29,442	5,87,214	4,55,496	3,25,224	2,14,120
Life-years gained per GC deaths averted	NA	10.8	11.0	10.0	9.7	7.6	4.2	3.5
Endoscopy screenings per GC deaths averted	NA	138	126	112	100	125	147	151
Endoscopy screenings per life-years gained	NA	13	11	11	10	16	35	43
NNS to prevent 1 GC death	NA	14	14	15	17	27	45	71
Complication-related deaths	NA	166	163	187	150	149	129	93
Net number of deaths averted [d]	NA	7,208	6,834	6,308	5,698	3,490	2,079	1,323
Benefit-to-harm ratio	NA	0.392	0.416	0.430	0.464	0.651	0.909	1.181
Costs[c,e], $	103.6	960.3	834.1	700.0	566.6	459.0	349.8	267.9
QALYs[c,e]	19.293	19.361	19.357	19.345	19.338	19.314	19.302	19.300
ICER ($/QALY)								
Vs. no screening	NA	12,601	11,476	11,464	10,315	17,164	27,446	22,420
Vs. previous[f]	NA	29,115	14,254	ED	10,315	ED	ED	ED

[a]Compared with no screening.
[b]Per 1,00,000 individuals.
[c]Per-person averages.
[d]Number of GC deaths prevented minus number of complication-related deaths.
[e]Discounted at an annual rate of 5%.
[f]Compared with previous less costly strategy.
GCRSS, gastric cancer risk score scale; GC, gastric cancer; NNS, the number needed to screen; QALYs, quality-adjusted life years; ICER, incremental cost-effectiveness ratio; NA, not applicable; ED, extended dominated (less effective and less cost-effective than a more expensive strategy).

status every 5 years, while level D would undergo annual endoscopic screening. Level B and C would receive triennial and biennial endoscopic screening, respectively, following standard quadruple therapy for Hp eradication (1,000 mg amoxicillin, 500 mg clarithromycin, 20 mg esomeprazole, 220 mg bismuth potassium citrate, twice daily for 2 weeks) (38).

According to the GC treatment guideline in China, individuals with an endoscopy result of dysplasia or asymptomatic GC stage I were subsequently offered an endoscopic submucosal dissection (ESD) or surgery to remove the mucosal lesions (9). The screening-related complications of bleeding and perforation were considered in ESD and surgery, and we assumed that individuals undergoing surgery would suffer surgery-related death. The corresponding progression risk was assumed to be decreased after ESD or surgery (39). We considered the characteristics of screening methods, such as sensitivity and specificity (40, 41). In the model, we assumed perfect adherence in all scenarios. The baseline values and plausible ranges of model parameters were listed in Supplementary Table S1.

Cost and utility estimates

We considered direct medical costs, such as serological tests costs; treatment costs for Hp, complications, and GC; endoscopic costs; and surgical procedures costs, which were obtained from local hospital (pricing of a local hospital, which was set by local governments according to national regulations) and published studies (Supplementary Table S1). All costs are reported in 2021 US dollars (1 USD = 6.4856 RMB, in 2021) (42).

Quality-adjusted life years were used to evaluate the health outcomes of each strategy and were defined as the survival time adjusted by the health utility. We assumed a utility score of 1 for normal and precancerous states because there is no available data on the quality of life of patients with GC precancerous lesions (43). The utility values for the four GC stages were derived from a Chinese population-based study (Supplementary Table S1) (43). We discounted costs and QALYs at 5% per year according to the China Guidelines for Pharmacoeconomic Evaluations (44).

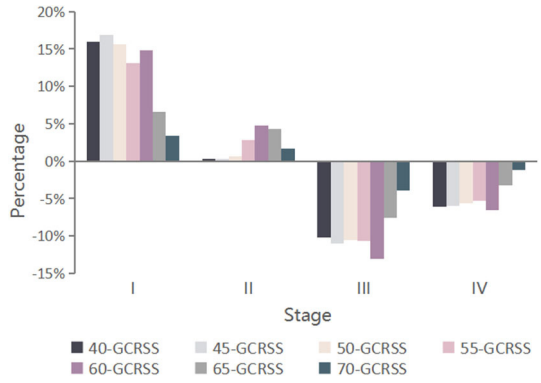

FIGURE 2
Changes in GC stage distribution for seven alternative screening strategies compared with no screening. GCRSS, gastric cancer risk score scale.

Sensitivity analysis

To explore the effects of parameter uncertainty, we conducted univariate sensitivity analyses for all parameters, and the plausible range was either determined by ±20% of the base value or based on the reported 95% uncertainty bounds (Supplementary Table S1). Additionally, probabilistic sensitivity analysis was performed based on 1,000 Monte Carlo simulations to estimate the combined uncertainty of all parameters and the probability of the strategy being cost-effective. To further evaluate the model robustness, we also conducted additional subgroup and scenario analyses.

Results

Clinical outcomes

Among the 100,000 hypothetical individuals aged 20 years followed up over a lifetime, there were 9,995 GC-related deaths in the unscreened cohort, with 11.6% GC incidence. For the 7 GCRSS strategies, as the starting screening age increased, the relative reduction in GC incidence and the estimated number of GC deaths prevented decreased from 70.6 to 15.4% and 7,374 to 1,416, respectively (Table 1 and Supplementary Figure S4). Furthermore, compared with no screening, the GC stage distribution of all strategies was significantly improved, with a substantially decrease in advanced GC stages (Figure 2). The proportion of GC stages III and IV increased slightly with increasing screening start age (Supplementary Figure S8).

Screening with the GCRSS strategy at the age of 40 years (40-GCRSS), the lifetime number of endoscopies was 1,018,390 per 100,000 individuals (Table 1). Although the 40-GCRSS strategy resulted in the greatest number of endoscopies, it provided the largest life-year gain and the greatest number of GC deaths averted among all strategies. We also calculated the incremental endoscopy screenings and life-years gained ratio by incremental endoscopy screenings divided by incremental life-years gained. The 40-GCRSS strategy was associated with the largest ratio of 49 endoscopy screenings per life-years gained (Supplementary Figure S6).

As another way to examine the strategies, the benefit-to-harm ratio was calculated. Screening from age 40 years would have the lowest benefit-to-harm ratio of 0.392. In contrast, there were more complication-related cases than GC deaths averted when screening was started at age 65 or older (Table 1).

Cost-effectiveness analysis

Compared with no screening, GCRSS screenings were associated with additional QALYs ranging from 0.007 to 0.068 at additional costs ranging from $164.3 to $856.7, giving ICERs ranging from $10,315 to $27,446 per QALY gained (Table 1). All the ICERs were lower than three times per capita GDP ($37,655 per QALY).

Further comparisons across all strategies were performed, and we calculated the corresponding cost-effectiveness frontier curves (Figure 3). This frontier was comprised of four strategies: the no screening strategy, the 55-GCRSS strategy, the 45-GCRSS strategy, and the 40-GCRSS strategy. At a WTP threshold of three times per capita GDP ($37,655 per QALY), although the 40-, 45-, and 55-GCRSS strategies were all cost-effective, the 40-GCRSS strategy was considered to be the leading cost-effective strategy because of its better effect.

Sensitivity analysis

Univariate sensitivity analyses found that the results were largely unchanged under the changes of each parameter. The relative risk of progressing from dysplasia after surgery and the surgery cost generated a significant influence on the ICER compared with no screening (Figure 4).

In the probabilistic sensitivity analyses, for a WTP between $0 and $6,300 per QALY, no screening was the most cost-effective strategy (Figure 5). When WTP was increased between $9,990 and $15,390 per QALY, screening with GCRSS from age 55 had the highest probability of being cost-effective. The 45-GCRSS strategy was the most cost-effective screening strategy in the WTP threshold range from $15,480 to $25,920 per QALY. Additionally, at a threshold of $26,010 and $37,655 per QALY, the 40-GCRSS strategy outperformed other strategies and showed 0.502 and 0.856 probability of being cost-effective, respectively.

In the three smoking subgroups, the relative reduction in GC mortality was similar between the 40- and 45-GCRSS strategy, which was slightly lower than that in the Hp+

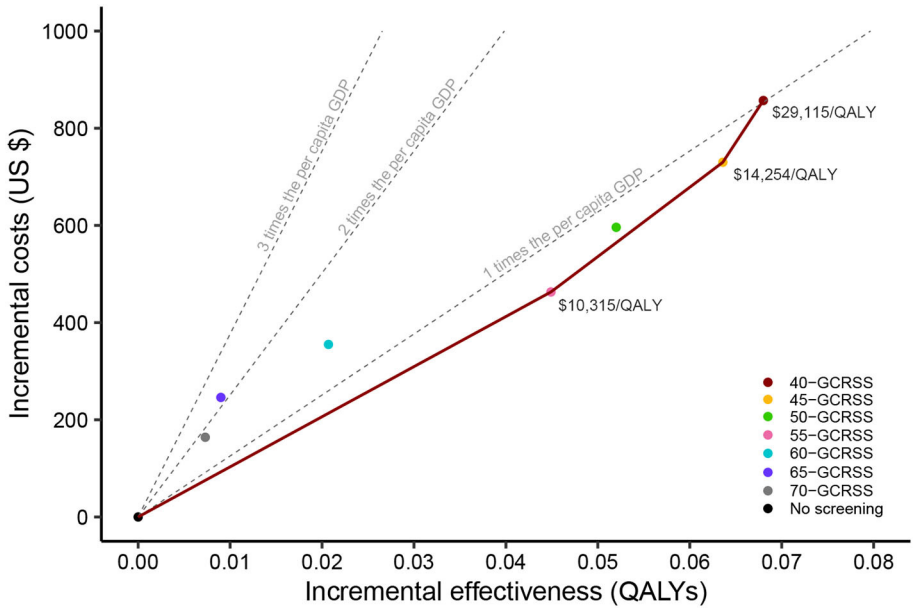

FIGURE 3
Cost-effectiveness frontier of seven alternative screening strategies and no screening. QALYs, quality-adjusted life years; GDP, gross domestic product; GCRSS, gastric cancer risk score scale.

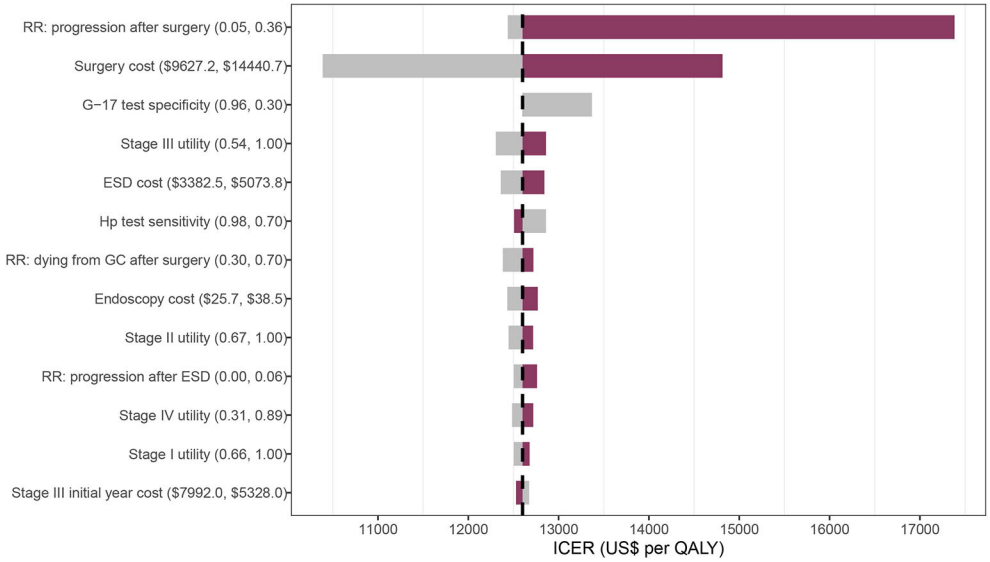

FIGURE 4
Tornado diagram on one-way sensitivity analysis of the 40-GCRSS strategy compared with no screening. RR, relative risk; G-17, gastrin-17; ESD, endoscopic submucosal dissection; Hp, *Helicobacter pylori*; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life year.

subgroups (Supplementary Figure S4). Obviously, almost all clinical outcomes performed best in the current smokers and Hp+ subgroups (Supplementary Table S3). Compared with no screening, the GC stage distribution changed significantly in stages I, III, and IV in subgroups (Supplementary Figure S7). In addition, screening in current smokers was more cost-effective than in the overall population or other subgroups (Supplementary Table S3).

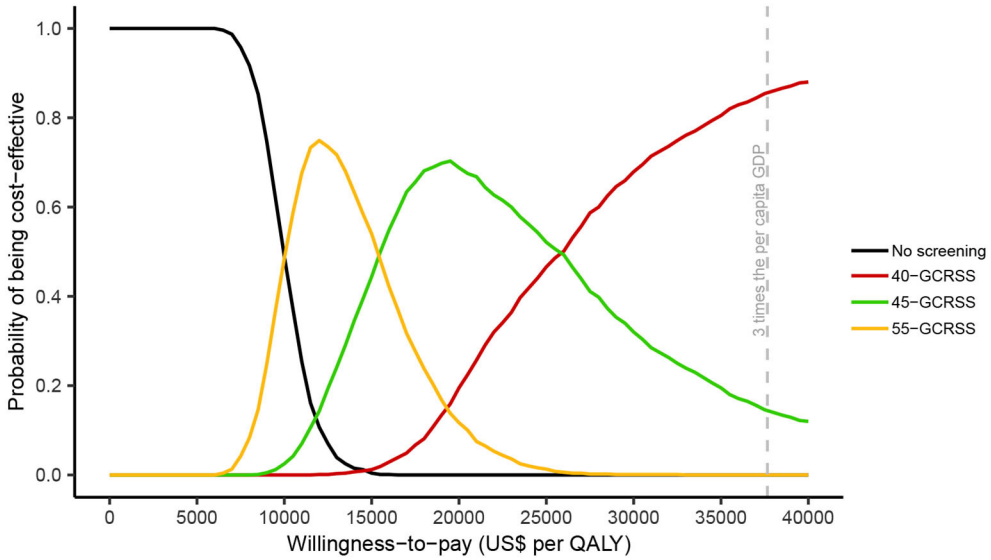

FIGURE 5
Cost-effectiveness acceptability curves. QALY, quality-adjusted life year; GDP, gross domestic product; GCRSS, gastric cancer risk score scale.

Discussion

We constructed a well-calibrated model to simulate the GC progression over the lifetime course under seven screening scenarios, and estimated the corresponding clinical benefits, harms, and cost-effectiveness over the lifetime course. The base case results of our model-based study suggested that screening with the GCRSS strategy from age 40 could improve the clinical benefits, benefit-to-harm ratio, and the cost-effectiveness of GC screening among all the strategies, with an ICER of $29,115 per QALY compared with the 45-GCRSS strategy below the WTP threshold of $37,655 per QALY.

To our knowledge, this is the first study based on a calibrated microsimulation model to comprehensively evaluate the long-term clinical and economic consequences of GC screening strategies. The previous studies mainly evaluated the cost-effectiveness of endoscopic screening programs directly for GC high-risk populations (45, 46). Actually, most of the high GC risk areas in China are rural, with scarce medical resources or limited endoscopic screening facilities (47, 48). If all individuals at high risk of GC undergo endoscopic screening, the endoscopy resources will not be enough to meet the huge demand (49). In addition, endoscopic screening is an invasive examination with poor repeatability and low compliance, which is not conducive to the early detection of GC, so that it is limited in the popularization of screening. Serological diagnosis of Hp and atrophy, as preferable to non-invasive measurement, can provide a more acceptable way for the detection of early GC. Although the serological test prior to endoscopy may entail additional cost, this cost may be offset by the reduction of GC disease burden caused by less endoscopy and higher compliance.

Different strategies have benefits and harms, thus the optimal strategy may depend on the acceptable trade-off. We found that the earlier the age of starting screening, the more screening-related adverse consequences are caused, but the more corresponding benefits are also obtained. The 40-GCRSS strategy was associated with a lower benefit-to-harm ratio of 0.392, while the ratio would exceed 1 as the starting age increased to 65. This means that there were more cases of screening-related adverse events than GC deaths prevented when screening was targeted to individuals aged 65 or older. Considering the balance of benefits and harms, it is not appropriate to start implementing the GCRSS strategy after the age of 65. China has a vast territory, and the level of economic development in different regions is uneven (50). Likewise, when choosing appropriate screening strategies, decision-makers should consider the local economic level and GC disease burden. Compared with the 40-GCRSS strategy, the 45-GCRSS strategy had a similar GC incidence improvement and the highest probability of being cost-effective at a WTP ranging from $15,480 to $25,920 per QALY. Consequently, if appropriate, it is preferable to set the starting screening age at 45 years for areas with limited health resources and underdeveloped economies.

With the implementation of the Healthy China 2030 initiative, the Hp infection rate and smoking rate in China will reach the goal of <20% (51, 52). Our scenario analysis results demonstrated that the ICERs of the 40-GCRSS strategy remained lower than $37,655 per QALY WTP threshold

compared with no screening, despite the Hp infection rate and smoking rate decreased (Supplementary Table S4). The simultaneous implementation of actions to reduce GC risk factors and cost-effective GC screening strategies will facilitate the reduction of the GC disease burden in China.

Eradication of Hp infection can improve the gastric mucosal inflammatory response, and prevent or delay the progression of atrophy or intestinal metaplasia (53). Hp infection is considered to be the most important and controllable risk factor for the prevention of GC, thus eradicating Hp should be the primary preventive measure (14, 54). Our study found that compared with Hp– subgroup, the GCRSS strategy screening for Hp+ individuals would provide Hp eradication therapy, which significantly improves the GC distribution and reduces the incidence and mortality of GC. The GCRSS strategy combined Hp detection and eradication with endoscopic screening, which obtained additional benefits from eradicating risk factors than endoscopic screening alone. Furthermore, it also provided individuals with appropriate endoscopy screening frequency according to the Hp infection status, which improved their compliance with endoscopy. We changed the effect of the progression relative risk for surgery for a further sensitivity analysis. When the relative risk was lower than 0.9, the ICER of the 40-GCRSS strategy was lower than the $37,655 per QALY threshold compared with no screening (Supplementary Figure S9). Even if there is little to no improvement after surgery, it remains a high-value strategy for improving cancer outcomes. The traditional method for the treatment of early GC is surgical resection, after which the 5-year survival rate can reach more than 90% (55). However, surgery destroys the normal anatomical structure of the stomach and affects the long-term physiological function of the patient. ESD is superior to surgery in safety and effectiveness (56), and it is recommended by the guidelines as the preferred alternative for dysplasia or early GC (57). If ESD treatment is mature and widespread, the corresponding screening strategy will be more effective and cost-effective.

This study has limitations. First, utility values of precancerous lesions states might not accurately represent the patients' quality of life. Patients with precancerous lesions may have a worse quality of life than the general population, while the reasons for the decrement are unclear and the evidence is limited (58). Second, we used perfect adherence to all scenarios. However, this assumption provided the model with the ability to predict the maximum achievable benefits of public health strategies. Third, although there are many factors that may play a role in the development of GC, smoking and Hp factors, which we considered in our model, are the two strongest risk factors for GC (25, 26). Finally, future studies can further compare the GCRSS strategy with different GC screening strategies to explore the more suitable GC screening strategies for the China setting.

Conclusions

This modeling study suggested that from the Chinese healthcare system perspective, the GCRSS strategy screening from age 40 was an effective and leading cost-effective strategy in China. The findings provide an important basis for policymakers to formulate and optimize GC prevention and control policies in China.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

SQ, XWang, XWan, CT, and XZ conceived and designed the study. SQ, XWan, XWang, SL, MW, YP, and LW developed the economic model, collected the data, performed the analyses, and interpreted the results. CT, XZ, and XWang supervised the analyses. SQ and XWan drafted and critically revised the manuscript for important intellectual content and approved the version to be published. All authors had full access to all the data and take responsibility for the integrity of the data and reviewed and approved the final version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Investigating revisit intention of medical tourists in China through nutritional knowledge, perceived medical quality, and trust in the physiologist: A recommendation on health tourism policy measures

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Good medical care has long been a top priority in health tourism to keep the flow of visitors coming for medical treatment. Medical tourism encompasses a range of treatments, from basic check-ups to surgical operations. For its friendly character and high quality of service, China has earned a reputation as one of Asia's top destinations for health tourism. Along with India and Taiwan, Japan, Thailand, and South Korea are China's top tourism destinations. Considering the above fact, this study aims to examine the influence of nutritional knowledge, perceived medical quality, and trust in physiologists on revisiting the intention of medical tourists in China. This study is cross-sectional and follows a quantitative approach. The researchers used questionnaires as a survey tool to obtain information from the respondents. The respondents of this chosen international tourists in China who come for medical treatment purposes. A systematic random sampling technique was used to select the respondents, and 315 usable responses were collected from the respondents and proceeded with further analysis. The study conducted structural equation modeling using Smart PLS version 3. The results found that nutritional knowledge, perceived medical quality, and trust in physiologists significantly influence the revisit intention of medical tourists in China.

KEYWORDS

revisit intention, medical tourists, nutritional knowledge, perceived medical quality, trust in the physiologist

Introduction

Chinese consumers with a substantial spending capacity are mostly interested in regular check-ups and cosmetic surgery. Many people go to South Korea for popular chemotherapy, cosmetic surgery, and skin procedures. Chinese patients accounted for 10% of the 320.000 tourists seeking treatment (1). Thailand is another popular location because of its high-quality treatments, affordable costs, and closeness to other famous vacation spots. Between January to April 2019, Chinese medical visitors grew by 30%. Aesthetic surgery, dental operations, and fertility treatments are some of the most in-demand services in the nation. China has several medical clinics that cater to international visitors. One of the most well-documented instances occurred on a tropical island in southern China. Traditional Chinese medical facilities established an international health centre that has since treated many foreign patients (2). Its services are in great demand.

Patients may get treatment at the facility while also enjoying Hainan's sun, beach, and surrounding natural beauty. The state government has made significant contributions to the growth of medical tourism. The government established an experimental zone for foreign medical tourism in a community on the island's east coast. It is referred to as the "Lecheng Pilot Zone" because it has medical products instruments from Japan, the European Union, and the United States that are currently unavailable in other regions of China. Provincial areas have promoted tourism projects and developed tourist routes like Beijing and Hainan since 2011.

The relationship between healthcare and tourist has resulted in one of the greatest service businesses in many nations. Medical tourism provides considerable economic advantages to many destination countries. Indeed, medical tourism is one of the world's fastest expanding tourist businesses (3, 4). To compete in an increasingly competitive medical tourism sector, many medical clinics in destination nations have upgraded their facilities and services to match those found in many top hotels (5, 6). These organizations often provide their overseas clientele with high-quality medical treatment and better service. Some potential difficulties or inconveniences overseas patient travelers encounter (e.g., language barriers, inefficient communication, low-quality medical care, uncomfortable atmospheres, low-quality services, unkind staff) are drastically decreased in dedicated medical tourism clinics (7, 8). To alleviate these difficulties and inconveniences in South Korea, many clinics have improved the quality of clinical services and lowered nurse-patient ratio and service performance (9, 10). As facilitators, these initiatives contribute to the rising number of overseas tourists visiting Korean clinics for medical treatment/healthcare/aesthetic treatments (11).

Medical tourism and allied enterprises have long been recognized as one of the most profitable hospitality industries in many destination nations, especially developing countries (12). The industry is growing at a breakneck pace, and rivalry in the worldwide medical tourism sector is heating up (13). In such a competitive climate, practitioners' primary objective is to acquire new medical travelers through marketing and motivate them to make repeat purchases *via* quality efforts/strategies (14). Recent statistics indicate that retaining current customers is around five times more lucrative than customer acquisition (15). Higher customer retention will likely boost any firm's profitability (16). Thus, in the medical tourism industry, identifying critical elements influencing medical tourists' repurchase decision-making procedures and comprehending their unique function is becoming more critical for every destination country and its associated medical facilities. Quality of product and service, contentment, and loyalty have long been viewed as essential factors in understanding the post-purchase behavior of customers. Most researchers think that these elements lead to positive attitudes about a business and impact loyalty and retention (17). Recognizing the significance of such elements, every organization in the tourism and tourist industries is becoming more concerned with efficiently controlling and enhancing quality, trust, and satisfaction. Thus, how to guarantee that consumers get a higher degree of quality from a product or service increase their level of pleasure and build their trust in the product's/performance services are some of the critical problems confronting today's hospitality and tourist marketers. This study examines the influence of nutritional knowledge, perceived medical quality, and trust in physiologists on revisiting the intention of medical tourists in China. This study is expected to provide insights for practitioners and academicians for further enhancement of practices in medical tourism and its research development.

Literature review and hypothesis development

Theoretical underpinning

The Theory of Planned Behavior (TPB) is aimed at improving the predictive power individual's intention. Initially, the behavioral intention was predicted by subjective norms and attitude; however, later on, Ajzen (18) realized that volition behavior control was excluded in the previous model. According to this theory, behavioral intention best predicts actual behavior. Behavioral intention has been described as a state of an individual's readiness to perform a certain behavior. This factor has also been identified to be an immediate antecedent of actual behavior (18). Several researchers have used the TPB to predict and understand people's intentions in various tourism contexts, such as leisure time physical activity (19), outdoor recreation (20–22), leisure travel behavior (23, 24), casino gambling (25, 26), and exercising behavior (27, 28). Most of the above studies

demonstrated that the TPB could be used in predicting and explaining participation in diverse leisure activities or behaviors. Hrubes et al. (29) applied the TPB to predict and explain outdoor recreationists' hunting intentions and found several factors strongly influenced hunting intentions. The Theory of Planned Behavior underpins the framework established in this study as this study aimed to explain the revisit intention of tourists for medical purposes in China.

Hypothesis development

Nutritional knowledge and revisit intention

Human growth, development, and long life depend on a healthy and productive diet. Healthy nutrition relies on adequate nutrients tailored to the individual's age, gender, and physiological state (30–33). A wide variety of dietary options are available to the public daily, making it difficult for individuals to get the required nutrients in adequate quantities. One food product is preferred over another because of the consumer's preferences. People's perception of basic tastes may be altered by biological changes, influencing their food choices. In addition, food preferences are influenced by psychological aspects that begin in infancy and continue throughout a person's life and diverse food-related learning experiences (34, 35).

The impact of food on healthy eating practices is well established (36). Dietary habits have been shown to reduce the risk of various chronic illnesses and death (37) WHO considers a lack of fruits, legumes, vegetables, nuts, and grains an unbalanced diet. A further risk factor for chronic illnesses is a diet high in fat, sugar, and salt (38, 39). When consumed in suitable quantities for developing and maintaining health *via* their vitamins and minerals, fruits and vegetables are considered healthy and savory (40). Studies show that individuals should take 400 g of fruit and vegetables daily, equivalent to five servings of 150–200 g each of veggies and 200 g each of fruit (41, 42). Fatty foods might be tasty, but they are also considered harmful depending on the dish in question. In order to maintain a healthy daily caloric intake, it is advised that individuals eat a maximum of 35 percent of their total daily calories from fat, which means avoiding meals high in saturated and trans-fatty acids (43). Proteins derived from animals, such as red and white meat and fish, eggs and dairy products, are likewise regarded as healthy and suggested for frequent consumption since they include important amino acids that promote growth and development (44–46). Consuming at least 48 g of whole grain food items with high carbohydrate content is also suggested since this increases satiety. It improves digestive health thanks to the dietary fiber they contain (47). Chocolate and ice cream are often delectable treats (48). This study posits the following hypothesis:

H1: Nutritional knowledge is positively related to revisit intention of medical tourists

Perceived medical quality and revisit intention

When it comes to describing what it means to judge a company's goods and services for excellence vs. alternatives given by rivals, existing literature on the subject offers few new conceptualizations (49). This quality has two primary aspects: core and service products (50). Core product quality measures how well a product performs concerning its price, while service product quality measures its performance due to interactions with the service staff (51). As part of the current research, perceived clinical quality refers to an individual's evaluations of the core medical product performance (e.g., excellence of medical care and clinical skills, wider access to medical products). In contrast, quality of service indicates the assessment of the performance of medical practitioners and staff (e.g., delivering services skills and competencies). Even though several conceptions of contentment have emerged over the last few decades, academics generally believe that individual contentment is an appraisal of the total experience with consuming (52). Customers' desire and ability to make more purchases will rise if they have a positive impression of their whole shopping experience (53).

Research has shown that quality and pleasure are key in creating intentions (54, 55). There is a clear link between quality and satisfaction, and the connection between quality and satisfaction is a substantial predictor of satisfaction (56, 57). The service links customer satisfaction and behavioral intentions, and product quality impacts customer satisfaction (58).

Li and Shang (59) found that in the service industry, the quality satisfaction connection is crucial to creating one's intention. These elements likewise influence customers' behavior (60, 61). Shen and Yahya (62) repeatedly found that the quality components of food, atmosphere and service had a substantial impact on satisfaction, and these linkages could explain the establishment of an intention. According to these most current research findings, the quality-satisfaction link heavily influences individuals' decision-making processes. This study posits the following hypothesis:

H2: Perceived medical quality is positively related to revisiting the intention of medical tourists

Trust in physiologists and revisit intention

The customer-provider relationship's long-term sustainability depends heavily on the mutual trust of both parties (63, 64). Ndubisi and Nataraajan (65) defined expectations formed by the customer that the provider is trustworthy and can be relied upon to execute its commitments. Academics widely accept trust as an efficient technique for reducing or exacerbating the causes of ambiguity (66, 67). Both employee/staff and company policies/practices must be trusted in order for trust to exist. One aspect

of trust is dependent on client impressions of employee behavior/performances in a service experience context, while another aspect relies on corporate performance, such as its rules and procedures.

According to the idea of the agency, regardless of the depth of the connection between a firm and its clients, trust is more likely to lead to loyalty (68). Client business relation type was shown to have a moderating effect on intention development, and confidence in both the workers and firm was established based on customers' satisfaction with techniques used to manage complaints. In turn, this trust influenced customers' inclinations to promote good word-of-mouth and to repurchase. Sullivan and Kim (69) found that consumers' levels of trust strongly influenced their willingness to repurchase a product online. Customers' confidence in a seller grows when they have a positive experience buying from an online store. Customer satisfaction with exceptional product performance increases their faith in the provider's dependability and integrity, leading to the success of these satisfying experiences as a key influencer of repeat-purchase willingness. According to Gu et al. (70), trust is especially important in medical tourism because of the rising concerns about inadequate continuity of treatment and low-quality care in the quickly developing international medical business. Overall, this prior research has experimentally supported the idea that patient-satisfied customers are a substantial driving factor of trust and that this confidence plays an important part in creating behavioral intentions about medical treatment. This study posits the following hypothesis:

H3: Trust in physiologists is positively related to revisiting the intention of medical tourists.

Methodology

Sampling design and data collection

This study is cross-sectional and follows a quantitative approach to examine the influence of nutritional knowledge, perceived medical quality, and trust in physiologists on revisit intention of medical tourists in China. A cross-sectional study usually involves measuring all variables for all cases within a short period and once only. A systematic random sampling technique was used to select the respondents, and 315 usable responses were collected from the respondents and proceeded with further analysis. The researchers used questionnaires as a survey tool to obtain information from the respondents. The respondents of this chosen international tourists in China who come for medical treatment purposes.

Measurement of the study

The measurement of this study was adopted from previous studies. One-to-seven-point Likert scales have been used to measure responses (1) Strongly disagree, (2) Disagree, (3) Somewhat disagree, (4) No opinion/ Neutral, (5) Somewhat agree, (6) Agree, (5) Strongly Agree. Five items were adopted from Oh (71) and Taylor and Baker (72) to measure perceived medical quality. Nutritional knowledge was measured using five items adapted from Ceylan et al. (73). Trust in physiologists was measured using five items adapted from Santos and Basso (74). Revisit intention was measured using three items adapted from Han (75).

Data analysis

SEM measures and accommodates observed variables, representing any ambiguity in a construct of latent variables and simultaneously explaining casual relationships among latent and observed variables (61, 76). Besides, some of the measurement errors prevalent in tourism research can be solved using PLS-SEM with many latent variables (77–79). The initial analysis was conducted using SPSS version 23, and structural equation modeling was conducted using Smart PLS version 3.

Analysis and hypotheses testing

The researchers examined the data using PLS-SEM to assess nutritional knowledge, perceived medical quality, revisit intention and trust in physiologists. We report results using a significance level at $p < 0.01$ and $p < 0.001$.

To develop the research variable, several important procedures were followed to construct validity, reliability, and content validity. In terms of content validity, a variety of operational aspects were evaluated using pre-existing research and multiple-item measurements. Both confirmatory and exploratory analyses confirm the factorability of the variables. An example of this is depicted in Figure 2. One item had a loading above 0.60, and the rest exceeded the recommended 0.70 loadings. Table 1 lists all the constructs, and the Cronbach alpha for each is $\geq$0.70.

We checked the average variance extracted to ensure convergent validity and found that every variable was more significant than or equal to the recommended value of 0.50. As a result, all variables point to the validity and dependability of the content. Furthermore, the overall reliability of the composite was above the standard.

Figure 3 shows the factor loading of individual items and confirms the confirmatory factor analysis. To evaluate the discriminant validity of the 4-variables used in the study, Heterotrait-and Monotrait (HTMT) analysis was performed.

The result of the confirmatory factor analysis shown in Table 2 and Figure 1 supports the empirical evidence of the distinctiveness of the variables. No correlation exceeds the limit of maintaining an HTMT value of 0.85. Thus, all the study variables ensured the discriminant validity for further analysis.

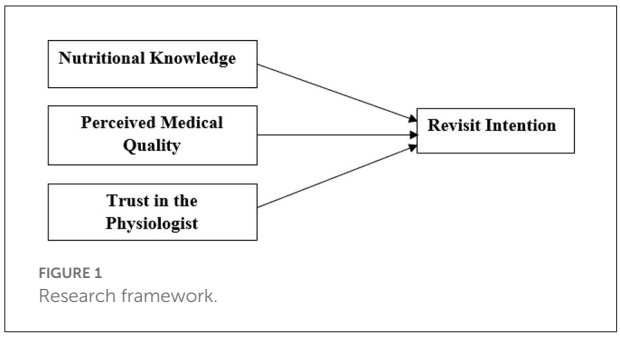

FIGURE 1
Research framework.

Structural equation modeling

In Smart-PLS, two models examine the effects of independent variables on the dependent variable: the measurement model and the structural model. These include

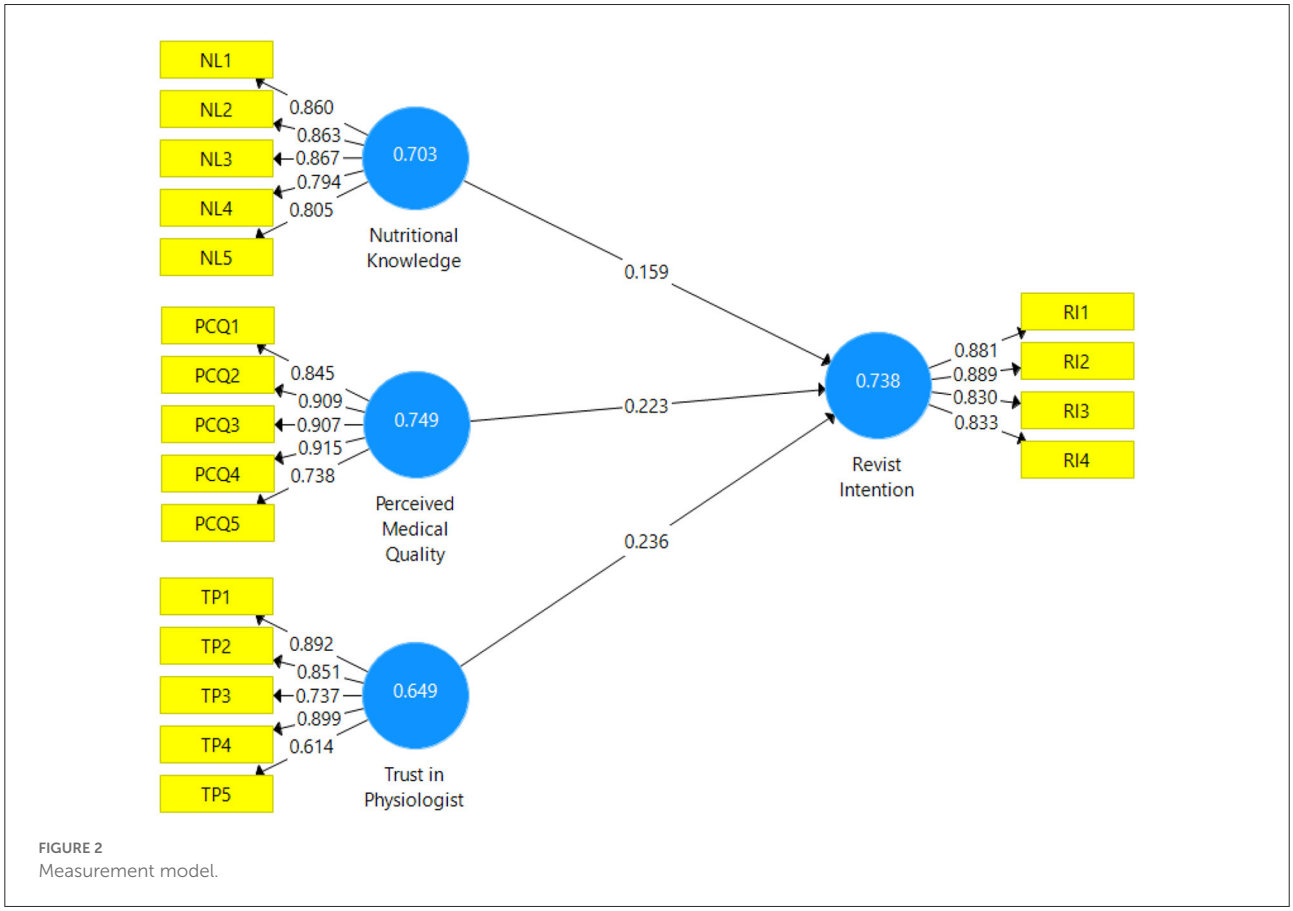

FIGURE 2
Measurement model.

TABLE 1 Construct validity and reliability.

Variables	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Nutritional knowledge	0.896	0.922	0.703
Perceived medical quality	0.916	0.937	0.749
Revisit intention	0.881	0.918	0.738
Trust in physiologist	0.862	0.901	0.649

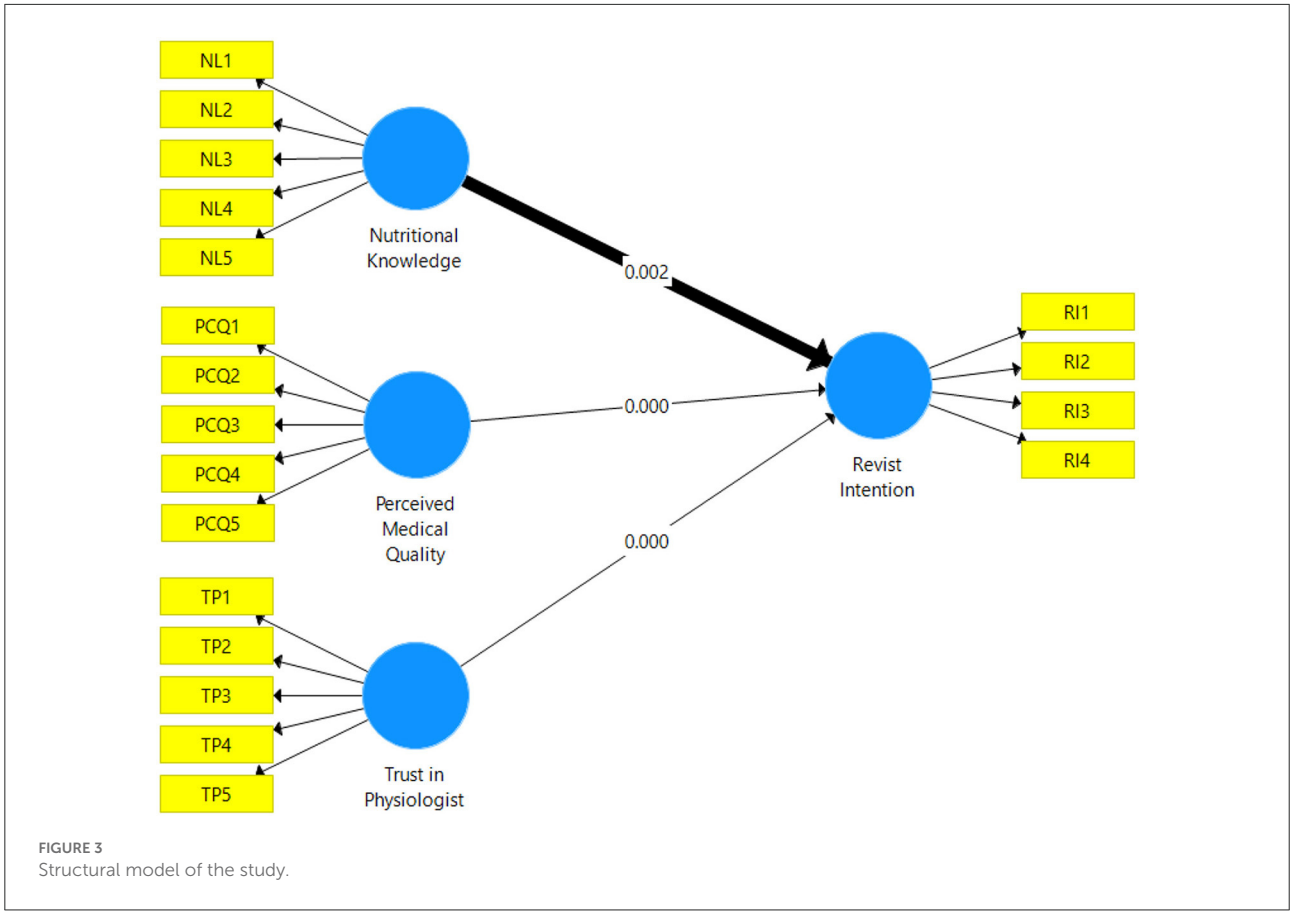

FIGURE 3
Structural model of the study.

TABLE 2 Discriminant validity (HTMT).

	Nutritional knowledge	Perceived medical quality	Revisit intention	Trust in physiologist
Nutritional knowledge				
Perceived medical quality	0.123			
Revisit intention	0.234	0.337		
Trust in physiologist	0.152	0.367	0.369	

constructing validity and reliability, which have already been discussed in detail. R square is also shown in the structural modeling equation for the ability of independent variables to predict the outcomes of their underlying dependent variables. The three variables chosen to have an R2 of 0.178, indicating a connection between nutritional knowledge, perceived medical quality, revisit intention and trust in physiologist. As a further measure of model fit, the SRMR (statistical correlation coefficient) was calculated, which was found to be 0.07.

As demonstrated in Table 3, the nutritional knowledge (β = 0.159, T value = 3.166, *P*-value = 0.002), perceived medical quality (β = 0.223, T value = 3.931, *P*-value = 0.000), and trust in physiologist (β = 0.236, *T* value = 4.263, *P*-value = 0.000) all have a significant influence on patient satisfaction. Nutritional knowledge has the greatest impact on revisit intention. Besides, perceived medical quality has a significant positive influence on revisit intention. And trust in physiologist has a positive effect on revisit intention, as does perceived value positively affect patient satisfaction. As a result, all hypotheses are supported.

Discussion and conclusion

Although medical tourism has grown rapidly, little is known about the significance of quality, satisfaction and trust in the post-purchase behavior of overseas patients. The major goal of this research was to build a conceptual background that clearly explains the creation of foreign medical tourists'

TABLE 3 The direct effects of HRM practices on operational performance.

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	*P*-Values
Nutritional knowledge -> revisit intention	0.159	0.167	0.050	3.166	0.002
Perceived medical quality -> revisit intention	0.223	0.225	0.057	3.931	0.000
Trust in physiologist -> revisit intention	0.236	0.239	0.055	4.263	0.000

intentions by examining the influence of perceived medical contentment, service quality, confidence in the personnel and clinic, and pricing reasonableness. Study participants were asked about their intentions to return to the clinic and the target country for medical treatment, and researchers looked at the relationships between these constructs to determine the moderating effect of perceived price rationality, as well as the relative importance of the various study variables that influence participants' intentions.

The current research effectively integrated the theoretical framework explaining the establishment of repurchase intention into the health center and its medical staff quality and trust. Medical travelers' opinions of price reasonableness were also included in this research, which effectively identified the underlying moderating effect of this variable. Although we do not claim that our conceptual model is highly robust, our model illustrated how international medical tourists' behavioral intentions might be developed. Although our theoretical framework incorporates these crucial elements, it has a solid foundation. Despite the lack of research on medical tourists' price-related decision-making in the medical tourism business, this study adds to that literature. To retain and grow their client base, medical clinics and the nations where they do business need to understand the critical role that pricing plays in attracting new business and maximizing existing income. Any transaction in which a client is engaged is likely to be judged on the basis of how they exploit it (80, 81). Customers are generally more inclined to think of a company's pricing as fair the more advantages they obtain (82, 83). Understanding the complexity of reasonable pricing is essential for practitioners who want to encourage repeat customers to believe they can expect a wide range of essential outcomes from their purchases [e.g., complementary aesthetic services to non-aesthetic repeaters (e.g., skincare evaluation, chemical peels for increasing skin glow, facial cleanses), gift certificates for local restaurants, local souvenirs]. Segmenting the market is also a good idea. Some developed countries choose lower-cost medical care, although upper-class citizens from developed and developing countries go overseas for high-quality and secure medical treatment while seeking hotel-style comforts in clinics rather than spending several hours in crowded areas (84). Customers of this kind will want detailed service and price strategies. Even though the costs of some treatments are exorbitant, wealthy patients who go to the clinic for treatment may think that these higher costs are justified since the clinic provides a luxurious amenities floor with hotel-style facilities and medical care.

Policy implications

The study's policy ramifications are clear. Hospital use in urban and rural locations differs from a new routine due to evidence of rural inhabitants traveling to metropolitan areas for medical care. With the adoption of intra-provincial referral systems, branches of major hospitals in suburban regions have to be given greater attention than before. The central government should consider the local metropolitan community and the adjacent rural population when supplying precise medical resources. Facilities and resources should be distributed fairly and efficiently. Other developing nations with comparable medical systems and rapid urbanization may benefit from this study's findings. Because of this, policy implications may be used as a point of reference.

Practical implications

This study examines the influence of nutritional knowledge, perceived medical quality, and trust in physiologists on revisiting the intention of medical tourists in China. This study is expected to provide insights for practitioners for further enhancement of practices in medical tourism and its research development. The outcome of this study is expected to benefit the practitioners by looking into the aspects of Chinese tourism industry, more specifically medical tourism. The practitioners will get more ideas on tourists' perspectives how it can be improved in future in terms of nutritional knowledge, perceived medical quality, and trust in the physiologist. The practitioners could take the note based on the study's outcomes and utilize it practically for more positive implications.

Limitations and future directions of the study

Further studies should examine the variations in perceived and expected efficiency between non-profit and for-profit medical institutions, between private and public-owned facilities and between the perspectives of patients and service providers. Patients' expectations and satisfaction could also be analyzed to see statistical significance variations between persons in a healthcare facility due to an injury or recovery and those who utilize medical services to enhance their wellbeing. New items and questions on the significance of specific characteristics for patients might be added to the study instrument.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

ZF: conceptualizing and introduction. WB: literature review. BJ: method. LL: data collection and reporting. AP: data analysis. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Official tenure and governance effectiveness of China's basic pension insurance system: An inverted U-shaped curve

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Objectives: Based on incentive theory of motivation, this paper aims to estimate China's basic pension insurance's annual efficiency and inter-period efficiency changes from 2015 to 2019 and further examine the relationship between official tenure and basic pension insurance governance performance.

Methods: The DEA—BCC model was used to evaluate the operating efficiency of basic pension insurance in 31 provinces of China. And four panel Tobit models were constructed to examine the heterogeneous linkages between officials' tenure and governance efficiency in different regions of China.

Results: The results showed that there was an inverted U-shaped relationship between the official tenure and the governance efficiency of basic pension insurance. The younger an official was in his current position, the more apparent the inverted U-shaped relationship between the tenure of an official and the governance efficiency of basic pension insurance. We also found that localized government officials showed better governance efficiency of basic pension insurance. However, as the term of office of officials increased, the governance efficiency of non-localized officials showed a steeper negative effect.

Conclusion: This study firstly reveals a significant relationship between the characteristics of officials and the operation of China's basic pension insurance system, which is a complement to the study of China's basic pension systems.

KEYWORDS

basic pension insurance, official tenure, governance efficiency, DEA-Tobit, CLAD model

Introduction

At the Fifth Plenary Session of the 19th CPC Central Committee, the Chinese government proposed the central task of improving the multi-level social security system. Consequently, promoting people's well-being is one of the main goals of economic and social development during the 14th Five-Year Plan period (1). Since its establishment, China's pension insurance system has had a strong capacity to pay, and its significance

in maintaining social stability and promoting economic growth has been continuously reinforced (2). However, the aging of the population and unbalanced structure of the pension system impose a heavy governance burden on the fund regulator (3). Actually, the fragmentation of China's basic pension insurance system is not only characterized by geographical differences, but also by urban-rural differences (4). Therefore, the effective adjustment and allocation of the basic pension insurance system are gradually becoming an essential part of the basic security for the elderly, which is closely related to the overall situation of reform, development and stability.

There are many studies on China's basic pension systems, such as evolution of pension reform (5–7), assessments of urban employees' pension plan and new rural pension scheme (8–11), and simulation of the effect of delayed retirement on welfare of the elderly (12–15). It is noteworthy, however, that the current literature on basic pension insurance system still lacks systematic and integrated research to examine the relationship between official characteristics and governance performance. To our knowledge, the rational allocation of basic pension insurance system is related to officials' performance, and the implementation of officials will affect personal promotion (16). Therefore, officials also have governance motives, hoping that basic pension insurance system will be more efficient and it can be promoted accordingly (17). In view of theoretical knowledge of politician' incentives and behaviors for career advancement (18), we believe that there is a relationship between the characteristics of officials and the governance performance of China's basic pension insurance system. This paper aims to address three questions: (1) What is the specific relationship between official tenure and the governance effectiveness of the basic pension insurance system? (2) How does the age of officials moderate the relationship between the tenure of officials and the governance effectiveness of basic pension insurance system? and (3) How does the localization of officials moderate the relationship between the tenure of officials and the governance effectiveness of basic pension insurance system? To solve these problems, we use the data of the basic pension insurance system provinces from 2015 to 2019 as a sample to empirically examine the impact of officials' characteristics on the governance performance of China's basic pension insurance system.

The study offers some important insights into three ways. First, it uses the DEA-Tobit method and combines the sample data of the basic pension insurance system in each province of China. This study firstly reveals a significant relationship between the characteristics of officials and the operation of China's basic pension insurance system, which is a complement to the study of China's basic pension systems. Second, this paper uses the sample data related to the characteristics of officials in the regression analysis, and further confirms the empirical results obtained by the Tobit model through CLAD method. We found that there is an inverted U-shaped relationship between official tenure and governance effectiveness in the field of social security, which is a new finding in the study of official incentives and governance. Third, in the early 1980s, China established a cadre retirement system, which created institutional conditions for personnel management and realized the rejuvenation and knowledge of government officials and cadres. Meanwhile, the research finds that the current age of officials can moderate the relationship between official tenure and the governance effectiveness of basic pension insurance system, which also verifies the scientific nature of the system. Therefore, this paper also has management inspiration and guiding significance for the actual decision-making of government departments.

We conducted a literature review based on the variables and propose three hypotheses in the second part. The third part discusses the research methods and variables of the operation efficiency of China's basic pension insurance system. The fourth part makes an empirical analysis and test on the operation efficiency of pension insurance system based on the characteristics of officials. In the fifth part, we draw conclusions and suggestions on improving the operational efficiency of China's basic pension insurance system from the perspective of official characteristics in practical terms.

Theoretical background

Official tenure and governance effectiveness of basic pension insurance system

In the 1990s, scholars discussed the role of the political system and government governance on regional or national economic development (19). The role of governance, quality and effectiveness of regional economic growth has aroused interest (20, 21). Since then, official tenure, as an important factor affecting political incentive of motivation, has aroused many thoughts on its impact on economic growth (22). Since the reform and opening up, economic development data and tenure records of provinces across China show that the relationship between tenure and national economic development exhibits an inverted U-shaped non–linear relationship (23). A similar phenomenon also occurs in marine environmental pollution and environmental efficiency. Jiang and Li (24) confirmed that the tenure of local officials and marine environmental pollution have an inverted U-shaped non–linear relationship, and the effect of promotion incentive on the quality of the marine environment is aggravated by the tenure of local officials (24). In addition, Lu. et al. (25) also confirmed that this inverted U-shaped relationship also existed in mayors' tenure and environmental efficiency (25). Based on the above analysis, we put forward the hypothesis:

H1: There is an inverted U-shaped relationship between the official tenure and the governance efficiency of China's basic pension insurance system.

The current age of officials and the governance effectiveness of basic pension insurance system

Visions are important to organizational effectiveness (26). In China, the age of an official reflects the ability and professional experience to a certain extent, and the knowledge and experience of local officials increase with age (27). Economic development and environmental governance are two significant indicators related to the level of social welfare. With the increase of tenure, the impact of local officials on carbon emissions showed an inverted U-shaped relationship, and younger local officials were more likely to lead to a rise in carbon emissions (28). By constructing an official competition game scenario, young officials hope to maintain a good record and upward momentum in all tenures, and tend to improve their jurisdictions' economic performance in a short time. At the same time, it is found that veteran cadres are good at overall planning. They tend to balance economic development and environmental protection (29). Therefore, we assume that the current age of officials will moderate the relationship between official tenure and the governance effectiveness of China's basic pension system. The hypotheses are developed as follows:

H2a: The younger the official is, the more significant the inverted U-shaped relationship between official tenure and the governance effectiveness of the pension system.
H2b: The older the official is, the weaker the inverted U-shaped relationship between official tenure and the governance effectiveness of basic pension insurance system.

The localization of officials and the governance effectiveness of basic pension insurance system

In China, government officials play an indispensable role in promoting the rapid development of the regional economy (22). At the same time, China's unique cadre system has the function of promoting the diffusion of local policy innovations. Among them, government officials' cross-regional redeployment (or relocation) significantly affects local economic development and environmental protection (30). Furthermore, the diffusion method of policy innovation after officials was transferred to different places, and the reasons they were able to quickly promote their own innovation experience could be effectively explained by democratic evaluation reform and institutional merger reform (31). Hence, we hypothesize that official localization will moderate the relationship between official tenure and the governance effectiveness of basic pension system. The hypothesis is developed as follows:

H3: Official localization moderates the relationship between official tenure and the governance effectiveness of basic pension system.

Methods

DEA-BCC model

We use the input-oriented BCC model to calculate the technical efficiency, pure technical efficiency and scale efficiency of each decision-making unit (DMU). When the technical efficiency is equal to 1, it means that the DMU is at the technical frontier; when the technical efficiency is <1, it means that the DMU has not yet reached the production frontier, indicating that the basic pension insurance allocation efficiency has not yet reached the optimum. The BCC model can be expressed as:

$$\begin{aligned} \min[\theta - \varepsilon(e^T S^- + e^T S^+)] &= V_{TE} \\ \sum_{i=1}^{n} X_i \lambda_i - S^- &= \theta X_{i0} \\ \sum_{i=1}^{n} Y_i \lambda_i - S^+ &= \theta Y_{i0} \\ \sum_{i=1}^{n} \lambda_i &= 1 \end{aligned}$$

Among them, $\boldsymbol{\lambda_i} \geqq 0$, i=1,2,3,...,n, $S^+ \geqq 0$, $S^- \geqq 0$; θ represents the effective value of the decision-making unit, S^+, S^- and e represent the input slack variables, the remaining variables and Non-Archimedes infinitesimals. X and Y represent the input and output combinations related to the governance performance of pension insurance system, respectively, and $\boldsymbol{\lambda_i}$ represents the weight of the *i-th* decision-making unit.

Tobit regression analysis

The sample used in this paper is panel data of China's provinces from 2015 to 2019. Since the efficiency evaluation result of BCC model calculation, that is, the technical efficiency of DEA (Data Envelopment Analysis) model calculation, was constrained between [0, 1], it is an indirect observation variable. When it was used as a dependent variable, an estimation bias occurred if the Ordinary Least Squares (OLS) method was used to estimate the incompleteness of the data presentation.

Therefore, we used the Tobit panel regression model to analyze how the characteristics of Chinese officials affect the governance efficiency of the basic pension insurance system. The model is as follows:

$$TE_{i,t} = \alpha_0 + \alpha_1 Age_{i,t} + \alpha_2 Local_{i,t} + \alpha_3 Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$TE_{i,t} = \alpha_0 + \alpha_1 Tenure_{i,t} + \alpha_2 Tenure_{i,t}^{2} + \alpha_3 Age_{i,t} + \alpha_4 Local_{i,t} + \alpha_5 Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$TE_{i,t} = \alpha_0 + \alpha_1 Tenure_{i,t} + \alpha_2 Tenure_{i,t}^{2} + \alpha_3 Age_{i,t} \times Tenure_{i,t}^{2} + \alpha_4 Age_{i,t} + \alpha_5 Local_{i,t} + \alpha_6 Controls_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$TE_{i,t} = \alpha_0 + \alpha_1 Tenure_{i,t} + \alpha_2 Tenure_{i,t}^{2} + \alpha_3 Local_{i,t} \times Tenure_{i,t}^{2} + \alpha_4 Age_{i,t} + \alpha_5 Local_{i,t} + \alpha_6 Controls_{i,t} + \varepsilon_{i,t} \quad (4)$$

As shown in the above formula, the dependent variable $TE_{i,t}$ is the technical efficiency (TE) of the operation of the endowment insurance system in region i in period t. α_0 is the intercept-term. α_1,α_2,α_3,α_4,α_5,α_6 are the regression coefficients or coefficient matrices for the respective variables, respectively. i and t represent year t of province i respectively. ε_{it} represents a random variable.

Descriptive statistics

Table 1 shows the descriptive statistics of each variable. The data shows that the average value of TE is 0.85, indicating that there is still room for improvement in the operation efficiency of the basic pension insurance system in provinces at this stage. The mean value of tenure is 4.81, suggesting that on average, it takes nearly five years for officials to be promoted or changed in each province. The mean value of age is 53.15, the minimum value is 42, and the maximum value is 60, indicating that the age of officials is closely related to their work experience and official rank status.

The mean value of localization of officials is 0.61 and the mean value of gender of officials is 0.90, indicating that officials in the provinces serve as officials in their home provinces more than officials in other places, and there are more male officials than female officials. The average value of education is 1.44, showing that there are a large number of officials with a bachelor's degree or above, and a good level of education also helps officials to be promoted to a certain extent. In addition, the previous work history of the vast majority of officials involves finance and social security. The standard deviations of public expenditure and social security are both around 30% of the mean, suggesting that there is little difference in local government spending in different public areas.

Dependent variables

Technical efficiency (TE). According to the input and output variables determined by the efficiency evaluation index system, we estimate the BCC model, and obtain the annual efficiency value of the governance performance of the basic pension insurance system in each province, as well as the technical changes and efficiency changes. We therefore adopt the technical efficiency to measure the governance effectiveness of China's basic pension insurance system.

Independent variables

Tenure. The article uses the provincial social security bureau director or the deputy director in charge of the Human Resources and Social Security Department to measure the tenure, which is conducive to studying the impact of officials' characteristics on the governance performance of China's basic pension insurance system.

Moderating variables

The moderating variables of this paper are as follows: (1) *Current age of officials*. We use the age of the director of the provincial social security bureau or the deputy director of the department of human resources and social security to measure the age of the official. (2) *Localization of officials*. We use 0 to indicate that the place where officials take office is different from the place of birth, and 1 to suggest that the place where officials take office is the same as the place of birth.

Control variables

We control the following variables: (1) *Gender of officials (Gender)*. We use 0 for female and 1 for male. (2) *The education of officials (Education)*. We use 0 for junior college and below, 1 for undergraduate, 2 for master, and 3 for doctorate. (3) *Official work experience (Experience)*. We use 0 to represent that the official's previous work history does not involve finance and social security, and 1 to mean that the previous work history involves finance and social security. (4) *The scale of government public expenditure (Public Expenditure)*. The level of regional public financial expenditure is measured by the ratio of local public financial expenditure to provincial GDP. (5) *Social security expenditure scale (Social Security)*. The level of social security expenditure is measured by the proportion of local social security and employment expenditure to local public service expenditure.

Data sources

This paper aims to reveal the impact of the characteristics of officials in China's provinces on the governance efficiency

TABLE 1 Descriptive analysis of inputs, outputs and environmental variables.

Type	Variables	Definition	Mean	Standard deviation	Minimum	Maximum
Dependent variable	TE	The annual operating efficiency of basic pension insurance system estimated by the BCC model	0.85	0.14	0.51	1.00
Independent variable	Tenure	Tenure	4.81	3.28	1.00	12.00
Moderating variable	Age	Official age	53.15	4.16	42.00	60.00
	Localization	1 for the place of employment is the same province as the place of birth, 0 otherwise	0.61	0.49	0.00	1.00
Control variable	Gender	1 for males, 0 for females	0.90	0.30	0.00	1.00
	Education	0 for junior college and below; 1 for undergraduate; 2 for master; 3 for doctorate	1.44	0.56	0.00	3.00
	Experience	Whether the previous work history involves finance, financial and social security is 1; otherwise, it is 0	0.97	0.17	0.00	1.00
	Public Expenditure	Local public service expenditure/local GDP	0.28	0.11	0.15	0.63
	Social Security	Social Security and Employment Expenditure/Local Public Service Expenditure	0.14	0.04	0.08	0.27

TABLE 2 Pearson correlation analysis results.

Variables	TE	Tenure	Age	Localization	Gender	Education	Experience	Public expenditure	Social security	VIF
TE	1									–
Tenure	0.0472	1								1.15
Age	0.0329	0.1293	1							1.38
Localization	0.2559*	0.0351	0.1875	1						1.23
Gender	0.1488	0.2255*	0.294**	−0.1982*	1					1.50
Education	0.1302	0.0075	−0.2733**	−0.2163*	0.265*	1				1.36
Experience	0.0063	0.1513	−0.0786	0.2199*	−0.0586	0.1398	1			1.16
Public expenditure	−0.0887	−0.0972	0.2033*	0.171	0.1137	−0.0774	0.1268	1		1.14
Social security	0.4034**	−0.0449	0.0376	−0.0562	0.2485*	0.2369*	−0.0233	−0.0584	1	1.13

*Indicates significant p values at the 5%. **Indicates significant p values at the 1%. ***Indicates significant p values at the 0.1%.

of China's pension insurance system from 2015 to 2019. The data of the inputs, outputs, government public expenditure and social security expenditure in the efficiency evaluation indicators come from 2016 to 2020 *China Statistical Yearbook* and the statistical yearbooks of individual provinces, covering the relevant data of the basic pension insurance system in 31 provinces across China. The information on the characteristics of officials comes from the leaders of the department disclosed in the government affairs disclosure section on the official website of the Human Resources and Social Security Bureau or related news reported by the media.

Correlation analysis

Since the DEA-BCC model requires a strong correlation between outputs and inputs, it is necessary to analyze the correlation between variables. The results of the Pearson correlation analysis between the variables are shown in Table 2. There is no significant correlation between tenure and the governance effectiveness of basic pension insurance system. There may be a non–linear relationship between tenure and the governance effectiveness of the pension system, but not a linear correlation. At the same time, to test the multi-collinearity problem, we consequently calculated the variance

TABLE 3 Results of mediation and moderated mediation regression analyses.

Variables	Model 1	Model 2	Model 3	Model 4
Tenure		0.0222445**	0.0284933**	0.0206107*
Tenure^2		−0.0018264*	−0.0131436***	−0.0028526***
Age	−0.0063902*	−0.0092824**	−0.0142232***	−0.0099972**
Localization	0.077064**	0.0799235**	0.0789798**	0.0535124
Tenure^2 × age			0.0001976**	
Tenure^2 × localization				0.0016955**
Gender	0.1675998***	0.1641058***	0.1568517***	0.1632861***
Education	0.0159188	−0.0007987	0.0064307	0.0048638
Experience	0.0457511	0.0431129	−0.0129012	0.0267285
Public expenditure	−0.1228898	−0.1317106	−0.1428199	−0.1515982
Social security	0.2706763	0.3643664	0.5907052	0.7095143
_cons	0.9474027	1.046152	1.325041	1.072054
LR test of chibar^2	43.81	42.76	34.14	41.59
Prob ≥ chibar^2	0	0	0	0

*Indicates significant p values at the 5%. **Indicates significant p values at the 1%. ***Indicates significant p values at the 0.1%.

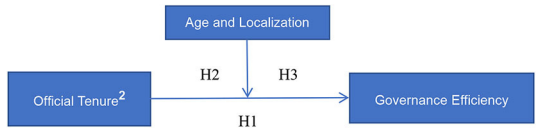

FIGURE 1
The research model.

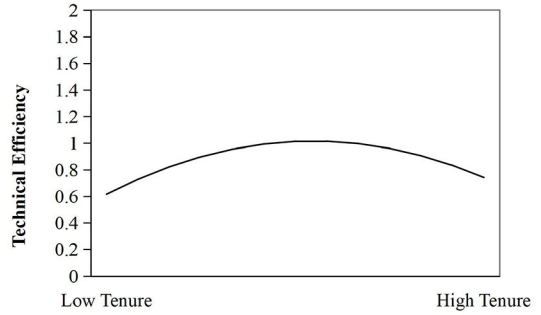

FIGURE 2
The inverted U-shaped curve between Tenure and TE.

inflation factors (VIFs), and found that the maximum value of VIF was 1.50 and the average value was 1.26, which effectively indicated that there was no apparent multicollinearity relationship between the variables selected in this paper. Figure 1 provides a summary of our conceptual framework and shows the hypotheses to be tested in the empirical analysis.

Empirical results

Hypothesis testing and analysis

Both the mixed Tobit regression model and random effects panel Tobit regression model are typical Tobit regression models for panel data. In addition, the results of the likelihood ratio test (LR test) can be effective in helping to determine which model should be used. The results of the LR test for this model show that the null hypothesis was rejected (p value was 0.000), so it was considered that there was an individual effect, and a panel Tobit regression with random effects could be used. Therefore, we conducted a Tobit regression analysis on the model. The results of the regression analysis of the official characteristics and governance performance of the Chinese pension system are shown in Table 3.

As shown in Table 3, Model 1 is the regression result of control variables and moderator variables on the governance efficiency of China's basic pension insurance system. Model 2 is the regression result after adding explanatory variables. Model 3 and Model 4 are the regression results after adding interactive items of age and localization respectively. The data show that these models are statistically significant. Among the moderating variables, age has a significantly negative correlation, and localization also has a significantly positive correlation in model 1, indicating that the younger the officials serving and when they are the locals, the higher the governance efficiency of the fund. The results in Model 2 show that the regression coefficients of tenure and governance effectiveness are both significantly positive ($r = 0.0222445$, $p < 0.05$), but their square terms show a significant negative relationship ($r = -0.0018264$, $P < 0.1$), indicating that the relationship between the tenure and the governance effectiveness of the basic pension insurance system presents an inverted U-shaped relationship.

According to the results of Model 2, the value of the explanatory variable at the inflection point of the curve is $-\beta_1/2\beta_2 = 6.09$, indicating that when tenure is in the 6.09th year, the governance efficiency of the basic pension insurance system will reach the optimum. Therefore, H1 is supported. The inverted U-shaped curve between tenure and fund governance effectiveness is shown in Figure 2.

H2a and H2b discuss the moderating effect of age on the relationship between tenure and fund governance effectiveness, respectively. In Model 3, the regression results show that the coefficient of interaction between the square term of tenure and age is significantly positive ($r = 0.0001976$, $p < 0.01$). Therefore, both H2a and H2b are supported. Specifically, when the official is younger, the work enthusiasm is higher, and the inverted U-shaped relationship between tenure and the governance efficiency is more significant, which confirms the

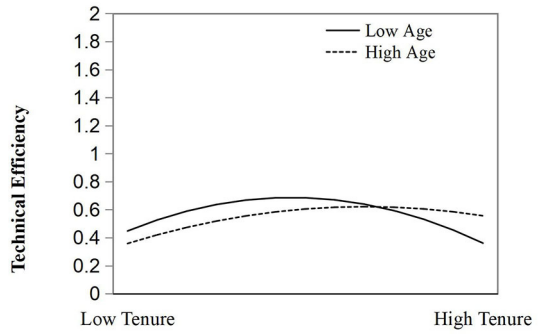

FIGURE 3
The moderating effect of official age.

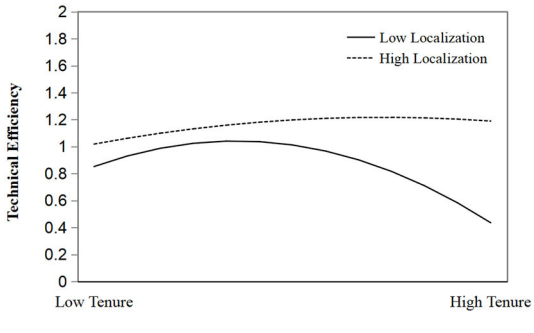

FIGURE 4
The moderating effect of localization.

moderating effect of age on the relationship between tenure and fund governance effectiveness. However, as the age of official increases, once young officials reach a certain age and have not been promoted, this relationship will reverse, showing a trend of declining governance efficiency. Corresponding older government officials have similar problems, but the declining trend is smaller than the negative effect of young officials. The moderating effect is shown in Figure 3.

In addition, in Model 4, the regression results show that the coefficient of the interaction term of the square term of tenure × localization and the governance efficiency of basic pension insurance system is significantly positive ($r = 0.0016955$, $p < 0.01$), which confirms the interaction effect, and H3 is supported. This shows that compared with non-localized government officials, localized government officials show better governance efficiency of basic pension insurance system. However, with the increase of official tenure, the governance effectiveness of non-localized government officials shows a steeper negative effect. This may be due to the fact that local officials have richer network resources and maintain a certain degree of emotional dependence on the place of birth, hoping to leave a better reputation. On the other hand, non-localized officials are limited by their own resources and lack emotional attachment. If they fail to be promoted during their expected tenure, there will be a huge psychological gap, which is more likely to lead to the phenomenon of sloth administration. The adjustment effect is shown in Figure 4.

Robustness analysis

According to research of Wilhelm and Pullenayegum (32, 33), the estimation results of the censored least absolute deviations (CLAD) and Tobit models should be similar. Therefore, we use CLAD as a robustness test for the Tobit model. To further confirm the empirical results obtained by the Tobit model, we adopt a more robust CLAD estimation method. The results of using the CLAD model to regress the tenure and the governance performance of China's pension insurance system are listed in Table 4.

TABLE 4 Results of regression analysis based on CLAD Model.

Variables	Model 1	Model 2	Model 3	Model 4
Tenure		0.0360932***	0.0412751***	0.033619***
Tenure^2		−0.003562***	−0.0141469***	−0.0045271***
Age	−0.0010828***	0.0020477***	−0.0064169***	−0.0048568***
Localization	0.1055972***	0.1092921***	0.0687195***	0.0476373***
Tenure^2 × age			0.0001862***	
Tenure^2 × localization				0.0019585***
Gender	0.1085609**	0.0950154***	0.1366039***	0.1338566**
Education	−0.001022***	−0.0072942***	0.0136494***	−0.0367022**
Public expenditure	−0.3296014*	−0.3240177**	−0.1949042**	−0.2370363**
Social security	1.124524	1.048904	0.6551612	1.024752
_cons	0.5231172	0.5231172	0.9443152	0.9063769

*Indicates significant p values at the 5%. **Indicates significant p values at the 1%. ***Indicates significant p values at the 0.1%.

By comparing the regression results of the Tobit method and the CLAD method, it is found that there is a certain difference in the coefficient estimates of the variables, and the standard error of CLAD is smaller than that of Tobit. Regarding the impact of tenure on governance efficiency, there is no essential difference between CLAD and Tobit in the level of variable significance, so the regression results obtained in this paper can be considered robust.

Conclusions and implications

In order to more effectively explore the governance performance of China's basic pension insurance system based on the characteristics of officials, we use the DEA-BCC model, and take the fund income and the number of insured as

input indicators, and the fund expenditure and the number of recipients as the output indicators, further estimate changes in the annual and inter-period efficiency of the basic pension insurance system in China's provinces from 2015 to 2019. At the same time, by constructing Tobit regression models, the normality and homoscedasticity of the disturbance term in the Tobit model are tested, and the influence of officials' characteristics on the governance efficiency of basic pension insurance system is examined. Finally, we further validate the empirical results of the Tobit model by means of CLAD. The results are as follows: (1) We found that the operational efficiency of China's basic pension insurance system needs to be improved. After further research, there is an inverted U-shaped relationship between the tenure of officials and the governance effectiveness of China's basic pension insurance system. In other words, the newly appointed officials showed better governance effectiveness of of China's basic pension insurance system in the early tenure, but when the official's tenure exceeds 6.09 years, the governance efficiency of China's basic pension insurance system will decrease accordingly. (2) The current age of officials will moderate the relationship between official tenure and the governance effectiveness of China's basic pension insurance system. The younger the current age of officials, the more steeper the inverted U-shaped relationship between official tenure and the governance effectiveness because of officials' self-efficacy and negative emotional responses. (3) The localization of officials will moderate the relationship between official tenure and the governance effectiveness of China's basic pension insurance system. For those officials whose current employment and birthplace are in the same province, the positive relationship between officer tenure and fund governance efficiency becomes more pronounced in the early stages, and the negative relationship flattens out in the later stages. While for those officials whose employment and birthplace are not in the same province, the positive relationship between officer tenure and fund governance effectiveness is relatively stable in the early stages, but the negative relationship becomes steeper in the later stages, when they are not promoted.

To sum up, in order to further optimize the allocation of fund-related resources and effectively improve governance efficiency, we put forward the following suggestions: Firstly, this study has provided a deeper insight into the government, which needs to pay attention to the psychological state of officials in a timely manner, and conduct appropriate emotional counseling. Every official will gradually have his own professional expectations as his tenure grows, hoping to feel fairness and justice from the government's response. Secondly, the results of this paper support the view that governments should avoid age discrimination and ensure that all officials have access to experience, training and promotion. For government officials, age is not only a natural physiological indicator, but also a comprehensive social indicator that reflects professional identity. To a certain extent, young officials have a strong pioneering and progressiveness, which is conducive to accepting new things and confirms the government's new requirements for officials in the era of rapid development. Thirdly, it is necessary for the government to encourage local officials to make efforts to create a government culture that keeps pace with the times and makes everyone progress. Localization officials have a thorough understanding of the actual situation of the province, and have a strong awareness of resource allocation and organizational coordination, which is conducive to the improvement of the governance efficiency of basic pension insurance. Therefore, localization factors can be taken into account in job transfer and personnel arrangement to maximize the motivation of officials.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ZL contributed to conceptualization, methodology, validation, investigation, analysis, writing of the study, administration, and funding acquisition. WZ and ZF supervised the study and contributed to conceptualization, methodology, investigation, writing and editing, and visualization. TL and YG contributed to methodology and review and editing. XS contributed to data validation and review of the study. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Adopting social health insurance in Nepal: A mixed study

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Objective: The Social Health Insurance Program (SHIP) shares a major portion of social security, and is also key to Universal Health Coverage (UHC) and health equity. The Government of Nepal launched SHIP in the Fiscal Year 2015/16 for the first phase in three districts, on the principle of financial risk protection through prepayment and risk pooling in health care. Furthermore, the adoption of the program depends on the stakeholders' behaviors, mainly, the beneficiaries and the providers. Therefore, we aimed to explore and assess their perception and experiences regarding various factors acting on SHIP enrollment and adherence.

Methods: A cross-sectional, facility-based, concurrent mixed-methods study was carried out in seven health facilities in the Kailali, Baglung, and Ilam districts of Nepal. A total of 822 beneficiaries, sampled using probability proportional to size (PPS), attending health care institutions, were interviewed using a structured questionnaire for quantitative data. A total of seven focus group discussions (FGDs) and 12 in-depth interviews (IDIs), taken purposefully, were conducted with beneficiaries and service providers, using guidelines, respectively. Quantitative data were entered into Epi-data and analyzed with SPSS, MS-Excel, and Epitools, an online statistical calculator. Manual thematic analysis with predefined themes was carried out for qualitative data. Percentage, frequency, mean, and median were used to describe the variables, and the Chi-square test and binary logistic regression were used to infer the findings. We then combined the qualitative data from beneficiaries' and providers' perceptions, and experiences to explore different aspects of health insurance programs as well as to justify the quantitative findings.

Results and prospects: Of a total of 822 respondents (insured-404, uninsured-418), 370 (45%) were men. Families' median income was USD $65.96 (8.30–290.43). The perception of insurance premiums did not differ between the insured and uninsured groups ($p = 0.53$). Similarly, service utilization (OR = 220.4; 95% CI, 123.3–393.9) and accessibility (OR = 74.4; 95% CI, 42.5–130.6) were found to have high odds among the insured as compared to the uninsured respondents. Qualitative findings showed that the coverage and service quality were poor. Enrollment was gaining momentum

despite nearly a one-tenth (9.1%) dropout rate. Moreover, different aspects, including provider-beneficiary communication, benefit packages, barriers, and ways to go, are discussed. Additionally, we also argue for some alternative health insurance schemes and strategies that may have possible implications in our contexts.

Conclusion: Although enrollment is encouraging, adherence is weak, with a considerable dropout rate and poor renewal. Patient management strategies and insurance education are recommended urgently. Furthermore, some alternate schemes and strategies may be considered.

KEYWORDS

health insurance, adherence, premium, enabler, barrier, package, prepayment, Nepal

Introduction

In the context of existing inequalities in health in Nepal, achieving universal access to healthcare necessitates a new form of financial hardship protection, reduction of out-of-pocket costs through subsidy or copayment, or coverage of healthcare charges. Despite the government's desperate efforts, over a quarter of the population (23%) and more than two-fifths (42%) of the population are, respectively, outside of overall preventive and treatment coverage under basic care (1, 2). The government's expenditure on health as the share of current health expenditure was below one-fourth (24.8%) and there was a high out-of-pocket expenditure for health care (58%) (3). Meanwhile, 17.4% of the population was multidimensionally poor in 2019/20 were multi-dimensionally poor (4). Furthermore, studies conducted in Kathmandu Valley in 2012 (5) and Kailali in 2019 (6) reported that 13.8 and 17.8 % of households, respectively, had experienced catastrophic health-related spending overall, whereas it was nearly 5 (4.7)% in Kaski district when age-specific (only neonatal) health problems were taken into account (7). Moreover, it was found to be 10.3% monthly at a national level, as calculated from nationally representative data from the National Living Standard Survey-2010/2011 (8). Interestingly, the study conducted in Kailali revealed the protective effect of insurance on catastrophic spending (6). The majority of people's financial incapacity is one of the main barriers to receiving healthcare in this situation. Low-income individuals and rural households could only struggle to pay for healthcare services, which would worsen their health (2) and slip into poverty and debt traps (9). On the contrary, insurance protects them from getting poorer, and thus preserves their health (6).

Various initiatives, such as the safe motherhood program in 2005 and the free health care program in 2007, have striven in the past to provide enhanced coverage of health care services in several key areas. However, those initiatives were lacking the principle of risk pooling. As a result, everyone with a stake in Nepal was concerned about safeguarding the public from catastrophic medical expenses. To reduce the financial risk associated with health care through prepayment and risk-sharing, the GoN initiated the Social Health Security Program (SHSP) in 2015, of which SHIP was a major component (10).

A seminal contribution by Arrow regarding two kinds of risks in medical care: the risk of becoming ill and its outcomes (risk of total or incomplete or delayed recovery), if not addressed with suitable insurance policies, implies a loss of welfare (11), which is very much pertinent in Nepal's context. Furthermore, it is even imperative to increase health insurance coverage as it potentially contributes to the sustainable economic growth of the nation (12). A Social Health Insurance Scheme is a mechanism that helps to mobilize resources, pool risk, and provide more access to health care services for all, particularly for the poor. This eventually helps in accessing universal health coverage (13). It is a comprehensive social contributory scheme with a subsidy to the poor and universal health coverage (UHC). It was started to ensure access to quality health services (equity and equality) and protect them from financial hardship and reduce out-of-pocket payments. GoN rolled out the first round of the SHIP in the fiscal year 2015/2016 and then registration started on 7 April 2016, in the Kailali district, followed by Baglung and Ilam on 28 June 2016. Services provisions were started in the second week of July 2015 (14) and covered all 77 districts in June 2021.

The health insurance program is a voluntary program based on family contributions. Families of up to five members have to contribute a prepayment of NPR 3,500 per year and NPR 700 per additional member. It is a cashless system for members seeking health services, information technology-based; with enrolment assistants using smartphones (15). The insureds have to choose their first service point and, can access specialized and emergency services from listed health institutions across the country on production of a referral slip from their first contact point. In 2017, only 12% of the population was covered under financial risk protection (1), and the trend was found to be increasing, i.e.,

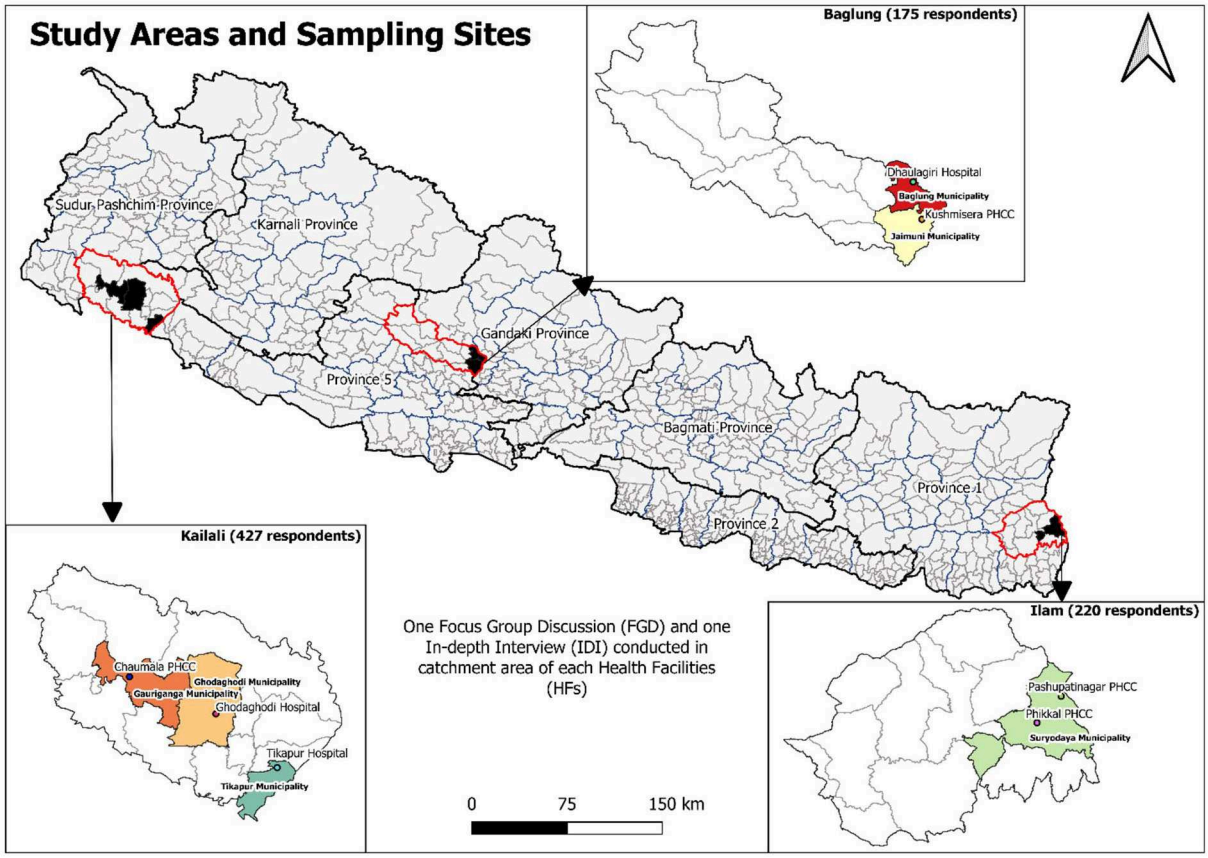

FIGURE 1
Map of the study clusters with number of respondents.

17.63% in 2022. Currently, 736 local levels are in operation, covering 18.87%% of the total population (16). According to National Health Policy 2019, diversification of equitable health insurance is mentioned in the guiding principle, and specialized services shall be made easily accessible through health insurance (15).

The adoption and future success of insurance programs are dependent on clients' perceptions and experiences regarding various attributes and their levels toward the program, such as a premium level, unit of enrollment, service management, health service benefits package, transportation coverage, and copayment levels (17). The sustainability of the program is also significantly influenced by moral hazard and other relevant elements. The SHIP has a tri-polar connection between the board, clients, members, and healthcare providers. Program adherence and continuation are affected by how each of the three components perceives the other and the program, particularly how beneficiaries and providers do. In the interim, no new studies of the SHIP had been found carried out to look at public perception, experiences, and provider views to better understand the program (18). Therefore, we aimed to assess and explore the perception, experiences, and adherence of insured and uninsured beneficiaries, and the service providers of the SHIP in early implemented districts. From this, we are able to identify the key bottlenecks and possible ways forward to adopt and sustain the program, thus starting with the service beneficiary-provider dyad.

Materials and methods

We conceptualized the demand side perceptions from the Health Belief Model (HBM) (19, 20), whereas, for the supply side, the perceptions illustrated by Wagner (21) were considered for guidance (Supplementary Table 1). From this, we operationalized health insurance perception as perceived belief, attitude, intention, or action regarding susceptibility, vulnerability, enablers, barriers, and motivations to or against a disease or health problem or risk of acquiring them, health service or its utilization, health care provider, or insurance scheme, its premium, and benefits package (19–22).

Study design and sites

We carried out a cross-sectional, facility-based, concurrent mix methods study. Qualitative findings were explored to triangulate the quantitative results and to explore beneficiaries' and providers' different perspectives toward the Social Health Security Program (SHIP). We selected three districts—Kailali, Baglung, and Ilam—where SHIP was piloted (Figure 1).

Sample size calculation and sampling technique

The participants were health service beneficiaries (both insured and uninsured) of the three districts and the health care providers and managers of the respective health institutions were the study participants. We selected all the insureds and the uninsured visiting the selected health facilities of three districts during the data collection periods.

The sample size for the quantitative data was determined using the formula, $n = f(\alpha,\beta)\ (p_1q_1+p_2q_2)/(p_1-p_2)^2$; after estimating service utilization among the insureds (p_1) and the uninsureds (p_2), proportions from (Burtibang Primary Health Care Center (PHCC) of Baglung district), (one district of study setting with a lower utilization rate) taken from PHCC records up to 12 February 2017 ($p_1 = 0.029$, and $p_2 = 0.004$), with 0.05 and 0.8 for alpha and beta, respectively, we obtained 407 for each group of insureds and uninsureds (total of 814), and enrolled 825 (insured-407, uninsured-418) to be safe. Three insured participants' interviews were incomplete, thus, they were excluded. We finally analyzed a sample of 822 (insured-404, uninsured-418) participants (Figure 1).

For the quantitative study, we included a proportionate sample from three districts and below-level healthcare facilities (Supplementary Table 2) to randomly include at least one hospital and one PHCC from each district. For individuals, we used the records from the Department of Health Services (DoHS) and the respective districts. Participants were selected among the insured and the uninsured in a 1:1 ratio of those visiting the health care institutions. A total of 7 FGDs (Ilam-2, Baglung-2, Kailali-3) with mixed groups of insured and uninsured people and 12 IDIs (Ilam-2, Baglung-4, Kailali-6) with SHIP focal person/manager were conducted for the qualitative study (Figure 1).

Tools and techniques of data collection

Three pre-tested proformas, i.e., client-exit interview guideline, FGD guideline, and IDI guideline, were used to gather data from the participants from March 13 to October 21, 2020 (Figure 1; Supplementary Table 2). We tested the proformas among the patients visiting, and the health care providers of, Lekhnath community hospital in the Kaski district. We provided a two-day orientation to three undergraduate public health final year students as the enumerators. Two authors trained them with simulation exercises of interviews and discussions and also supervised them during data collection.

Data analysis and management

Quantitative data were entered in EpiData (V 3.5.1), checked for missing values, and then imported into SPSS (V20.0), MS-Excel, and Epitools, a web-based calculator (23) for further analysis. Data was described in frequency, percentage, mean, median, interquartile range, and standard deviations. Statistics such as odds ratios and their 95 % CIs, Pearson Chi-squared test, Chi-squared test for trend analysis, and their *p*-values were used to infer the results.

Qualitative data was taken with note-keeping and checked the same day to sort out any missing. In addition, we also recorded the interviews and discussions. The qualitative data were manually analyzed with thematic analysis, progressing with codes, patterns, sub-themes, and themes. The information generated from the focus group discussion and in-depth interviews was recorded in a notebook as well as on a memory card. Recorded information was transcribed verbatim and then organized under predefined themes, for beneficiaries and service providers. We clustered the providers' codes under themes: coverage, premium, beneficiaries' behaviors, problems, occupational risks, barriers and facilitative factors, and improving strategies, whereas, for beneficiaries' codes, we deduced under knowledge, utilization, and attitude/perception toward SHIP, private sector involvement, promoting factors, improving measures, and providers' behaviors. We presented a quantitative depiction of insured and uninsured Social Health Security Program (SHIP) beneficiaries in tables and figures, as well as qualitative findings in direct verbatims and intellectual translations, and then in tables. Then we triangulated both, especially the qualitative findings for reasoning the quantitative results and to explore the perceptions and experiences.

Ethical considerations

We obtained ethical approval from the Nepal Health Research Council, Ethical Review Board (ERB Protocol no. 835/2019 P; Ref no. 1691 dated 24 January 2020), and respective health institutions and municipality offices of the selected districts. All participants were informed about the study objectives and written informed consent from literate people and verbal from illiterate people were taken before the interview.

Results

The quantitative, descriptive, and inferential results and qualitative findings obtained from themes and sub-themes are presented under different sub-headings.

Socio-demographic and economic characteristics

More than half of the participants were from the Kailali district, followed by 26.8% from Ilam and 21.3% from Baglung. The majority of them (55.0%) were women, and men respondents outnumbered women in Kailali. The highest proportion of the participants was aged 20–29 years (30.0%), and the mean age was 37.4 (±14.1) years. Almost 4% were adolescents and 8% were elderly participants. The median monthly household income was NPR 20,000 (10,000–35,000) (US $ 1 = NPR 120.51) (24) with half of the participants having a monthly income below NPR 20,000(0–350,000). A majority (53.3%) of the participants were Brahmin followed by Janajati (22.1%) and others, as depicted in Table 1.

Awareness, enrollment, and adherence to a health insurance program

Positive perception towards SHIP is in progressive way, and the enrollment rate was also found to be in an increasing trend except in 2019. Meanwhile, the dropout rate is also increasing, nearly at the rate of one in every ten (162/342, 47.4% for 2 times; 131/342, 38.3% for ≥3 times; difference, −9.1%) as calculated from the total registered and insureds of 342 in three districts in 6 years (2014–2019) (Figure 3).

The perception of the need/importance of SHIP differed significantly between insured and uninsured beneficiaries ($p < 0.001$) (Table 2). In line with this, the high level of awareness of SHIP is reflected in the trend analysis, where year-wise enrollment trends of the family registered in health insurance scheme in three districts during 2014–19 showed differences although the trend, is increasing, in all districts, except for 2019 (Figure 2). Chi-square for linear trend analysis showed that year-wise enrollment in three districts was non-linear [X^2 (df), 25.6(3); $p < 0.001$] and remained unchanged even after excluding 2019 data [X^2(df), 23.66(2); $p < 0.001$] (Figure 2). However, the frequencies of registered HHs showed a linear trend [X^2(df), −0.778 (0), $p = 1$; slope = 0.007, $p = 0.005$] (Figure 3). The forecast model and equations show that a range of nearly 9–20 HHs, from 2 to 3 or more times registered respectively, will be increased when adding a next district (Figure 3). However, it may differ according to the district population and other socio-demographic and implementation variables. Respondents claimed that the enrollment in SHIP was encouraging and might have reached more than half of the population. These claimants are consistent with qualitative findings from the service providers. The enrollment trend (Figure 3) forecasted from our data was obvious as it was further explained during the interviews. However, a few participants also reflected a negative perception of SHIP.

> *I got enrolled in the SHIP since its inception (2015/16 AD).*
>
> *-A beneficiary of Phikkal PHCC, Ilam*
>
> *If we have an insurance card with us, we can get services from every government health institution up to 50,000.*
>
> *-A beneficiary of Chaumala PHC, Kailali*
>
> *SHIP saves health care costs and it is extremely useful when someone has financial hardships. If health insurance is done, treatment can be done at a minimal cost.*
>
> *-A beneficiary of Tikapur PHC, Kailali*
>
> *We did not enroll in SHIP due to a lack of money. We are not sick, so why do we need SHIP.*
>
> *-An uninsured beneficiary of Kushmishera PHCC, Baglung*
>
> *Stakeholders must encourage the uninsured to get enrolled in SHIP.*
>
> *-A beneficiary from Tikapur hospital, Kailali*
>
> *People are mostly unaware of the insurance and those who are insured, have no proper idea in the process of getting enrollments and service use under SHIP.*
>
> *-A beneficiary from Tikapur hospital, Kailali*

The reason for increased enrollment is further supported by the fact that the service providers also mentioned that it may have started as a result of more surgery facilities and a better referral system.

> *Emergency and referral services are provided from this hospital, and mostly insured patients attend PHCC and are referred to a higher center. Enrolled people have received services provided under SHIP. In the meantime, more than 60% of the insured population were not satisfied with service management under SHIP.*
>
> *-A hospital SHIP focal person, Baglung*
>
> *Some people received services for the first time, and thereafter they seldom received services due to the perceived poor quality of service and its management.*
>
> *-A beneficiary from Dhaulagiri hospital, Baglung*
>
> *If there is timely reimbursement to the service-providing institutions, then the satisfaction level among beneficiaries will be high, and as a result, coverage will also increase.*
>
> *-A service provider, Ghodaghodi hospital, Kailali*

Furthermore, some quantitative findings of the supply-side revealed that the insureds received twice as many timely follow-up services (OR = 2.3; 95% CI, 1.2–3.0) as their

TABLE 1 Socio-economic characteristics of participants ($n = 822$).

Variables		Districts			Total
Name categories		Ilam	Baglung	Kailali	
		220 (26.8)	175 (21.3)	427 (51.9)	822 (100.0)
Gender	Male	91 (11.1)	64 (7.8)	215 (26.2)	370 (45.0)
	Female	129 (15.7)	111 (13.5)	212 (25.8)	452 (55.0)
Age (yrs)	<20	6 (0.7)	8 (1.0)	18 (2.2)	32 (3.9)
	20–29	59 (7.2)	39 (4.7)	149 (18.1)	247 (30.0)
	30–39	73 (8.9)	36 (4.4)	131 (15.9)	240 (29.2)
	40–49	39 (4.7)	30 (3.6)	53 (6.4)	122 (14.8)
	50–59	27 (3.3)	35 (4.3)	53 (6.4)	115 (14.0)
	≥60	16 (1.3)	27 (3.3)	23 (2.8)	66 (8.0)
	Mean (SD)	37.3 (12.4)	42.1 (15.9)	35.4 (13.6)	37.4 (14.1)
	Median (Min-Max)	35 (16–77)	40 (17–87)	33 (16–86)	35 (16–87)
Monthly income*	Median (Q_1–Q_3)	20,000 (10,000–30,000)	20,000 (12,000–40,000)	20,000 (10,000–30,000)	20,000 (10,000–35,000)
Ethnicity	Brahmin/ Chhetri	79 (9.6)	142 (17.3)	217 (26.4)	438 (53.3)
	Janajati	128 (15.6)	25 (3.0)	29 (3.5)	182 (22.1)
	Dalit	11 (1.3)	5 (0.6)	45 (5.5)	61 (7.4)
	Madhesi/ Tharu	0 (0.0)	0 (0.0)	100 (12.2)	100 (12.2)
	Others	2 (0.2)	3 (0.4)	36 (4.4)	41 (5.0)

*In NPR (USD 1 = NPR 120.51 as per NRB, July 1, 2020).

counterparts ($p < 0.001$). This might have prevented a further decrease in the dropout rate.

Service quality and utilization

Poor service utilization was associated with physical distances of more than 30 min that it took to reach the health facility. In addition, the poor quality of the services was also a co-factor.

A significant difference was observed in the time taken (with a cut-off of 30 min) to reach HFs, between the insureds and the uninsureds ($p = 0.023$, Supplementary Table 5), specifically, that of Kailali district ($p = 0.013$, Supplementary Table 5). Moreover, accessibility (OR = 74.4; 95% CI, 42.5–130.6) and service utilization (OR = 220.4; 95% CI, 123.3–393.9) both were very strongly associated with the insured beneficiaries (Table 4), however, this may need further cautious interpretation. The availability of emergency services and SHIP services managed in HFs (all p's > 0.05, Table 3) did not differ between the two beneficiary groups. Similarly, the distance between the health facility (HF) and home (5 km or less) ($p > 0.05$, Table 3) and time taken (with a cut-off of 30 min) to reach HFs, in case of Ilam and Baglung districts, did not differ between the two types of beneficiaries ($p > 0.05$, Supplementary Table 5). The quality factors were explored during the interviews with beneficiaries and the service providers.

> *Some people received service for the first time, and thereafter they seldom received services due to the poor quality of service and its management.*
>
> *-A beneficiary, Kailali*
>
> *I visited a health institution three times for the treatment of a single disease but didn't receive any treatment. At different times, I faced a shortage of medicine, equipment, or health personnel.*
>
> *-An insured beneficiary, Ilam*
>
> *Initially, it was very good but, in the middle, there was a scarcity of medicines, which resulted in a decrease in the number of insured people. However, the coverage is increasing now.*
>
> *-Service provider, Tikapur hospital, Kailali*

Service coverage, accessibility, and availability

Since perception toward the SHIP was found to be positive, which might have been associated with the availability and as a result, increased coverage. Consideration of an alternate

TABLE 2 Associative demand-side perceived factors among the beneficiaries.

Variable description		Insurance status		Total	*p*-value	UOR (95 % CI)
		Insured	Uninsured			
Perception of premium	Expensive	125 (30.9)	121 (28.9)	246 (29.9)	0.53	-
	Not Expensive	279 (69.1)	297 (71.1)	576 (70.1)		
Perceived differences in service availability	Yes	301 (74.5)	206 (49.2)	507 (61.6)	<0.001**	3 (2.23–4.03)
	No	103 (25.5)	212 (50.8)	315 (38.4)		Ref
Perceived importance of SHIP	Important	365 (91.0)	259 (64.1)	624 (75.9)	<0.001**	5.74 (3.91–8.44)
	Not Important	39 (9.0)	159 (35.9)	198 (24.1)		Ref
Perception of the family as a unit	Important	362 (89.6)	272 (65.0)	634 (77.1)	<0.001**	4.62 (3.17–6.74)
	Not Important	42 (10.4)	146 (35.0)	188 (22.9)		Ref
Perception of SHIP for underprivileged	Important	385 (95.2)	320 (76.5)	705 (85.7)	<0.001**	6.20 (3.71–10.36)
	Not Important	19 (4.8)	98 (23.5)	117 (14.3)		Ref
Perception of annual renewal rule/system	Important	278 (68.9)	223 (53.4)	501 (60.9)	<0.001**	1.92 (1.45–2.56)
	Not Important	126 (31.1)	195 (46.6)	321 (39.1)		Ref
Perception of the benefits package	Effective	197 (48.7)	109 (26.0)	306 (37.2)	<0.001**	2.69 (2.01–3.61)
	Not Effective	207 (51.3)	309 (74.0)	516 (62.8)		Ref
Perception of referral system	Effective	150 (37.1)	96 (22.9)	246 (29.9)	<0.001**	1.98 (1.46–2.68)
	Not Effective	254 (62.9)	322 (77.1)	576 (70.1)		Ref

*Statistically significant at $p < 0.05$; **Statistically significant at $p < 0.001$.

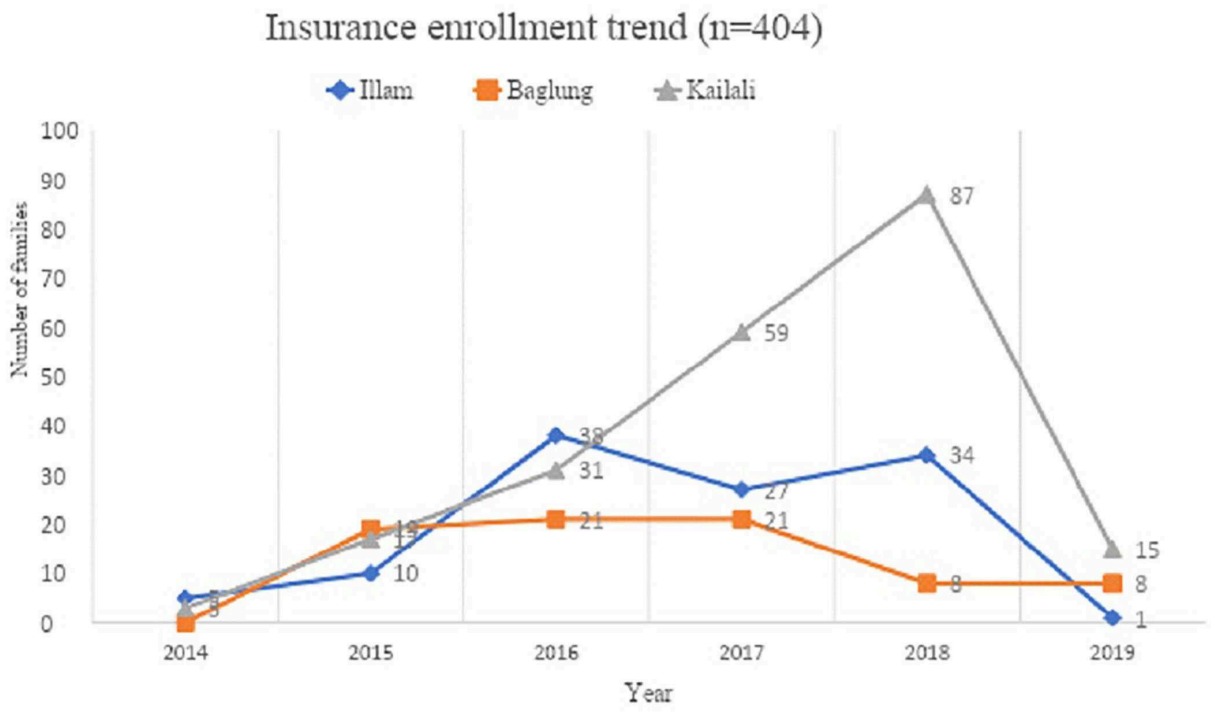

FIGURE 2
Trend showing year-wise enrollment of insureds in three districts (Pearson Chi-squared (df), 34.29 (4); $p < 0.001$; Chi-squared for slope (df), 8.69 (1); p, 0.003; slope, −0.007; Chi-squared (df) for non-linearity; 25.59 (3), $p < 0.001$; After removing 2019 data, Chi-squared (df) for non-linearity; 23.66 (2), $p < 0.001$).

benefits package that may include the medicines for major Noncommunicable Diseases (NCDs) along with kidney-related problems and related essential medicines was emphasized by the beneficiaries.

From the demand side, quantitative findings indicated that service accessibility (OR = 74.4; 95% CI, 42.5–130.6) and service utilization (OR = 220.4; 95% CI, 123.3–394.0) were highly associated among the insured beneficiaries as compared to their counterparts. Among the types of services, general health checkups (OR = 109.8; 95% CI, 64.0–188.3), emergency services (OR = 80.8; 95% CI, 19.8–329.6), and referral services (OR = 81.4; 95% CI, 11.2–589.7) were also strongly associated with insured beneficiaries (Table 4). These strong associations are further verified by the perceptions of beneficiaries toward SHIP (Table 2). Availability of services was differently perceived three times (OR = 3; 95% CI, 2.23–4.03) and benefits package was perceived more than two times (OR = 2.69; 95% CI, 2.01–3.61) as "effective" among the insured beneficiaries compared to their counterparts.

> *I had undergone surgery for gallstones and was satisfied with the services and the referral system.*
>
> *-An insured beneficiary, Pashupatinagar PHCC, Ilam*

Although the demand-side factors favored the insureds, the uninsured and some insured claimed that the coverage of the SHIP is low and services are not satisfactory.

> *My mother is suffering from a kidney-related problem, but the treatment is not available through SHIP.*
>
> *- A beneficiary, Tikapur PHCC, Kailali*
>
> *We can't get any of the services that we are seeking. Very few services are included in SHIP.*
>
> *-A beneficiary, Pashupatinagar PHCC, Ilam*
>
> *All medicines are not available; all diseases are not treated; and there is no coverage for expensive medicines.*
>
> *-A beneficiary, Kushmisera PHCC, Baglung*
>
> *The services should not be limited to minor diseases only. They should be more focused on treating major NCDs, too.*
>
> *-A beneficiary from Phikkal PHCC, Ilam*

Beneficiary-provider communication and behaviors

A non-significant difference in experiencing the unfriendly behavior of health workers was observed between two beneficiaries (p = 0.626) (Table 5). However, during the interviews, beneficiaries revealed their dissatisfaction with the healthcare provider's behaviors (Table 4).

> *I am quite unsatisfied with the services, as the service provider's way of dealing with the public was not appropriate. Therefore, I discontinued the SHIP program.*
>
> *-A discontinued beneficiary from Pashupatinagar PHCC, Ilam*
>
> *When we go to the hospital, they ignore the patients and say there is no medicine.*
>
> *-A beneficiary of Dhaulagiri hospital, Baglung*
>
> *Service providers pay less attention to the insured people than the uninsured, and services are not provided on time to the insured ones.*
>
> *-An insured beneficiary, Ghodaghodi hospital, Kailali*

It is not all the healthcare provider's behaviors, but a few having poor communication skills that might be creating problems, as, on average, no difference was experienced by the two beneficiaries. In addition, the Healthcare Provider (HCP) further clarified that the high expectations of the beneficiaries and poor patient management might be creating some problems (Table 6).

> *Insured people sometimes feel irritated waiting in a queue to receive services. Both insured and uninsured patients face some problems during high patient flow.*
>
> *-A service provider, Pashupatinagar PHCC, Ilam*
>
> *It is only their feelings, but there are no problems they have to face. He further added, "Both the insured and uninsured have to wait for their checkup time to come in queue if the patient flow is high."*
>
> *-A service provider, Ghodaghodi hospital, Kailali*
>
> *HCP provided services to infectious patients without personal protective equipment (PPE) such as gloves and masks.*
>
> *-A service provider, Pashupatinagar PHCC, Ilam*
>
> *Dealing with the rude behaviors of patients, when their high expectations were not met, and the existing state of service delivery creates an unusual and unpleasant environment. Many patients are unaware of the SHIP and come to the hospital expecting to receive all free services. If their services are not covered by insurance, they become annoyed and badly scold the service providers.*
>
> *-A service provider, Tikapur hospital, Kailali*

In addition, some service providers are also lacking the necessary personal protective equipment (PPEs).

Premium, risk pooling, renewal, and benefits package

The premium for insurance was not found to be significantly different among the two groups of beneficiaries. However, it was

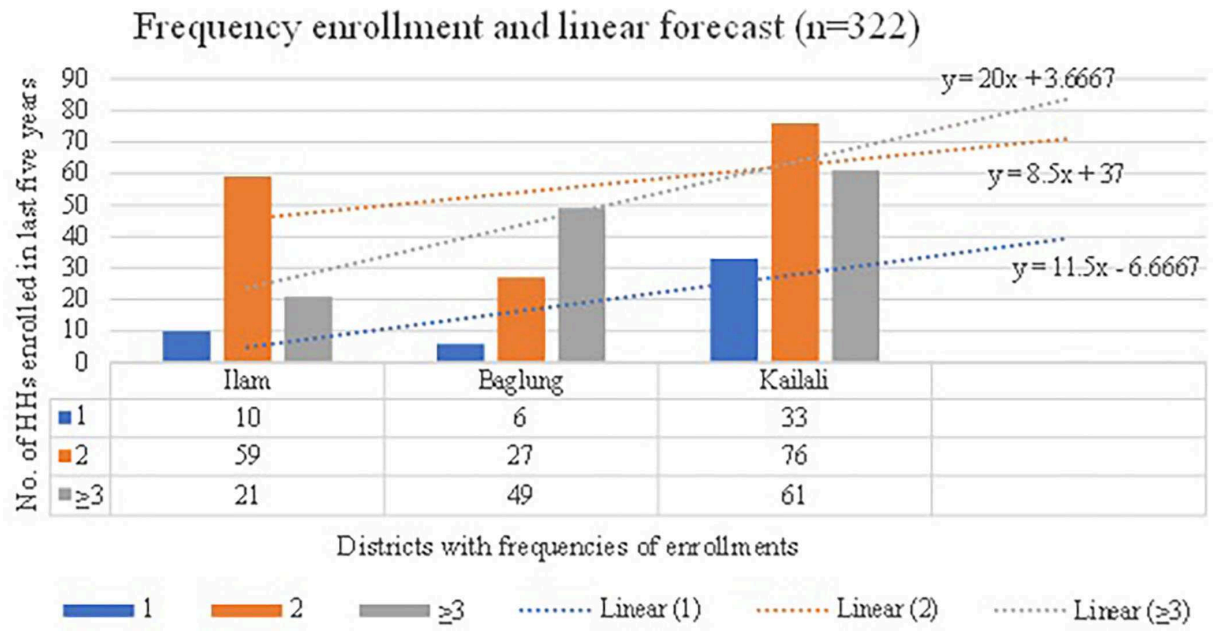

FIGURE 3
Frequencies of HHs registered in insurance program and forecasting with equations (Pearson Chi-squared (df), 7.01(1); *p*, 0.008; Chi-squared for slope (df), 7.79 (1); *p*, 0.005; slope, 0.007; Chi-squared (df) for non-linearity, −0.778 (0); p,1).

TABLE 3 Associative supply-side quality and availability factors of insurance providing HFs.

Variable description		Insurance status		Total	*p*-value	UOR (95 % CI)
		Insured	Uninsured			
Distance between health institution and home	>5 Km	316 (78.2)	339 (81.1)	655 (79.7)	0.30	-
	≤5 Km	88 (21.8)	79 (18.9)	167 (20.3)		
Follow-up services/visits	Yes	253 (62.6)	190 (45.5)	443 (53.9)	<0.001**	2.01 (1.52–2.65)
	No	151 (37.4)	228 (54.5)	379 (46.1)		
Timely follow-up service received	Yes	246 (60.9)	170 (40.6)	416 (50.6)	<0.001**	2.27 (1.17–3.0)
	No	158 (39.1)	248 (59.4)	406 (50.4)		
Availability of emergency services	Yes	342 (84.6)	347 (83.0)	689 (83.9)	0.52	-
	No	62 (15.4)	71 (17.0)	133 (16.1)		
Proper service management	Yes	262 (64.9)	286 (68.4)	548 (66.7)	0.27	-
	No	142 (35.1)	132 (31.6)	274 (33.3)		

*Statistically significant at $p < 0.05$; ** Statistically significant at $p < 0.001$; #Fisher Exact Test.

perceived that the program is important for the underprivileged. The underprivileged, on the other hand, are less health-conscious and needed to be enrolled through alternative means even if they cannot afford the premium.

Even though perception regarding the SHIP premium did not differ significantly between the two beneficiary groups ($p = 0.53$), perception toward other related variables was found to be highly associated with the SHIP. When compared to their counterparts, insured beneficiaries perceive the importance of annual premium renewal as nearly two times higher (OR = 1.96; 95% CI, 1.45–2.56), the perceived benefit package as nearly three times higher (OR = 2.69; 95% CI, 2.01–3.61), and the perceived referral system as nearly two times higher (OR = 1.98; 95% CI, 1.46–2.68) (Table 3). In addition, the experience of expanding the benefits package significantly differed between the two beneficiaries ($p < 0.001$) (Table 5).

> *There was once a villager whose treatment cost for a disease was about Rs 50,000(US $1 = NPR 120.51) (24), of which about Rs 40,000 of that cost was borne by the insurance.*

TABLE 4 Associated demand-side factors of insurance providing health facilities.

Variable description		Insurance status		Total	*p*-value	UOR (95 % CI)
		Insured	Uninsured			
Accessibility	Yes	389 (96.2)	108 (25.8)	497 (60.5)	<0.001**	74.4 (42.5–130.6)
	No	15 (3.8)	310 (74.2)	325 (39.5)		Ref
Services utilization	Yes	367 (90.8)	18 (4.3)	385 (46.8)	<0.001**	220.42 (123.32–393.99)
	No	37 (9.2)	400 (95.7)	437 (53.2)		Ref
Types of services received						
General health checkup	Yes	336 (83.1)	18 (4.3)	354 (43.0)	<0.001**	109.82 (64.02–188.31)
	No	68 (16.9)	400 (95.7)	468 (57.0)		Ref
Emergency service	Yes	113 (35.7)	2 (0.5)	115 (13.9)	<0.001** #	80.76 (19.79–329.55)
	No	291 (64.2)	416 (99.5)	707 (86.1)		Ref
Referral services	Yes	66 (16.4)	1 (0.3)	67 (8.2)	<0.001** #	81.42 (11.24–589.74)
	No	338 (83.6)	417 (99.7)	755 (91.8)		Ref

*Statistically significant at $p < 0.05$; **Statistically significant at $p<0.001$; #Fisher Exact Test.

TABLE 5 Experiences of the insured and uninsured beneficiaries toward the SHIP and providers.

Items (multiple responses)	Total#	Insurance status		*p*-value
		Insured	Uninsured	
IEC materials	229	136 (59.4)	93 (40.6)	<0.001**
Expanding service package	130	88 (67.7)	42 (32.3)	<0.001**
Availability of human resources	110	72 (65.5)	38 (34.5)	<0.001**
Public awareness about SHIP	92	51 (55.4)	41 (44.6)	0.200
Services for underprivileged	89	56 (62.9)	33 (37.1)	0.005**
Availability of laboratory services	79	44 (55.7)	35 (44.3)	0.220
Free/low-cost services	72	51 (70.8)	21 (29.2)	<0.001**
Improving service management	65	47 (72.3)	18 (27.7)	<0.001**
Household visit by enrollment staff	59	32 (54.2)	27 (45.8)	0.417
Waiting time	179	101 (56.4)	78 (43.6)	0.027*
Service delivery	167	89 (53.3)	78 (46.7)	0.230
Availability of medicine /services	154	88 (57.1)	66 (42.9)	0.027*
Crowding	123	56 (45.5)	67 (54.5)	0.383
Providers' behaviors	121	57 (47.1)	64 (52.9)	0.626
Coverage of health problems	107	48 (44.9)	59 (55.1)	0.341
Enrollment process	106	49 (46.2)	57 (53.8)	0.519
Public trust in services	98	46 (46.9)	52 (53.1)	0.641
Available human resources	67	33 (49.3)	34 (50.7)	0.985
Financial status	49	22 (44.9)	27 (55.1)	0.539

*Statistically significant at $p < 0.05$; **Statistically significant at $p < 0.001$; #Multiple responses; figures in parentheses are %ages.

> *This incident increased the enrollment and motivated people toward SHIP.*
>
> *-An insured beneficiary from Phikkal PHCC, Ilam*

Similarly, the perception of both families as a unit and underprivileged (*p's* < 0.001) (Table 2) were significantly different in the two beneficiary groups, with higher proportions among the insureds. However, mixed findings were revealed during the interviews.

> *Family as a unit is very supportive in healthcare; however, it can be a problem for a joint family with more than ten members.*
>
> *-A beneficiary of Tikapur PHC, Kailali*

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TABLE 6 Summary findings from service providers (qualitative).

SN	Theme/Pattern	Summary (intellectual translation)
1	Coverage of SHIP	Service providers and managers reported that there was almost 60–80% coverage of SHIP among the population in Illam, Baglung, and Kailali. Insurance agents of the respective wards in different districts facilitated the beneficiaries for SHIP enrollment. However, their limited mobility in the community had made a steady increment in SHIP coverage. Although there was incremental acceptance of SHIP was observed in the initial days, the declining trend was observed in subsequent years due to the limited availability of medicines and services under SHIP. It was noted that almost all people with chronic diseases have made health insurance.
2	Perceived premium and benefit package	The existing premium was perceived to be appropriate and affordable. Coverage of the service has been improving; however, the availability of limited services sometimes makes questionable about the premium. Services under SHIP were perceived as cost-effective and mostly used by insured people. Insured people who had hypertension mostly utilized the services of SHIP. Community acceptance was improved with 80–90% of people being satisfied with SHIP. Nevertheless, community acceptance of SHIP in Kailali was low because of the lower level of awareness among the population. The referral center was limited to a few hospitals only. There were problems in accessing and purchasing the equipment and medicines. Patients referred to higher centers have to be in the queue for care in higher health care institutions because of this, some insured people also discontinued. The annual renewal system of SHIP was not perceived to be user-friendly due to which there was poor adherence and a high proportion of drop out.
3	Providers' perception of beneficiaries' behavior	There was an affirmative perception of the insured and uninsured people regarding SHIP. Insured people have good availability and coverage of care. Insured people perceived that the services must be made available even from private institutions. Beneficiaries become disappointed when the uninsured got limited services to those insured beneficiaries and they feel irritated waiting in a queue to receive services. In addition, sometimes it is difficult to avail of services in time, and the referral system is also felt hectic.
4	Problems faced by insured and uninsured beneficiaries availing services	Limited availability of services from SHIP-implemented health institutions, long waiting times for their checkup/health care, and perception of difficulty in dealing with a hectic referral system. In the meantime, there were no verbal complaints as well as written feedback from the public and beneficiaries in regard to the problems faced.
5	Providers' perception of underprivileged	Effective delivery of services at all times, waiving the premium and renewal amount for insurance, making the SHIP compulsory for people with low SES, and providing awareness at the household level through mass campaigns or frequent visits made by the insurance agents may be useful to make insurance coverage of the underprivileged population.
6	Problems faced by service providers	Limited human resources, service packages, and financial resources regarding patients' expectations, nagging from the public, delayed reimbursement of expenditures made, and dealing with the rude behaviors of some people at the time-of-service delivery were the major problems encountered by service managers and providers in the study districts.
7	Occupational risk experienced by HCPs	The unavailability of the PPEs was experienced as an occupational risk among the SHIP providers and they also added that some patients' behaviors put them at occupational risk.
8	Facilitative factors of the SHIP program	Regular monitoring of the program, regular supply of services and medicines, good inventory management, monthly progress reporting, review meetings, and distribution of responsibilities among the staff facilitated the management of SHIP.
9	Ways to reduce the barriers (by HCPs)	Timely reimbursement of expenditures made for health care, promoting service provider-community bonding, use of technology and Apps, and mobilizing the trained human resources are useful to strengthen SHIP.
10	Measures to improve coverage, accessibility, and implementations modalities of SHIP	Mobilization of insurance agents, publicizing the program highlights among beneficiaries through different individual, group, and mass methods, expansion of services to both the public and private institutions, and development the effective referral mechanisms gradually improve the coverage of services and effective implementations of SHIP.

> *It is a total waste of money. My family doesn't get the chance to utilize that much.*
>
> *-A beneficiary of Tikapur PHC, Kailali*

Although there was a significant difference in experiences of free or low cost SHIP between the two groups ($p < 0.001$) (Table 5), some families only revealed their willingness to pay a threshold of 1000 NPR during the interviews (Table 7).

> *The premium is a little expensive and it would be more appropriate if the amount was around Rs 1,000 (US $8.30) instead of paying Rs 3500 ($34.14) annually* (USD 1 = NPR 120.51) (24).
>
> *-A beneficiary from Pashupatinagar PHCC, Ilam*

The coverage of one lakh by insurance was found satisfactory among the beneficiaries. However, on one hand, it seems that less risk perceiving people may repel the program, such by assuming that it would be a waste when there was nobody sick from their family, and on the other hand, those unable to pay are needed to be enrolled through other safety nets, such as by local bodies or the similar.

> *It is good that NPR per family pertains to coverage of 1 lakh.*
>
> *- A beneficiary, Dhaulagiri Hospital, Baglung*
>
> *The package is incomplete. I once extracted a tooth, but there is no provision for replacing that tooth with a new one.*
>
> *-A beneficiary, Tikapur hospital, Kailali*
>
> *If we fall sick, then there is an increase in expenditure for treatment, so SHIP is good, while in the case of no sickness, it is a waste of money.*
>
> *-A beneficiary, Kushmisera PHCC, Baglung*
>
> *A respective municipality must enroll underprivileged groups into SHIP rather than providing them with relief funds.*
>
> *-A service provider, Ghodaghodi hospital, Kailali*

Barriers, facilitative factors, and ways forward

Since public trust toward the scheme is similar in both groups, the program may be scaled-up provided that people are aware of the availability and affordability of medicines, better managed with regular human resources, and service packages can be modified as per the population's health needs. Integration with other programs and further technology and user-friendly improvements are also important.

In quantitative findings (Table 5), experiences of difficulty in the enrollment process ($p = 0.519$), limited human resources ($p = 0.985$), overcrowding ($p = 0.383$), the poor financial status of relevant health facilities ($p = 0.539$), and HH visits by enrollment staff ($p = 0.417$) remained non-significant in the difference between two groups. However, people from the rural parts of the respective catchment areas are still unaware, and the public perception is not favorable (Table 7).

> *It has neither covered a large population nor has the awareness regarding SHIP reached the rural parts of Nepal.*
>
> *- A beneficiary from Pashupatinagar PHCC, Ilam*
>
> *Change in public perception is much needed.*
>
> *-A beneficiary, Pashupatinagar PHCC, Ilam*
>
> *Stakeholders must encourage the uninsureds to get enrolled in SHIP.*
>
> *-A beneficiary from Chaumala PHCC, Kailali*

Another barrier is the non-transferability of the insurance scheme. They are not getting the benefits outside their catchment areas (Table 7).

> *The people who are currently living in Kathmandu but enrolled in Phikkal PHCC cannot avail of service under SHIP and they cannot come to Ilam for renewal or referral cards. Due to such conditions, the dropout rate has also increased and motivation for SHIP has decreased.*
>
> *-An insured beneficiary from Phikkal PHCC, Ilam*
>
> *Information should be reached to all sections of the population, including marginalized people.*
>
> *-A beneficiary, Pashupatinagar PHCC, Ilam*

To further expand the program, integration with other programs such as the elderly allowance card, aligning with the Female Community Health Volunteer Program, and local governments are important. Beneficiaries' experiences differed in information education and communication materials significantly ($p < 0.001$) (Table 5), which shows that they can be helpful to create awareness for the program extension.

> *Many people still do not have awareness about the SHIP. Community acceptance is increasing though. Some elderly people expect the SHIP services to come with an old age allowance card.*
>
> *-A service provider, Chaumala PHCC, Kailali*

Although there was a significant difference in experience in improving service management ($p < 0.001$) and availability of human resources ($p < 0.001$) between the two groups, public trust toward the program did not differ significantly ($p = 0.641$) (Table 5).

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TABLE 7 Summary findings of the beneficiaries (insured and uninsured) (qualitative).

SN	Theme/Pattern	Summary (intellectual translation)
1	Knowledge about the SHIP	The proportion of the population knowing SHIP ranged from a few to a 100%. A Participant from Baglung reported that all of them had the knowledge and knew few too many participants from Kailai and Ilam had heard about SHIP. The majority of the insured participants were more ere knowledgeable than the uninsured while some of the insured participants did not have comprehensive knowledge about SHIP.
2	Utilization of SHIP	Enrollment in SHIP was encouraging in all the study districts as almost 50–90% population were enrolled in the program. The new enrollments each year from the inception of the program have been increasing; however, the dropout among the insured population was also continued. Among the uninsured population, they remain uninsured because of a lack of awareness, and financial limitations and some felt that less importance of the program. Both the insured and uninsured people had received the services from SHIP-implemented health care institutions. For those who discontinued the SHIP, the major reasons for the discontinuation were the poor perceived quality of care, limited availability of care, and health workers' unfriendly behaviors.
3	Perception of SHIP	There was a mixed perception regarding the premium amount charged for SHIP enrollments. The majority of the beneficiaries opined that it is appropriate and affordable while some others stated that it is expensive. It is better if the premium cost is borne by the government in the case of marginalized people or those who face financial hardship. Participants from Baglung stated, "If we fall sick, then there is an increase in expenditure for treatment, so SHIP is good while in case of no sickness, it is a waste of money." Household/family size as the unit beneficiary for SHIP was perceived to be a good idea. Nonetheless, it's a problem for a family with members of more than 10. The inclusion of members up to 6 with a minimum premium could cover the grand parent's insurance which may become a useful model in Nepal. Coverage of care under SHIP has been increasing since its inception with 70-80 % population in SHIP-implemented areas being covered for this scheme while dropout/discontinuity was also reported among large populations. Door-to-door visits made by insurance agents made it possible to improve enrollments in SHIP. Since the nature and the type of services covered under the SHIP do not meet the needs of health care, patients have to seek care from other health care institutions which limit the coverage. In the meantime, the uninsured claimed that the coverage of the SHIP is low and services are not satisfactory. Participants from Ilam opined that the management of services has been improving gradually whereas it was reported to be poor in Baglung and Kailali. Shortage of medicines and equipment, limited availability of service items, poor smoothing in service delivery, long waiting time, non-coverage of expensive medicines, and unfriendly renewal system of SHIP have made limiting attractions toward the program. Therefore, the benefits package under the SHIP was perceived to be low and expressed the need for expansion.
4	Private sector involvement	The private sector's involvement in SHIP was negligible except in areas where the SHIP was implemented in Private hospitals.
5	Perceived promoting factors	Community and group-based awareness programs, spreading the information to the peripheral level, the addition of service packages, placement of citizen charter, orienting the benefits of service packages under SHIP, mobilizing FCHVs to inform people, engaging local authorities, timely follow up for renewal, timely delivery of services and mobilizing insured beneficiaries to motivate the public might have promoted the acceptances of SHIP.
6	Suggestions to improve SHIP	Effective mobilization of insurance agents, an extension of services to private institutions, periodic monitoring continuously, tracking of the service delivery mechanism, further addition of services into existing benefit packages, extending services for NCDs, availing services from all service points irrespective of the first contact point and developing the user-friendly referral mechanisms are useful in strengthening SHIP. Similarly, advertising of SHIP program in wider dimensions, paying equal attention to both the insured and uninsured people, training the health workers, and social leaders, and orienting the local people could promote the SHIP. Furthermore, the provision of insurance free of cost for an underprivileged population with increasing awareness and improving the management of health institutions for effective delivery of services are also useful strategies for the promotion of SHIP.

Regular monitoring of the program, regular supply of services and medicines, good inventory management, monthly progress reporting and review meetings, distribution of responsibilities among the staff, and contingency meetings for the immediate issues facilitated the management of SHIP. Moreover, an online management system, the use of a mobile app, improving public awareness to reduce rumors, and effective mobilization of insurance agents at the grass-root level are also important.

-Service providers from Kushmisera PHCC and Dhaulagiri hospital, Baglung

Spreading awareness through FCHVs and working in coordination with local bodies could improve the coverage, and the health institutions could discharge their responsibilities on par with their job descriptions.

-A service provider, Ghodaghodi hospital, Kailali

Discussion and prospects

We discuss the enrollment, service utilization, premium and risk pooling, behavioral aspects, barriers, and facilitative factors of SHIP. Some alternate but relevant strategies have also been argued in national and international contexts.

Awareness, enrollment, and adherence

This theme of SHIP addresses and supports the breadth of universal health coverage (UHC). Awareness regarding the SHIP was increasing but adherence was poor, i.e., dropping down but slower than enrollment. As our forecasting equation shows, a minimum of around nine to 20 HHs may be increased by rolling up with an additional district (Figure 3). It looks obvious when observed that mandatory enrollment and providing up to 60% subsidies to all insured people took 20 years to cover 100 % of the population in Mongolia (25). It could take a long time, or it could never reach universal enrollment, as in our case, where a voluntary mechanism is in place.

Furthermore, a scaled scenario of the Pokhara metropolitan Kaski district also showed that the dropout proportion is as high as one-fifth, as revealed by Sharma et al. (26), which is nearly double our study (9.1%). This may show in high dissatisfaction among families, especially among urban dwellers. Another similar study carried out in Bardiya, Chitwan, and Gorkha showed that enrollment increased from 1% in 2016 to 11% in 2019, and dropout decreased from 67% in 2016 to 38 % in 2018. However, dropout remained a key challenge for the sustainability of the health insurance program in Nepal (27).

The HI Board mentioned some challenges like it is unable to provide free-of-cost services to poor families due to the absence of poverty cards for the poor; supply-side barriers, i.e., the availability of drugs, diagnostic services, and doctors are significant drivers of enrolment and service utilization; and still a lack of enrolling all the targeted population due to low level of awareness (28). Despite this, the survey in the same districts showed a majority of the participants (90%) had heard of the insurance scheme and believed that enrolling in it would be a proper way to minimize their financial burden (29).

The reasons for such a low enrolment rate must be sought in the limited capacity of schemes that are based on only one health facility (public schemes) or a small group of motivated individuals (private schemes). Such isolated local Community Based Health Insurance (CBHI) schemes lack the management and human resource capacities to have a significant impact on the population (2).

The survey of the three districts and the review of 182 countries regarding the UHC, both revealed that there is a high proportion of dropouts and subsidy enrollment, which is the key challenge for the sustainability of health insurance programs in Nepal. Revisiting of existing HI policy on health care packages, more choices on copayment, capacity building of enrollment assistants, and better coordination between the health insurance board and health care facilities can increase enrollment and minimize dropout (27, 30).

Service quality and utilization

Although insured beneficiaries had better experience and perceptions of service quality and utilization, coverage was not as expected. The uninsured are perceiving and experiencing the SHIP differently than their counterparts. However, the trust did not differ between the two groups, which is very important for program scale-up. A similar finding was found in a survey carried out in Ghana, which has roughly a similar socio-economic status as ours, as both insured and uninsured were satisfied with care (13).

The idea of budget and financial adequacy, as well as the quality of service, is constant. According to research conducted by the National Planning Commission of Nepal (NPC-N), when the disability allowance of social security was granted only up to a particular quota, the service quality deteriorated, resulting in even the qualifying applicants (disabled) not being able to get it. Worse still, the issue of prejudice may imperil service consumption even more (31).

A hypothetical pre-post-quality-change study carried out in Wenzhou, China focusing on a multitiered copayment system that provisioned the increasing proportion of copayment at higher-tier hospitals than at primary health care (PHC) levels reflected that service quality is not only important overall but also more important to leverage quality services at the PHC level if we want to enhance the insurance scheme at all levels. Moreover, this hypothetical intervention would impact older adults and those with moderate health status more (32).

An insurance-related study in Kailali revealed that households without health insurance, low economic status, and heads with a low level of education were more likely to face catastrophic spending. The findings suggest a policy guideline in the ongoing national health insurance debate in Nepal. The government's health insurance program is currently at the expansion stage, thus, an increase in insurance coverage could financially help vulnerable households by reducing catastrophic health expenditures. The study concludes that households with insurance coverage, wealthier groups, headed by a male member, and heads with a higher level of education were less likely to suffer from catastrophic spending (6).

Another study digging out the renewal-related predictors showed that almost 64 % of the respondents were willing to renew their membership upon improved services. The primary determinants of annual membership renewal in HI are HH income, health care quality, and health service usage. Healthcare quality and service usage were two of the top three reasons for dropout. The study, however, did not differentiate between moral hazards or actual service utilization, thus demanding further studies on the health service utilization of the insured members (33). The GON had proposed that the procedure of treatment expenditure for chronic diseases for the ultra-poor be gradually included in health insurance under 2078 BS (16), which might increase enrollment.

Premium, risk pooling, renewal, and benefits package

Even though the premium on perception did not differ between the two groups, the importance of annual renewal and perceived referral were found with high odds of favoring the insured beneficiaries. The benefits package was perceived as good, but some crucial health problems have not been included in the package, mainly kidney disease and other NCDs and related essential medicines. Moreover, the household heads (HHs) reluctant to enroll had lower ill susceptibility. As a result, both type-1 and type-2 moral hazards may increase. In type-1 moral hazard, the presence of insurance coverage may affect actions that affect an individual's probability of illness, for example, neglecting to prevent behaviors; and in type-2, the presence of insurance may also affect the amount and cost of care once illness has occurred, such as insured individuals demanding more medical care and possibly more expensive types of medical care. Here, the predictability among the clients of chronically ill or manifesting earlier signs and symptoms of such diseases may be differently dealt with than under an insurance policy, unless they are being insured on a lifetime basis. Having surety of risk will make higher chances of enrolling, thereby diminishing the utility of risk pooling (11). Furthermore, before including any medicine or healthcare in the benefits package, a process of the Health Technology Assessment (HTA) is needed, not only from a cost perspective but also to reach the UHC (34). Updating the benefits package has also been emphasized as an alternate strategy for UHC (30).

Some beneficiaries revealed their denial of risk pooling by not being willing to enroll as they are not sick. Having said that, Arrow hypothesizes that insurance requires the maximum possible discrimination of risks; pooling of unequal risks; i.e., those at higher disease risk should pay higher premiums (11). Moreover, a study carried out in Saudi Arabia showed that the risk perception of the general population differs, and so do preventive behaviors (35). The Saudi study reflected that people's first preference is to invest in real estate, followed by insurance, including property and health. It shows that disease-related risk awareness delivery may help to understand better and, thus, increase risk pooling. The preference of choice may also be implicated in the renewal system. A dropout analysis of SHIP carried out in Pokhara metropolitan showed that families living in rented houses have four times more odds of dropout than their counterparts. This may indicate that SHIP may be less preferred than paying for rent or other things (26). However, inversely, some HHs' willingness to pay the threshold for SHIP seemed to be as low as NPR 1,000 (1 US$ = 120.51 NPR) (24) indicating the inclusion groups to be identified. The current premium may have been perceived as higher due to the experience of catastrophic health expenditure recently or in the past. A study carried out in one of the same districts showed that nearly one-fifth of households (17.8%) suffered catastrophic health expenditure (CHE). However, there exists a vicious cycle, as the same study showed that insured beneficiaries are 57 % less likely (OR = 0.43, 95% CI, 0.26–0.70) to suffer from CHE than their counterparts (6).

The experience of expanding the benefits package was found to be significantly different between the groups. It may be further explored as food for thought that a study carried out in the Kailali district showed that a household having any member with a chronic disease has nearly two times (OR = 1.98, 95% CI, 1.67–2.34) going through catastrophic expenditure than without having such a disease (6). Thus, beneficiaries from such backgrounds (may be uninsured) may propose a similar benefits package to be expanded as some medicines for non-communicable diseases have already been covered in the package.

Risk pooling also indirectly inhibits a causal pathway in catastrophic payment, including reaching out to universal health coverage. A recent study carried out in China with longitudinal data for the last 15 years showed that even after reaching nearly universal health coverage, the richest-poorest gap has widened, the concentration index decreasing from −0.202 in 1991 to −0.613 in 2015, even though the authors suggest medical health insurance as a means of decreasing the gap (36). Another recent study carried out in China showed that inclusive insurance impacts positively income distribution and inclusive

growth as well. More than this, such a type of policy strategy is more pronounced in rural and low-income households (37). Thus, health insurance and social security programs are very important tools not only to reach universal health coverage but also to reduce inequality of different types.

Alternatively, a study carried out among patients with lung cancer in Shanghai and other two cities in China showed that out-of-pocket expenditures (OOP) in two cities were less by more than one-third (36–40%) than that in Shanghai but there were more and better health services in those two cities. Inside the cities, employees had a lesser financial burden, compared to resident city dwellers (38). Another study from rural Rwanda shows that to pay bills, nearly half of the patients had to borrow money from family or friends, accruing an informal debt that they would have to repay, and 12% had to sell their belongings (39). These findings may suggest pondering fragmented health insurance policies for people from different geographic and socio-economic strata.

In the benefits package, in line with the findings in this study, a similar study showed that revisiting the healthcare packages and more choices on copayment may reduce dropout and increase enrollment (27). Another study that was carried out in the same districts showed that more than 90% of insured groups were willing to renew their membership and recommend a friend about HI. The study found that 61% had not sought any health services from health facilities outside the HI among insured groups (29).

Financial sustainability is the core of the insurance program. Gradually expanding risk pooling would improve CBHI's financial sustainability. Improving health service quality and the availability of medicines are the priorities to increase and sustain population coverage (40). Among other strategies and schemes, a multi-tiered copayment system is an alternative to a blanket policy of a health insurance scheme. A hypothetical study of changing the quality of services at the PHC level would be effective in increasing the insureds' compliance if different proportions of copayments were provided. Such proportions may be 50% and 10% at PHC levels and increase to 60 and 20 % at secondary level hospitals, and then 75 and 25% at tertiary level hospitals, respectively, for outpatient and inpatient services, as being practiced in Wenzhou (32). However, as revealed by an Australian study, physical deformity and dementia (both mainly affecting the older population) affect economic wellbeing and increase out-of-pocket expenditure, with women spending 13.1% more than men (41). Thus, the strategy for providing subsidies in premiums to older adults may increase service utilization and provide maximum benefit.

Communication and behavioral aspects

Although there were no variations in the behavior of health care professionals between the two groups, communication appeared to be a key obstacle in SHIP, even when it came to programming satisfaction, coverage, and use. This may be obvious when we ignore the extraneous factors in communication and behavior between the beneficiaries and the HCPs. Furthermore, in the same line, a dropout analysis carried out in Pokhara metropolitan showed moderate odds (OR, 3.09; 95%CI, 1.01–9.49) of dropout due to unfriendly behavior of HCP (26). This may indicate that there is a sheer of background variables behind the poor beneficiary-provider communication, such as perceived opportunistic behavior of the insureds by providers and, thus, deviating toward the uninsured, long waiting time, poor patient management, and unmet expectations of the beneficiaries. The Ghanian survey also found that greater insured use of health-care services causes doctors' workloads to grow, influencing their behavior toward the insured. Similarly, in addition, the perceived opportunistic behavior of the insured beneficiaries by providers might have psychologically led to deviating toward the uninsured to treat them softly and behave rudely toward the insured ones. In addition, the long waiting queue of the insured beneficiaries may add to the jeopardized situation (13). However, another study in Nepal emphasized that the HCW's financial competing interests of attracting the insured patients at their private clinics would have guided them to treat them indifferently at HFs, as it was also found that most of the dropouts were relatively from well-off families, government employees, businessmen, migrant workers, and also poor class families (27).

Radio, newspapers, and TV were the most common sources of information about the SHI. Most of the participants were positive about the enrollment assistant and other services provided by the SHI scheme. Participants were more than 90% satisfied with the nature of changes in different aspects of health services after the SHI scheme. In contrast, in Pokhara, a sizable portion of households have left the SHI program. Lack of medications is the most frequently linked factor to discontinuing SHI, followed by rented housing, family members reporting good health, and unpleasant service provider conduct. Efforts to decrease SHI dropout must focus on addressing medicine supply difficulties and enhancing providers' conduct toward scheme holders. Rented households may experience fewer dropouts if insurance awareness is raised and includes provisions to change first contact points (26).

Challenges, barriers, facilitative factors, and ways forward

Even though the factors like a challenging enrollment process, a lack of human resources, crowding, the underfunded state of health facilities, and HH visits by SHIP enrollment staff were not found to be significantly different between the two groups, we need to further discuss these as barriers since a

systematic review carried out by Ranabhat et al. in the Nepalese context showed that the volunteer type of health insurance, itself, is one of the major challenges (12). Furthermore, the SHIP message has not reached the rural people, as a result, the public perception is poor. A little earlier finding from eastern Nepal- an inadequate awareness toward health-protection demands at the institutional level and family and community networks (42) may further interact with an inadequate awareness level on risk pooling as revealed in a systematic review (12), has created a greater challenge to SHIP. Our study discovered that the non-universal use of insurance cards and only allowing them to limited health facilities has confounded and barred even UHC. In addition to our findings, another study from Nepal revealed that unavailability of enough drugs, HCWs' unfriendly behaviors, and indifferent behavior toward insured patients in healthcare facilities so that they take services from their private clinics, were the main barriers to health insurance programs in Nepal (27). In addition, a large number of sanctioned positions at public health facilities remain unfilled. Performance management was found to be rarely practiced at the facility level, and there was a lack of incentives in place for personnel. A high demand for specialized doctors was found, and interviewees mentioned a need for further training of administrative, record, and financial staff. Self-reported engagement in private practice by the staff of public health facilities ranged from 4 to 90% (29). The increasing trend of unnecessary service utilization is the main barrier in health insurance programs (16). Hypothetical pre-post change in the quality of services of PHC level HF study in China showed that in post-change, home to HF distance was an additional quality indicator, to age (older) and health status (moderate, self-rated), which were significant factors in pre-change (32). This shows that increasing PHC services may also sustain health insurance and, thereby, the health system.

The major benefits of enrollment were considered to be general treatment and a reduction in financial burden. Economic status was described as the main barrier to enrolment. A vast majority of the respondents had been invited to enrolment, and 73% agreed to enrolment. The severity of health issues and perceived susceptibility to them were both associated with HI enrollment, although they were not significant predictors. However, peers' requests to register in HI, discussions with relatives, and family members' approval of enrolment were the most significant predictors of enrolment. These factors may be incorporated into future intervention plans for increasing enrolment in HI (43). Local governments and stakeholders can play an important role. In addition, the two groups had distinct experiences using IEC materials. Integration with an old-age allowance card might make things easier. The initiative might be aided by a mobile app, online registration, patient management, and increased insurance agent mobilization at the grassroots level. Despite the disparities in service quality and use, the two groups must have the same level of confidence. Regulatory initiatives like the Health Insurance Coordinating Committee Operation Model Procedure-2021 were prepared and accepted at the provincial and local levels. In addition, Health Insurance Model Local Level Declaration Procedure-2021 was also created and authorized in the same way. Provincial and local level ownership building and strict pharmacy and drug availability management and monitoring systems for health insurance are keys to the promotion and advancement of the Health Insurance Program (16).

During qualitative research among the health personnel involved in the delivery of health services, different experiences and obstacles when implementing SHIP in Nepal were explored. According to the study, consumers originally showed interest in the insurance program, but it was discontinued in later years due to a lack of medications, acceptable laboratory services, poor human resources, awareness, and interpersonal communication. They believe that the health insurance policy was put in place to reduce poverty and catastrophic medical costs and that it is crucial to make sure that the underprivileged can sign up for the SHIP without difficulty. Participants in SHIP primarily used the services for communicable diseases, but when SHIP was implemented in the district, visits for chronic conditions including diabetes and hypertension began to rise. The pattern of service use also saw certain adjustments. Service providers noted that participants with health insurance schemes visit health facilities in earlier stages of disease compared to those who do not have health insurance (16). In line with this, a willingness to pay for the program is substantially related to awareness of the scheme. It is influenced in part by social capital and awareness of the Community Based Health insurance initiative (43). Thus, it is evident that social cohesiveness and solidarity in local communities are vital to raising awareness of the benefits of the CBHI and, thus, in SHIP and other social security programs.

Among other alternative schemes, Ranabhat and his colleagues in a similar study argued that CBHI through co-operatives would be among the better models because of its cost-effectiveness and self-responsiveness. However, results from its piloting in a Chinese context showed mixed results. They have also proposed the mandatory and single-payer health insurance models as superior to others (44). Other alternative strategies proposed to protect from the catastrophic situation and pool resources include adequate human resources for health; an efficient and quality health-care delivery system; a mix of public and private funds, including government revenues; SHI; private insurance; developmental assistance for health (DAH); a strong information system; a balanced mix of services; and actions addressing social determinants of health (30, 45).

Limitations

Despite these findings, the study has certain limitations as well. First, it was based on the information collected using records of the health facilities and the primary information

obtained through interviews at a longer cross-section of time duration between the districts, i.e., 8 months. Thus, there might be some variations in results due to longer time intervals. Since the chosen facilities were implementing the programs, and beneficiaries were selected only during data collection periods of certain durations, there would be a selection bias and they may not represent the diversity of illnesses. Second, although providing an important impression, only a district from Terai and two from the hilly region probably do not represent the variation by territory or ecology to scale-up and so, results and, more specifically, the prediction of enrollment may be cautiously interpreted. Third, the quality of services and utilization needed to be checked with trade-offs of moral hazard, benefits package, premium, and other tools of health economics, which were beyond the scope of the study. Fourth, qualitative data were coded by a single person, thus, inter-coder reliability was not calculated. Finally, the study was unable to include the perspectives of the third party of the tri-polar insurance mechanism, the board members.

Conclusion

Adherence to the SHIP trend has got momentum, weaker though, with enrollment and a bit sluggish dropout and poor renewal. Patient management, especially queue management, developing communication skills among the service providers, and timely reimbursement are recommended urgently to improve the SHIP. Community mobilization for insurance education, including benefits package with their regular updates, enrollment, and renewal processes, blended with prevalent disease threat and risk perception and the value of preventive measures to reduce moral hazard, are promoting factors to strengthen the program. Some alternate policy schemes and strategies based on three-tier governmental contexts, disease predictability, and pooling of unequal risks from different resources are warranted.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

The studies involving human participants were reviewed and approved by Nepal Health Research Council (NHRC). The patients/participants provided their written informed consent to participate in this study.

Author contributions

DP, CA, JB, and DN: study conceptualization and design. DP, JB, and DN: fund acquisition. DP, CA, KJ, KC, NP, NB, and AR: data collection. DP, CA, SP, and LA: analysis and interpretation of results and subsequent review and correction. DP, CA, SP, LA, and NP: draft manuscript preparation. All authors reviewed the results and discussions and approved the final version of the manuscript.

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Conflict of interest

LA was employed by HERD International.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.978732/full#supplementary-material

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Healthcare system development in the Middle East and North Africa region: Challenges, endeavors and prospective opportunities

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Background: Countries in the Middle East and North Africa (MENA) region have been investing in the development of their health systems through implementing reforms to improve health care delivery for their nations. However, these countries are still facing challenges in providing equitable, high quality healthcare services. There is limited published literature supporting the previous and ongoing attempts that have been made to improve health system performance in MENA countries.

Aims: This review aims to describe experiences of health system development efforts in the MENA region, highlight progress, identify challenges that need be addressed and future opportunities to achieve responsive and efficient health systems. It also aimed to provide recommendations to further support these health systems toward evolution and performance improvement.

Methods: A literature review was conducted by searching different databases including PubMed, Scopus, Google Scholar and other electronic resources to identify articles and publications describing health systems development in the MENA region from 1975 to 2022. It also included grey literature, reports and policy and planning documents by international organizations. The identified references were reviewed to extract, analyze, organize and report the findings.

Results: The review revealed emerging evidence describing governmental initiatives to introduce health system reforms at different levels in the MENA countries. These include initiatives targeting the various elements controlling health system reform: financing, payment, organization, regulation and behavior of providers and consumers. There are several challenges facing the health systems of MENA countries including the rising burden of chronic diseases, inequitable access to health services, deficiency in health workforce, shortage in the use of effective health information systems and leadership challenges. The review identified several key areas that can benefit from further improvement to support health system reforms. These include

improving the structure, organization and financing of health systems, health workforce development, effective data management and engagement of key stakeholders to achieve adequate health system reforms.

Conclusion: The MENA countries have made significant steps to improve the performance of their health systems; yet achieving a comprehensive health reform will require collaboration of various stakeholders including health policy makers, healthcare professionals, and central to the success of the reform, the patients.

KEYWORDS

MENA, health reform, health financing, health system performance, health outcomes, health workforce

Introduction

The MENA region includes several countries and territories geographically localized in the Middle East and North Africa (1). There is a wide variation among these countries with respect to demographic trends and dynamics, as well as in Gross National Income (GNI) (1, 2). Most of the MENA countries are at a stage of medium to high population growth and fertility, while some countries are at advanced phase of demographic transition (1). The population is mainly urban and young, with more than half of the population under the age of 25 (1, 3, 4).

More than half of the MENA countries contribute significantly to the energy production of the world (4). Despite the wealth of resources, there has been modest progress and reduction of poverty in the region in comparison with other countries (4). These countries vary considerably in their economic status and own various economic drivers, including oil, tourism, agriculture and manufacturing (3). MENA countries can be classified into three categories according to their economic and health outcomes achievements (4, 5). These includes (1) low-income countries which have the top infant death rates and maternal mortality ratios in the region that are witnessing the most significant challenges in health care (e.g., Yemen and Djibouti); (2) middle-income countries which have achieved substantial improvements in health outcomes even though some of these countries are challenged by rural/urban variations in health outcomes and fragmentation in health coverage (e.g., Algeria, Egypt, West Bank and Gaza, Jordan, Lebanon, Iran, Iraq, Syria, Libya, Morocco and Tunisia); and (3) high-income countries which have accomplished significant health outcomes as a result of oil revenues, e.g., the Gulf Cooperation Council (GCC) countries (Saudi Arabia, Kuwait, Qatar, Bahrain, the United Arab Emirates and Oman) (4, 5).

Over the years, political uprisings, protests, and armed conflicts have affected several countries in the MENA region and some large-scale conflicts still exist in countries such as Syria, and between Gaza and Israel to date (4). In addition, the following issues continue to pose major development challenges to the governments of the MENA countries: rapid population growth, high unemployment rates especially amongst the youth, gender inequality, scarcity of water resources and socioeconomic gaps between the rich and poor (4). Improving health care delivery services is a key to long-term stability of these countries (3).

All countries are striving to afford their population access to health services in the most efficient way through providing universal health coverage (UHC), a concept that has been supported by the United Nations (UN) and World Health Organization (WHO) (6). This implies the access to quality health services for all people without the risk of exposure to poverty as a result of payment for these services (7). This means that all people can utilize effective preventive, promotive, curative, palliative and rehabilitative health services that they need, while ensuring that this will not expose them to financial hardship (8). Primary health care is the basis of UHC (9). However, providing an affordable health care is a challenge facing all countries, as new therapies are developed and resource allocation demands increase (10). Demographic shifts including the increase in the size of the aging population put an enormous pressure on health systems to provide suitable care for the elderly patients who tend to experience co-morbidities, cognitive decline and fragility more than younger patients (10).

The MENA countries have achieved significant developments in their health systems and the health outcomes of their population over the past decades (3, 4, 11, 12). These

Abbreviations: COVID-19, Coronavirus disease of 2019; CHE, Current health expenditure; GGE, General government expenditure; GGHE, General government health expenditure; GDP, Gross domestic product; GNI, Gross National Income; GCC, Gulf Cooperation Council; IT, Information technology; LEB, Life expectancy at birth; MENA, Middle East and North Africa; MERS-CoV, Middle East Respiratory Syndrome; NCDs, Non-communicable diseases; OOP, Out-of-pocket; THE, Total health expenditure; UN, United Nations; UHC, Universal health coverage; WHO, World Health Organization.

involved improving health service delivery, developing public health programs and adopting new medical technologies, as well as educational and socioeconomic developments (4). These countries have achieved significant improvement in providing population access to basic health services (13). This has significantly improved morbidity and mortality patterns and other measures of health status including the mean life expectancy at birth (LEB) (3, 4, 11, 14). There has been a significant progress in the reduction of child mortality, improvement in maternal health and management of communicable diseases in MENA countries (3, 14). Indeed, the decline in child mortality in these countries has been achieved at rates faster than other developing countries in the world (13). Yet, there are significant variations among and within countries of the MENA region in these achievements (4, 11).

However, the MENA region still faces a multitude of political, macroeconomic, social and health challenges (3). These include the need to ensure social and political stability, equitable and comprehensive social and economic rights, and to expand the opportunities of employment for its population (1). Social justice in health care aligns with the principles of UHC (7). In spite of the progress achieved in the health systems of the MENA countries, people living in some of these countries still suffer from inequities in some health outcomes including maternal and child health outcomes (13). Examples include people living in the Gaza Strip, Iraq and Yemen who have experienced deterioration in health outcomes due to conflict-related problems (13).

The MENA region includes a wide range of different health systems in countries that share similar linguistic, cultural and historic backgrounds (15). There are significant differences among these countries in key parameters including per capita national income, percentage of total health expenditure (THE) out of gross domestic product (GDP), life expectancy and average years of schooling (15). The health systems in these countries have been increasingly facing multitude of challenges to deliver quality health services to the population (3–5, 13). To overcome the challenges facing the health systems in the MENA region, this requires a strong political commitment to implement rigorous efforts and consistent reforms to meet the population health needs, especially at a time of limited fiscal resources (16).

Health reform involves polices and measures taken by governments to improve health care delivery to the population of a country (17). The aim of this process is to expand healthcare coverage for the population and improve healthcare services through organizing policy-initiated changes that are achieved through operational, financial, systems, process or practice interventions (17). Examples include implementation of new or renewed safety and quality practices, application of advanced technology to support care improvement, achievement of efficiencies in health care delivery, and ensuring the availability of reliable information to facilitate cost-effective and appropriate healthcare decisions (18, 19).

Roberts et al. (17) in their textbook "Getting health reform right: a guide to improving performance and equity" proposed the control knobs framework for assessing health systems and facilitating health reform. This framework (The Flagship Framework) assigns five key mechanisms or processes (knobs) that can be adjusted or changed to design effective health reform and improve health system performance as illustrated in Figure 1 (17). These five knobs include *Financing*, which involves all the resources, including the mechanisms and activities intended to gather funds for the healthcare system such as insurance premiums, health-related taxes and out-of-pocket (OOP) expenses (17). This knob which is determined according to the country's politics and social values has significant impact on the access to health care, protection from financial risk, and the health status of the population and particular groups within the population (17). The second knob is *Payment* which reflects allocation of existing resources to health services providers (17). The third knob is the *Organization* of the health system which describes the structure of the providers of care, their roles, activities and operations, and structure of the care market (17). The forth knob is the *Regulation* which refers to the policies and actions that change the behavior of the different stakeholders in the healthcare system, including the healthcare providers, individual consumers, medical associations, insurance agents and others (17). Lastly, the *Behavior* knob which aims to change individual behavior (of both providers and patients) through population-based interventions to improve the performance and outcomes of the healthcare system (17).

Health reforms can be reflected by improving three intrinsic performance goals of the health system: the health status of the target population, customer satisfaction and financial risk protection (the ability of health system to secure the population from the fiscal burden of poor health or diseases) (17). Moreover, the authors determined three intermediate performance measures that reflect the performance of health system goals: efficiency, access to, and quality of care (16, 17). The Flagship Framework has been increasingly utilized to organize health systems planning, thinking and reform (16).

Reforms are usually complex; their success depends on multifaceted and interlinked factors and can be influenced by many elements, including the country's economy, geography, culture, population size, socioeconomic circumstances and its political structure and stability, along with several other variables (19). Achieving specific outcomes of a health reform might also require the fine-tuning of several knobs concurrently with no specific order of turning the control knobs (17). Health reforms also differ by settings and a successful reform in one context may not necessarily be applicable to another (17). This can be explained by the impact of cultural and structural factors in a given context on the actions of these knobs (17). However, each country can achieve successful health reforms. Evidence has shown that different countries from across the globe were able to report a successful or nearly successful

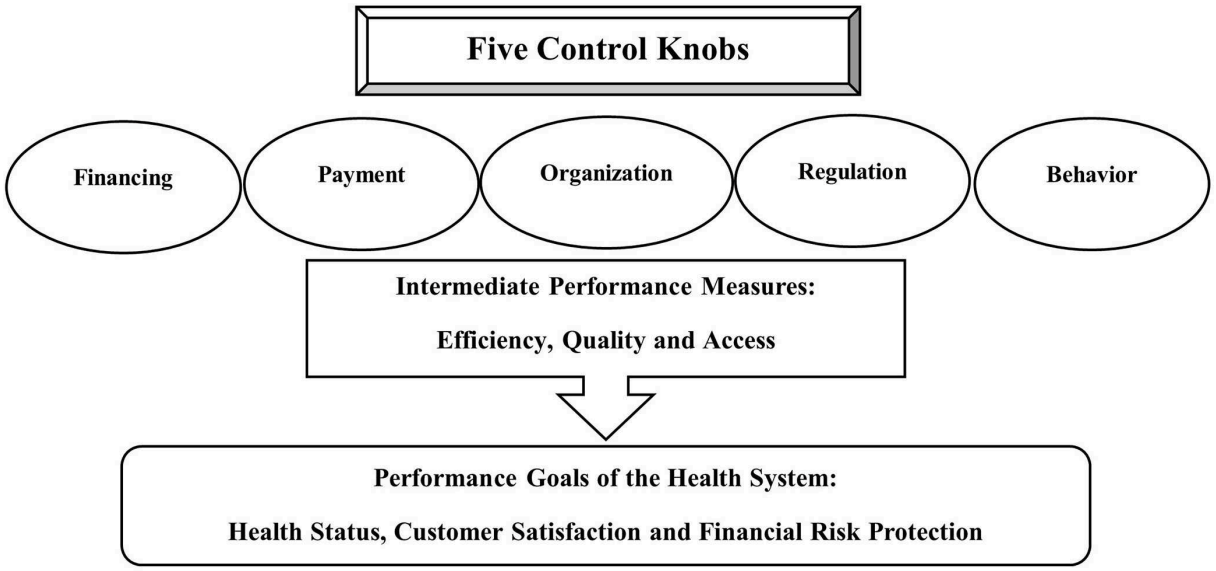

FIGURE 1
Visual illustration of the elements of the Flagship Framework.

reform experience, irrespective of their political or economic situation (20).

There is limited literature describing the previous and ongoing initiatives for development of health system performance in MENA countries. This review aims to describe examples of health system development efforts in countries of the MENA region and to outline them in light of the Flagship Framework, highlight the progress, identify the challenges facing these countries and the future opportunities to serve the health needs of their population. It also aimed to provide recommendations to further support the success of the efforts for achieving successful health system reforms in the MENA region.

Methods

A comprehensive literature review was conducted by searching different search engines and databases including PubMed, Scopus, Google Scholar and other electronic resources during the period from 1975 to 2022 to identify references describing health systems development in the MENA region. The review process also included grey literature, official reports, policy and planning documents, and online resources by international organizations such as the World Bank and WHO. The literature review was conducted using keywords related to the topic including health reform, health system, development, improvement, performance, health financing, health outcomes, Middle East and North Africa region, MENA, MENA countries, and by applying different combinations of these keywords. At the outset of the review process, all relevant titles, abstracts and resources were identified, then they were filtered to exclude irrelevant references. During the next review cycle, the identified references were examined to select the references that would suit inclusion and detailed examination. The references were included in the review if they were describing the MENA healthcare systems with a focus on health system reforms and challenges facing these systems. All included references were in English language. The retrieved references were reviewed to extract, analyze, organize and report the findings.

Overview on health systems organization in the MENA region

The health systems in most MENA countries were organized to provide primary health care services (4, 21). More recently, there has been a general trend toward curative care with large investments in acute hospital care (3–5). This has been driven by the health care and demographic changes that were accompanied by the growing burden of chronic diseases (4).

The state has been mainly responsible for the provision of health services in most MENA countries, *via* processes characterized by centralized financing, delivery and regulatory infrastructure (4). However, increasing attempts have been made by many governments in the region to separate these functions to help increase the efficiency and effectiveness of the health sector (4). These governments have also been shifting the delivery of health service to independent management systems for the operation of the primary and acute health care facilities (4). There has been an ongoing growth of national health insurance programs characterized by tiered coverage levels and

different resources in several countries in the MENA region (3–5, 16, 22). This has been accompanied by the growth of the private medical sector to fill gaps in health delivery coverage, with subsequent concerns about efficiency, equity and quality assurance because of lack of proper control of this sector by some governments (3, 4, 23). This sector is currently playing a key role in the health care delivery in some MENA countries, specifically the GCC countries (4, 16).

In low-income countries of the region, two-tiered health systems that provide health services by both government and private sectors have been developed and implemented (4). However, the quality of the provided health services has often been suboptimal due to poorly trained staff, lack of availability of medications and medical supplies and inadequate coverage of the population needs in the rural and remote areas (4). This has reflected on an increase in the OOP payments to access private health services, an action that can be impoverishing for the poor (4).

The governments of middle-income MENA countries have been adopting health reforms targeting the organizational and financing aspects of health systems such as the implementation of social health insurance systems (3, 4, 22). This has resulted in an increased demands for different providers, including the voluntary and private (for-profit and non-profit) sectors to overcome gaps in population and service coverage, resulting in fragmented health care delivery and financing systems (4).

The populations of the upper-income countries in the MENA region have been provided comprehensive health coverage, either free of charge or at highly subsidized rates as a result of significant oil revenues (4). However, the provided health services in these countries could benefit further from improved efficiency and quality reforms (4, 13). The GCC governments had to implement cost-containment measures and as a result, have been looking for new financing strategies, such as introducing national health insurance schemes (4, 16). Moreover, most of the GCC countries have developed visionary policies. For example, Qatar had a National Vision 2020; similarly Oman prepared Vision 2020 followed by Vision 2040; the Saudi Arabia, Kuwait, the United Arab Emirates and Bahrain each prepared a Vision 2030 for sustainable development (24). These policies call for diversify of the economy, industrialization, and an emphasis on the role of the private sector in the delivery of healthcare services and the investment in workforce capacity building (24).

Health patterns, disease burden and population dynamics in MENA region

Available evidence indicates significant improvements in key health indicators including a rise in life expectancy, decline in infant and maternal mortality, and expansion in health coverage, albeit to variable degrees in all the countries of the MENA region (3, 4, 11, 14). Table 1 summarizes selected health indicators for countries in the MENA region (25).

There has been an epidemiological transition that is manifested as a decline of the high burden of communicable diseases and an increase in the burden of injuries and non-communicable diseases (NCDs), but at a varying pace and timing among the different courtiers in the region (3, 20). Cardiovascular diseases, cancer and diabetes account for almost one third of the overall disease burden in the MENA region (26). The prevalence of risk factors for NCDs (obesity, raised blood glucose, hypertension and smoking) is far higher than the worldwide averages (11). The rising rate of smoking and tobacco product use is among the significant public health concerns in the region (4, 11). There has been an accelerated increase in obesity rates and tobacco smoking especially among women and adolescents which have been contributing to an accelerated rise in the prevalence NCDs (13). The main cause of mortality in the MENA region has been heart diseases which are anticipated to contribute to about 77% of total deaths by 2030 (13).

Some of the MENA countries such as the low-income countries and rural areas in middle-income countries (e.g., Egypt and Morocco) are challenged by dual burdens of disease characterized by increasing rates of NCDs accompanied by decreasing, but prevalent communicable diseases (4). An earlier study reported that NCDs and injuries are the underlying cause for more than 75% of the disability-adjusted life years in most lower middle-income countries except in Sudan and Yemen (11). In these two countries, NCDs account for less than 50% of the disease burden while infectious and parasitic diseases comprise a significant share (11).

On the other hand, middle- and upper-income countries in MENA are mainly impacted by the burden of NCDs while having largely eradicated communicable diseases (4). Cardiovascular disorders, diabetes mellitus, behavioral and mental disorders and malignant neoplasms account for more than 60% of the NCDs disease burden in most of the countries in the region (11). The rapid rise in NCDs is attributed to the rapid urbanization and changes in diet and lifestyle of the population of these countries (4).

The MENA region is also experiencing a high prevalence of stunting as a result of undernutrition, especially in low-income countries and some territories of middle-to high-income countries (4). There is also the prevalence of iron-deficiency anemia and other micronutrient deficiencies (4). Another major challenge is the increasing prevalence of overweight and obesity as a result of over-nutrition and sedentary lifestyle and their links to NCDs, especially in high-income countries in the region (4, 11, 13).

Another major cause of premature mortality in the MENA region is the increasing numbers of road traffic injuries which show no signs of reduction (4). This has mainly resulted from increased rates of urbanization and traffic volume in the presence of inadequate road infrastructure and safety measures

TABLE 1 Selected health indicators for some countries in the Middle East and North Africa region[a].

	Life expectancy at birth (years) (2019)	Adult mortality rate[b] (both sexes) (2016)	Infant mortality rate[c] (both sexes) (2020)	Hospital beds (per 10,000 population) (2017)	Medical doctors (per 10,000 population)	Nursing and midwifery personnel (per 10,000 population)
Algeria	77.13	95.03	19.46 (18.47–20.52)	19 (2015)	17.19 (2018)	15.48 (2018)
Bahrain	75.81	56.81	5.78 (4.34–7.73)	17.40	9.26 (2015)	24.94 (2015)
Djibouti	65.81	244.50	47.18 (28.17–76.07)	14.00	2.24 (2014)	7.29 (2014)
Egypt, Arab Republic	71.82	164.60	16.65 (11.31–24.23)	14.30	7.46 (2019)	19.26 (2018)
Iran, Islamic Republic	77.35	80.13	11.14 (6.53–18.92)	15.60	15.84 (2018)	20.77 (2018)
Iraq	72.42	173.50	21.32 (16.4–27.48)	13.20	9.66 (2020)	23.87 (2020)
Jordan	77.87	110.50	12.92 (9.35–17.66)	14.70	26.61 (2019)	33.47 (2019)
Kuwait	80.97	79.22	7.58 (7.04–8.16)	20.40	23.42 (2020)	46.83 (2020)
Lebanon	76.44	95.62	5.97 (2.77–12.04)	27.30	22.07 (2019)	16.74 (2018)
Libya	75.78	150.30	9.53 (5.58–16.16)	32.00	20.91 (2017)	65.31 (2017)
Morocco	72.99	69.06	16.02 (11.36–21.85)	10.00	7.31 (2017)	13.89 (2017)
Oman	73.90	96.25	9.45 (8.38–10.68)	14.70	17.74 (2020)	39.38 (2020)
Qatar	77.17	61.76	4.93 (4.42–5.5)	12.50	24.85 (2018)	71.97 (2018)
Saudi Arabia	74.31	89.13	5.99 (4.61–7.94)	22.40	27.38 (2020)	58.17 (2019)
Sudan	69.15	223.90	39.92 (29.96–53.04)	7.40	2.62 (2017)	11.46 (2018)
Syrian Arab Republic	72.67	301.10	18.45 (9.58–24.45)	14.00	12.87 (2016)	15.41 (2016)
Tunisia	77.04	91.00	14.29 (12.64–16.09)	21.80	13.03 (2017)	25.14 (2017)
United Arab Emirates	76.08	73.95	5.62 (4.95–6.4)	13.80	26.01 (2019)	57.46 (2019)
Yemen, Republic	66.63	221.30	45.71 (23.97–81.09)	7.10	5.25 (2014)	7.85 (2018)

[a]Most recent data from the World Health Organization Global Health Observatory Indicators Index Data. Source of data: (25).
[b]Adult mortality rate is defined as the probability of dying between 15 and 60 years per 1,000 population.
[c]Infant mortality rate between birth and 11 months per 1,000 live births.

(13). This has been estimated to account for the third top cause of mortality in the region and is expected to increase between 30 and 40 % by 2030 if no measures are implemented to change the existing policies (13).

Similar to other countries in the world, the MENA region has been facing emerging diseases such as HIV/AIDS, Middle East Respiratory Syndrome (MERS-CoV) and the Coronavirus Disease of 2019 (COVID-19) pandemic (4, 27, 28). The overall prevalence of HIV/AIDS is still low and limited to high-risk groups (4). However, it has been estimated that the MENA region has the second top growth rate of HIV infection in the world (4). This necessitates timely and effective preventive actions to be undertaken to combat the spread of the disease and limit its social and economic consequences (4).

The MENA region has been facing rapid expansion in the population (4). It had a 3.7-fold increase in population from 1950 to 2000, which was the highest population growth rate in the world (4). At present, it is estimated that MENA has the second top annual population growth globally (at 2% equivalent to about seven million additional individuals per year) (4). If this rate continues, the population is expected to double during the first half of the twenty first century (1, 4). The MENA countries vary widely with respect to their population size, with the highest population in Egypt (11). It is estimated that all MENA countries (except Lebanon) will witness a significant increase in the population during the next decades (1). The highest increase in the total population in absolute terms is expected to be seen in Egypt, followed by Iraq and Sudan (1). The population of some countries such as Iraq, Sudan and the State of Palestine are expected to double in size in the 30 years between 2015 and 2050 (1). In contrast, the population of Lebanon will decline by 480,000 by 2030 (1). Urbanization will continue to grow in many MENA courtiers such as Kuwait, Qatar, Jordan, Oman, Lebanon, Bahrain, and the United Arab Emirates (1).

The fertility rate in the region has been decreasing for years due to multiple factors such as delayed marriages and the use of contraception (1). It is estimated that the total fertility rates in half of the MENA countries will be at or less than the level of replacement by 2030 (1). However, a history of high fertility rate has yielded to an increasing number of women of reproductive age (1). This will lead to a larger number of births that is estimated to be 500 million births during the first half of the

twenty first century (1). The MENA countries stand at various stages of the demographic transition, varying from countries in the early transition stage, characterized by both high birth and mortality rates, to countries that achieved the transition with both low birth and mortality rates (4).

The number of children and youth (0–24 years) is expected to decrease in all MENA countries (except in Iraq and Sudan) in 2050 (1). The number of youth will be increasing in 12 MENA countries, but will contribute to a declining proportion of the overall population due to decreasing fertility (1). As mortality and fertility rates decrease in most of these countries, the population's age structure changes (1). The MENA region is undergoing a demographic dividend which happens because of the demographic transitions of the population of its countries, albeit at different rates (1). The United Nations Children's Fund (UNICEF) has classified MENA countries into three categories in terms of demographic phase (1). Pre-dividend countries are those with an increasing proportion of working age population between 2015 and 2030, due to ongoing rapid increase in population growth leading to a high child dependency ratio (1). These include four countries, the State of Palestine, Iraq, Yemen and Sudan (1). The early-dividend countries which are experiencing a relative rise in the working age population and are in their way toward decreased fertility; thus witnessing lower child dependency ratios and a higher share of working age population (1). This applies to ten MENA countries and includes Egypt, Libya, Algeria, Iran, Jordan, Bahrain, Saudi Arabia, Oman, Syria and Djibouti (1). Late-dividend countries are those experiencing a decreasing proportion of working age population between 2015 and 2030 due to low fertility rates, but raising elderly-dependency ratio and include six countries: Kuwait, Qatar, Tunisia, Morocco, Lebanon and the United Arab Emirates (1).

In the MENA region, LEB has increased dramatically since the 1950s and is expected to witness further increase during the coming decades, but at a slower rate and varying degrees among the different countries (1, 11). In countries like Lebanon, Morocco, Algeria, Iran, Tunisia, Oman, Qatar, Bahrain and the United Arab Emirates, the life expectancy is expected to increase to more than 80 years by 2050 (1). On the other hand, Djibouti, Yemen and Sudan are expected to have the lowest projected LEB which will be ∼70 years in 2050 (1).

An important contributor to the population dynamics in the MENA region is the migration to, from, and within the region (4). The MENA countries have been affected by migration and forced displacement as a result of conflict and war, as well as for employment and climate-related migration (1). The World Bank classified eight MENA countries as being conflict-affected or fragile contexts in 2018 (1). The MENA region also hosts the largest refugee population in the world (4). In 2010-2011, several MENA countries have witnessed a wave of mass uprisings over poverty, unemployment, lack of justice and political repression, the so called the Arab Spring (3). The main driver for the mass protests was a call for social justice, wellbeing and dignified life for all constituents (16). As a result, several MENA countries including Libya, Syria, Iraq and Yemen have been suffering from continued violent conflicts (3). This has created regional refugee crises and sustained impacts and pressures on the health systems of the countries that have been hosting the refugees such as Lebanon and Jordan (1, 3, 29). These include limited access to health services for the refugees who have chronic NCDs, rise in conflict-related injuries, destruction of health infrastructure, migration of most health workforce and outbreaks of infectious diseases (3). Lebanon, Gaza and the West Bank witness political instability and Iran is still experiencing world-wide banding measures (3). More stable countries such as Algeria, Morocco, Tunisia and Jordan have been also undergoing significant reforms (3). On the other hand, the oil producing GCC countries have been challenged by the significant influence of the economic migrants on their population size and structure (1, 4). These countries have been hosting millions of expatriates, constituting between 60 and 90% of their workforce since the exploration of oil in the 1970s (4). This has added responsibilities on the GCC countries to provide healthcare services to meet the health needs of the workers and their families (4).

Challenges facing health systems in the MENA region

According to the WHO, MENA countries will have to address several weak aspects of their health systems including weak policy analysis, formulation, coordination and regulation, limited cooperation among sectors, poor community participation in planning and provision, and inadequate health information systems, human resource policies and management of health services at all levels (4). Poor planning has resulted in inefficient and misuse of resources and consequently led to the growth of unregulated markets, decreased productivity and increased the pressure on limited financial and human resources (5).

In the MENA region, health care planners and providers have been facing major challenges (5). These include increasing pressure on health services as a result of growing demands due to demographic changes, technological advances and rising public expectations, augmented by economic sanctions in some countries (5). As stated earlier, the MENA healthcare systems have also been challenged by the growing burden of NCDs and a combined burden of malnutrition that involves both undernutrition and obesity (16). The increasing NCDs along with their social, economic and political implications have been among the significant challenges that have been hindering countries' effort to achieve UHC (30).

The MENA countries face challenges related to the financing needed for the provision of pharmaceuticals and medical

equipment (4). Lack of properly functioning pharmaceutical regulations, inappropriate medication prescribing and self-medication practices contribute to a high percentage of THE on pharmaceuticals (4). These countries largely depend on passive purchasing of health products instead of adopting active purchasing provider payment mechanisms which can enhance quality, productivity and equity (3). Expenditure on medical equipment and technology is also inefficient and excessive in view of the predominance of the curative care approach in the health systems in the MENA region (4). Many MENA countries adopt curative approaches, especially for NCDs management, rather than adopting preventive approaches, which leads to increased health care costs (3).

Another challenge is related to the legacy of health services reforms in the MENA countries which have been mainly financially driven instead of being need-driven (5). This has resulted in accelerated and disorganized expansion of medical services provided by the private sector, with a main emphasis on curative care than on preventive medicine or the wider public health agenda leading to further pressure on the limited available resources (5). Additionally, the regulation, monitoring and control of the private sector is uneven and limited in several MENA countries (3). However, some countries such as Egypt, Jordan and Tunisia have public or independent accreditation bodies for the public and private health facilities (3).

Among the prominent challenges facing the MENA region is the inequalities in health status which is characterized by wide variations in population health status among the MENA countries, and sometimes within countries due to unequal distribution of resources, variations in the population socioeconomic levels and inappropriate planning to target the most deprived groups of the population (5). Health infrastructure and services are mainly localized in urban areas in most of the MENA countries, reflecting the general distribution of the population (3). There is unequal access to care, a wide variation in access to health services across and within countries with large uncovered population in several countries and territories in the MENA region (3, 16). There have also been issues related to procurement, importation and provision of critical medical technologies, products, vaccines and other technologies in many countries in the MENA region due to the geographic adversity within some of these countries and existence of rural population living across an enormous geographic territories (4).

Many of these countries also face challenges in training and recruiting healthcare workers, especially in conflict settings and rural areas (3). In addition, variable and inconsistent quality and long waiting times with high absence rates among healthcare workers have been among the issues that face some healthcare systems in the region (16). Other challenges include the wide variation in the clinical standards and shortage of valid and reliable data on health systems performance (5). The MENA region generally lacks available, timely and reliable data to support conducting adequate health reforms (3, 4). Among the leadership challenges facing the MENA health systems include poor development of leadership skills, limited support beyond the top-most level of leadership, lack of comprehensive information for management and existence of competing interests posed by various stakeholders in these system (4).

These challenges have been coupled with the ongoing conflicts in several countries of the MENA region which have led to political instability, declined economic productivity and large decrease in governmental incomes (16). Providing adequate funding for health services for refugees is another main concern in the countries that host large refugees population (3).

Health workforce

Healthcare professionals represent the core of the health system (10). Poorly qualified health workforce is a commonly recognized problem (5). The main challenges facing MENA countries in terms of health workforce include the recruitment and retention of the properly trained workforce, professional licensing and continuous education and recertification for all health professionals, and the need to provide strong organizational culture with clear standards and policies to support a diverse health workforce needs (4).

The health systems in the MENA region are impacted by the universal challenges of preparing, maintaining and retaining health professionals along with a considerable variation in the human resource situation among and within countries of the region (4). A study in 2017 has found that the mean physician density in the MENA region (20 physicians per 10,000 population) is superior to the worldwide physician density of 13.9 (11). The region has also been found to have higher nursing and midwifery staff density (36.8 vs. 28.6 per 10,000 population) compared to the global averages (11). However, physicians and nursing density in many MENA countries was found to be lower compared to the averages of countries with comparable income and a decline in physician densities was detected in several countries in the region (11). The majority of the health staff practice in urban areas while rural areas often lack adequate number of well-equipped health personnel (4). In addition, there is a shortage of female health workers in MENA countries, which can be a main access issue as female staff are needed to attend to female patients due to cultural beliefs in these countries (4). This could reflect lack of adequate policy and regulations to support development and adequate distribution of healthcare professionals in MENA region (11).

The health workforce of the MENA region vary widely (4). This is evident in the disparities in the number of physicians per 1000 population among MENA countries (Table 1) (4, 25). Low-income countries in MENA experience a lack of employment, deployment and retention strategies for health workforce,

migration of competent health professionals (brain drain), and shortage of reliable information on human resources for health which hinders proper decision-making and policy formulation (2). The GCC countries, which rely heavily on expatriate medical staff have been focusing attention on motivating their citizens to receive education and training to serve in the healthcare sectors, while launching educational frameworks to guarantee the development of their professional skills (31).

Financing of health systems in the MENA region

Health financing encompasses all the resources that can be collected and utilized to improve the population health status and to protect the individuals within this population from risk factors that may harm their mental, physical and social development (3, 17). Financing describes the methods by which money is raised, risk pooled and billed to support changing the operation of a health sector (16, 17). Financial protection, which is an important health system outcome can be assessed by examining OOP spending on health services (15, 17). This in turn can be evaluated using different ways ranging from estimating the number of individuals that either fall into poverty or decline in the level of poverty because of OOP spending on healthcare to a simpler measure of the OOP spending on healthcare as a percentage out of total health spending (15). High OOP would indicate an increased financial risk on the population more than low OOP (15).

In general, countries of the MENA region have some of the lowest percentages of public expenditure on health when compared to other countries in the world, which is reflected as high levels of OOP expenses (16). The public spending in the MENA region has been low, representing about 3.2% of GDP in 2014 (16). The general government health expenditure (GGHE) as a percentage of general government expenditure (GGE), an indicator which reflects the priority of the government to spend on health was reported to be 7.0–8.0% on average in the period between 2000 and 2014 (11). This has been further diminished because of the political instability and fluctuation in the price of oil and gas in some of the region's countries (16). This has obliged many individuals living in these countries to either miss receiving adequate care or face hardship due to health expenses (16). Uncovered household expenditure on health care is still high in many countries in the region resulting in high levels of OOP household spending (3).

MENA countries, at the all income levels, have been spending a comparatively less percentage of their income on health represented as a percentage of GDP (13). There is also a wide variation of health care expenditure as percentage of GDP within the countries in the region (12). Table 2 shows some key health expenditure statistics for countries in the MENA region (25, 32). Along with that, public spending on healthcare as a percentage of total government expenditure has been lower as compared to other countries in the world, while private OOP spending being high (2, 11, 13). It has been shown that MENA countries spend less on health care when compared to high income countries (12). This could mean that the governments of the region have accomplished costs-containment and perhaps an efficient delivery of health services (13). However, there is an accumulative evidence suggesting quality issues and inefficiencies in many healthcare systems in the region (13). Examples include countries such as Egypt, Morocco, Tunisia and Yemen which reported considerable rise in OOP spending as a percentage of total health spending (13). The high income GCC countries have been able to extend coverage to their residents in view of their considerable fiscal space (13). However, questions have been raised around the quality of care and efficiency of utilizing the available resources in these countries (13).

Overall, there has been a trend toward increased health expenditure in all non-fragile MENA countries in per capita terms and as a percentage of public spending or as share of the income of a country (3). Asbu et al. (11) reported that per capita total expenditure on health has increased, albeit with a wide difference among the various income groupings in the MENA region. They indicated that total expenditure on health as a share of GDP has slightly increased over the years but the health system seems to constitute a small share of the economies of most countries in the MENA region (11). Their analysis of health systems financing in the MENA region revealed that the total health expenditure (THE) per capita in most of the MENA countries was lower than the averages for countries under comparable income category in the world (11). Additionally, the increase rate of THE per capita has not been correlating with the growth rate of GDP per capita (11). With the exception of the high-income countries in the group, OOP spending in MENA countries exceeds the limit for catastrophic spending indicating that households are at an increased risk of suffering poverty as a consequence of spending on healthcare (11). Their results showed that most MENA countries depend on OOP spending which ranged from as low as 6% in Oman to 76% in Yemen and Sudan in 2014 (11). The GCC countries were found to have lower OOP spending on health services than other MENA countries (11).

Overall, there has been a tendency toward spending a greater share of the GDP on health in the higher-income MENA countries (3). In a study assessing the impact of healthcare expenditures on healthcare outcomes in the MENA region between 1995 to 2015, Balkhi et al. (12) found that spending on healthcare has been rising for many countries in the region, with higher spending per capita on health in Kuwait and the United Arab Emirates than any other countries in the region. Their findings showed a correlation between health expenditures

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TABLE 2 Key health expenditure statistics for some countries in the Middle East and North Africa region[a].

	GDP US$ per capita (2019)	Current health expenditure (CHE) per capita[b] in US$ (2019)	Current health expenditure (CHE) as % of gross domestic product[c] (GDP) (%) (2019)	Government health spending as % of current health expenditure[d] (CHE) (%) (2019)	Out-of-pocket expenditure as % of current health expenditure[e] (CHE) (%) (2019)	Priority to health (GGHE-D%GGE)[f] (2019)
Algeria	3,976	248.20	6.24	65.00	33.44	10.73
Bahrain	23,443	940.40	4.01	59.20	29.73	7.23
Djibouti	3,437	61.81	1.80	53.70	24.15	4.28
Egypt, Arab Republic	3,161	149.80	4.74	27.80	62.75	4.66
Iran, Islamic Republic	7,010	470.40	6.71	49.50	39.49	21.40
Iraq	5,568	253.30	4.48	49.40	50.10	5.99
Jordan	4,405	334.00	7.58	51.20	30.29	12.80
Kuwait	31,999	1759.00	5.50	87.00	11.79	8.93
Lebanon	7,668	663.10	8.65	49.00	33.54	13.43
Libya	9,337 (2006)	309.90 (2011)	6.05 (2011)	65.40 (2006)	36.67 (2011)	6.42 (2011)
Morocco	3,282	174.20	5.31	39.90	46.81	7.12
Oman	15,343	624.70	4.07	86.40	6.56	7.98
Qatar	62,088	1807.00	2.91	72.80	12.33	6.50
Saudi Arabia	23,140	1316.00	5.69	69.20	16.50	11.05
Sudan	1,026	46.93	4.57	22.70	67.38	5.56
Syrian Arab Republic	1,958 (2012)	69.83 (2012)	3.57 (2012)	45.30 (2012)	53.69 (2012)	4.47 (2012)
Tunisia	3,349	233.10	6.96	57.10	37.94	12.58
United Arab Emirates	43,103	1843.00	4.28	52.30	12.51	7.40
Yemen, Republic	1,446 (2012)	73.18 (2015)	4.25 (2015)	23.90 (2012)	80.96 (2015)	2.23 (2015)

[a]Most recent data from the World Health Organization Global Health Observatory Indicators Index Data and the Global Health Expenditure Database. The data is for the year 2019 unless indicated otherwise next to the value. Source of data: (25, 32).
[b]Per capita current expenditures on health expressed in respective currency—US dollar.
[c]The level of current health expenditure expressed as a percentage of GDP.
[d]The share of governmental health spending of total current health expenditures.
[e]The share of out-of-pocket payments of total current health expenditures.
[f]Domestic general government health expenditure (GGHE-D) as percentage of general government expenditure (GGE) (%): is the share of general government expenditures funding current health expenditures.

and health outcomes across different countries in the region, yet some countries were found to have shorter life expectancy despite spending more on healthcare (12). Accordingly, they recommended for effective and efficient use of healthcare resources as a potential approach to improve health outcomes in any country (12). Other studies have shown the positive impacts of increasing health spending in MENA countries on the health outcomes of the population including improving LEB and reducing mortality rate (12, 33).

There have been wide variations in the access to health services and the coverage of health care for patients with NCDs across and within MNEA countries, with some countries providing public insurance schemes (3). However, patients who lack such coverage have limited financing solutions aside from OOP expenses (3). Elgazzar et al. (22) examined the scope of OOP expenditures and their impacts on policy reforms and living standards in six MENA countries in 2010. Their analysis showed that OOP spending was 49% on average in the MENA region, which represented a relatively high percent of total national health care financing with households spending about 6% of their total household expenditure on health mainly on medications, physician visits and diagnostic services (22). They identified the persistence of catastrophic health spending in MENA region despite the availability of services and insurance schemes directly provided by the governments with an incidence that is relatively high in comparison with similar low- and middle-income countries (22). Over time, OOP expenditure on healthcare services can become catastrophic with significant implications on the living standards of people (22). The WHO defines financial catastrophe as the situation when "direct OOP

payment exceeds 40% of household income net of subsistence needs" (34).

The private sector seems to have a limited role in providing and financing of health care in the MENA region with a limited private insurance market and most of the private spending originating from direct household OOP spending at the point of services (13). A limited number of health reform initiatives in the region have been focused on the expansion of contracting of private providers directly by the Ministries of Health or by social insurance funds (13). Examples include health reforms tackling this issue in Lebanon and the Palestinian Authority (13, 35).

Reforming health-financing systems is essential to achieving UHC, which has been endorsed by the WHO to help create or build health equity through financial protection (36). MENA governments have been actively working to extend financial protection and enhance access to health services by utilizing various risk-pooling mechanisms, including the development of private and social health insurance (4). Providing well-targeted social safety nets can help protect citizens against the depleting consequences of ill health (4). Indeed, most MENA countries are low- and middle-income countries with very limited fiscal space to allocate the financial resources to meet the expected increase in the demands for health care (13). Therefore, efforts have been made by some of these countries to expand the revenue base and improve the risk pooling to cover the additional resource requirements (13). For example, Egypt, Algeria, Morocco, Tunisia and Jordan have begun to adopt new health policies and strategies to address health financing in response to substantial health system challenges including large uncovered population and an inconsistent quality of healthcare services (3).

Among the options that have been considered and tested by some of the countries in the MENA region include: (1) introducing new, or expanding the existing, social health insurance schemes; (2) improving the regulation and organization of the private health insurance sector to help households to utilize their OOP spending on health for the purchase of a prepayment program; and (3) introducing taxes on certain services and goods that have direct impacts on public health to broaden the revenue base for health care (13). There has been a slow increase in prepayment schemes of health expenditure as health insurance and tax-based schemes in the region (3). In addition, there has been limited external support, such as receiving funds and assistance from international organizations and donors to some of these countries, mostly as budget support and specific funding for some projects (3). The health reforms initiatives in many countries in the MENA region can have an essential role in improving the health outcomes of the population of these countries while maintaining health-related costs (37).

Examples on health systems reform in the MENA region

Several countries in the MENA region have been adopting and implementing health reforms targeting different aspects of health system performance. The examples presented in this section do not comprise an inclusive overview or evaluation of health system reforms across all MENA countries but provide examples of such reforms and some country experiences during the last years. The presented examples are outlined in light of the Flagship Framework that has been adopted to guide health system reform (17).

In 2017, a special issue of Health Systems and Reform Journal encompassed a set of articles on health system reforms in some MENA countries which were supported by the World Bank to address health system needs and to meet the demand of their population for better health care equity, access and delivery (16). In this issue, Wang and Yazbeck examined and performed benchmarking of the health systems in the MENA region in terms of health status and financial protection, two of the three designated performance goals of the Flagship Framework (15–17). Their findings revealed wide vibrations in these outcomes across MENA countries even though these countries share considerable linguistic and cultural similarities (15). This article reported evidence supporting the varied health outcomes among these countries (15). They compared LEB between MENA countries and used it as a measure of health status (15). Their findings showed that there seem to be no strong relationship between Per capita national income and LEB in these countries (15). They found that Morocco, Lebanon, Algeria and Tunisia performed best on LEB after controlling for per capita national income and educational stock (15). They also found that most GCC countries, especially Qatar, Kuwait, the United Arab Emirates and Saudi Arabia were underperforming on LEB relative to their level of development and were also underspending on health (15).

They classified the countries into high and low performing health systems (15). With regards to health status, this article identified three categories of countries with certain trends in their levels of national income and educational stock, both of which are highly related to health outcomes (15). The three categories are: (1) countries with under-expenditure on health, sometimes significantly, along with underperformance in life expectancy; (2) countries with slightly better than anticipated health expenditure but significantly higher than anticipated life expectancy; and (3) countries with marginally lower health expenditure and slightly higher than anticipated health status (15). They identified Iran, Egypt and Bahrain as countries that could achieve good health outcomes at a reasonably low spending, indicating that their health systems were efficient in utilizing the available resources (15). Their results showed that Morocco, which was the best performer on

LEB exhibited the top percentage of OOP among the MENA countries (15). On the other hand, the GCC countries had the lowest percentage of OOP spending among all MENA countries but they did not perform well on the LEB compared to national income and educational stock (15). They concluded that within the MENA region, those countries with less performance in terms of financial protection (e.g., Egypt and Morocco) achieved better performance in terms of health status outcomes (15). Few countries such as Lebanon and Bahrain could achieve good health outcomes comparative to income and education with relatively good performance in providing financial protection (15).

In another article, Pande, El Shalakani and Hamed assessed the situation of the health system in Egypt and proposed a novel diagnostic tool to assess improvement toward achieving social justice in health care using the three performance goals defined by the Flagship Framework (7, 16, 17). They performed a thorough analysis of primary and secondary quantitative and qualitative data sources and identified six disadvantaged groupings in Egypt (7). These included households in the lowest wealth quintile, population resident in certain geographic areas, population with low parental education, workers in the informal sector who lack coverage by insurance schemes, women and disabled people (7). Then, they analyzed the status of these groups in terms of the three performance goals of a health system which include improving health outcomes, public satisfaction and financial risk protection (7). Their findings indicated that there were 11 challenges to the achievement of social justice in health care in Egypt (7). These included high OOP spending, poor quality of care in certain sub populations, rising burden of NCDs, and poor maternal and child health indicators (7). Accordingly, they suggested a number of short- and medium-term recommendations to address these challenges and advance social justice in health care in Egypt (7). These included recommendations to improve the health of disadvantaged groups such as introducing a family health services model of primary care, recommendations to enhance financial protection for disadvantaged groups such as the separation of providers from payers and recommendations to enhance the quality of health care such as introducing opportunities for the participation of citizens in service delivery (7).

Al-Mazrou et al. (23) described how the private health insurance for expatriates developed following a labor law was passed and how this influenced the financing, organization and delivery of health services in Saudi Arabia. This reform was directed toward the financing and payment knobs of the Flagship Framework (16, 17). Similar to other GCC countries, Saudi Arabia has been changing the financing and delivery of health care partly due to the high proportion of expatriate workers in the country (23). A labor law was implemented in 1999 which obliged the private employers to guarantee that expatriate workers have health care coverage by private health insurance instead of depending on the public health system (23). This labor law resulted in an expansion in the insured population with a steady progress in private health insurance market which became the primary funder for the private health sector (23). This resulted in a significant growth in the private hospital sector with an increase in the available private providers and private hospitals in urban areas (23). It also changed the payment methods of hospitals and other facilities (23). This experience demonstrates how the health systems can be influenced by policy reforms (23).

In Lebanon, the main provider of hospital care and contractor to the Ministry of Public Health for providing curative care is the private sector (35). Khalife et al. (35) described the experience of Lebanon in contracting reform and the development of a provider payment from the public sector to the private hospital sector and how this approach produced positive outcomes for the health system. This reform experience targeted the payment knob of the Flagship Framework (16, 17). A mixed-model hospital contracting model was implemented in 2014 (35). The reform program involved adopting several developmental strategies including the use of an automated billing system and a utilization review, and development of standardized criteria for admission and a hospital case mix index that accounts for the complexity of cases (35). This experience fits well with a regional strategy that is focused on developing a stronger partnership between public and private sectors and the development of the private sector to provide hospital care (35). The authors outlined important lessons from their experience about methods for provider payment, and how to link payments to different quality measures including accreditation, data management and effective use of information technology (IT), community engagement and the nature of public–private collaboration (35).

In another article, Alaref et al. (38) assessed the consequences of an organizational reform on the quality of care in Palestine. They examined the possible implications of prohibiting dual practice (defined as the practice of a health professional concurrently in both the public and private health sectors) on the access to, and quality of health services (38). This represented a case of reform that adjusted the organization knob of the Flagship Framework by focusing on policies to address dual practice among physicians (16, 17, 38). Based on their analysis, they outlined that a complete ban on dual practice would lead to several adverse consequences including the risk of losing the rare specialties from the public sector (38). They indicated that such policy would not decrease the fiscal burden on patients nor, does it improve their access to quality health services in the public sector in Palestine (38). They proposed a set of recommendations to tackle this issue including the need to conduct several studies, monitoring policy implications and provide incentives for health workers (38).

Le Pape et al. (39) reported the experience of the health sector in Morocco in adopting and implementing information and communications technology to enhance the productivity

and effectiveness of the sector. This is another example on a reform focusing on the organization knop of the Flagship Framework which examined the role of IT on the organization and function of the health sector (16, 17, 39). This organizational reform experience involved the establishment of a national health management information system in Morocco and showed how an effective information system can facilitate decision making at all levels of the health system (39). The authors recommended engaging all stakeholders from inception to implementation, promoting local ownership of the new system, implementing personnel rotation policies and supporting capacity building and staff upskilling efforts (39).

Several other reports on different experiences of health reforms have been emerging from the MENA region. An important direction in terms of health reforms in the region includes reforming or establishing health insurance systems to generate money for the health sector and to pool risk across the population (16). Examples of countries that have been adopting such strategies are the GCC countries (16). The government in Morocco has also undertaken a health finance reform supported by the World Bank and the European Union (5). The goals of this project were to improve equity in the health system and ensure sustainable and stable financing (5). This project required every individual who has an income to subscribe to a health insurance scheme (contributive system), while subsidizing those who are financially weak by creating a medical assistance mechanism (5). This would allow greater collective financing of health services and a reduction in the OOP payments by households, which represent a major cause for inequity (5). Similarly, in Tunisia, the government attempted to apply an insurance system that would cover the provision of health services by the private sector (5). These efforts can be viewed as health reforms targeting the financing and payment knobs of the Flagship Framework (16, 17).

Alhuwail (40) documented positive improvements in the compliance of the secondary care public hospitals in Kuwait with the information management accreditation standards. These included improvements in data privacy and security, transfer of information, data aggregation to support patient care, analytics for decision-making, information exchange, staff access to internet and identification of quality performance indicators (40).

In Saudi Arabia, the healthcare system has been undergoing several developments driven by the Saudi Vision 2030 (21). A comprehensive framework for addressing public health challenges through adopting the concept of primary health care services has been developed and implemented in the country (5). This initiative targeted the organization knob in the Flagship Framework (16, 17). Several studies have reported the public healthcare system and primary health care reforms in Saudi Arabia and provided a review of the reform process, challenges facing the development process and recommendations to overcome these challenges (9, 21). There has also been an increasing trend toward privatization of the health care sector (41). Privatization of health care involves increasing engagement of non-governmental actors in providing healthcare services *via* management and finance services (42). In 1999, the Saudi government implemented a reform in its health policy and adopted a privatization strategy of health services to improve these services and to keep pace with the advancement of medicine, leading the private sector to flourish in the country (41). This strategy can be considered as a reform affecting the financing and organization knobs of the Flagship Framework (16, 17).

As an example of a health reform targeting behavior of patients, the GCC countries have been implementing a comprehensive plan against tobacco (5). This plan included the following initiatives: raising taxes on tobacco and its derivatives, imposing low levels of tar and nicotine in cigarettes, banning shisha in some of the Emirates, implementing a program called "Quit and Win" that provides incentives to encourage smokers to quit smoking, organizing free clinics to help smokers quit, organizing a national control and prevention week and anti-smoking campaign in schools, and conducting research to estimate the prevalence rates of smoking in schools (5). This can be considered as a reform targeting the behavior Knob of the Flagship Framework (16, 17).

Braithwaite et al. provided an overview of case-study accomplishments related to health system reforms from different countries in their textbook "Health Systems Improvement Across the Globe: Success Stories from 60 Countries" and in a subsequent article in which they commented on these success stories (18, 19). Their textbook included several examples of health reform experiences, case studies and health systems development efforts that were accomplished in some MENA countries including Oman and the United Arab Emirates (health reforms involving improved data and IT infrastructure such as the implementation of electronic health records), Jordan (a reform involving enhanced accreditation and regulatory standards) and Qatar (developing "Qatar Early Warning System" for deteriorating patients) (18, 19). Other examples included the experience of the GCC countries in the procurement of pharmaceuticals and medical supplies from other GCC countries, Iran (the comprehensive reforms *via* the health transformation plan), Yemen (an initiative directed to improving basic health services), and Lebanon (social innovation and blood donations initiatives) (18, 19).

In a subsequent textbook entitled: "Healthcare Systems: Future Predictions for Global Care", the authors presented the experiences of 152 countries in health system improvement which were then summarized in an article (10, 43). Further examples of health system reforms from the MENA countries were presented in these publications (10, 43). These included: the experience from Iran in hospital accreditation, a human development initiative involving developing national human resources for health strategy in Jordan, and development

of m-Health for healthcare delivery reform in Lebanon (10, 43). Other examples included a reform involving patients empowerment in Oman, a reform influencing hospital palliative care in Qatar, development of a national medical record in the United Arab Emirates, and the experience of Yemen in integrating public health and primary care services (10, 43).

External support for health systems reform in the MENA region

The World Bank has been providing support to several governments in the MENA region to establish fair and sustainable health systems that can be transparent and accountable to the population of these countries (2). This has been achieved through providing expert advice and by financially supporting policies, reforms, processes, mechanisms, and tools that support transparency and quality of health care (2). It has also been supporting government initiatives aimed at enhancing the quality of healthcare services provided to the citizens, as actual purchasers at the point of service, or as tax or premium payers (2). The World Bank has been supporting initiatives to engage citizens and patients in deciding efficient ways for spending their money to provide more value and to become fully informed for active and purposeful engagement (2). It has also been providing countries financial and technical support in establishing health management information systems to help them improve accountability of payers (2). This can be mediated by decreasing costs through developing strategies aimed at promoting primary and preventive care, pharmaceutical reform, or addressing gaps in health care delivery (2). There has been increasing number of health system assessment and review reports describing the World Bank efforts in the support of health systems in different countries in the MENA region, especially middle- and low-income countries like Egypt, Morocco, Tunisia, Palestine and Yemen (44–48).

Health accreditation in support of health systems reform in the MENA region

Health systems have been applying accreditation of healthcare facilities as a quality assurance method to ensure the delivery of healthcare services of adequate quality to patients (49, 50). Countries that seek to grant health accreditation have the goal of strengthening their health systems and improving patient safety either *via* national policies and standards, and/or accreditation (10).

Several countries of the MENA region have been implementing healthcare accreditation (51). For example, Lebanon developed its national healthcare accreditation program in 2002 as one of the earliest accreditation programs in the region (52). The Central Board for Accreditation of Healthcare Institutions in Saudi Arabia was founded in 2005 to create and evaluate the quality standards of all healthcare sectors, and the public and private hospitals in the country have additionally been seeking accreditation from international accreditation organizations (53, 54). There have also been efforts in obtaining international accreditation of healthcare organizations in Qatar (55, 56). Another example is Jordan, in which the Health Care Accreditation Council was founded in 2007 to assure the quality of care of healthcare organizations, and similar to Saudi Arabia health facilities have also been seeking accreditation from international accreditation bodies (57–59). In Kuwait, the Ministry of Health established a partnership with Accreditation Canada International in 2008 to develop a national health accreditation program for the development, implementation and evaluation of healthcare quality standards at all public healthcare care facilities (60).

Health system responses to COVID-19 pandemic in the MENA region

The MENA region has been impacted by the COVID-19 pandemic in late 2019–early 2020. The social distancing measures such as workplace closures and lockdowns have reduced economic productivity and increased inequalities (28). This has mainly affected the most disadvantaged households who mainly work in informal jobs, lack health insurance, and are more susceptible to infectious diseases because of overcrowded living conditions (28). The risk of morbidity and mortality due to COVID-19 is also high in the MENA region due to the high burden of NCDs and a wide range of at-risk populations due to poverty, inequality and humanitarian crises (27).

The healthcare systems within the MENA region have been challenged by the COVID-19 pandemic which was a stress test for the resilience of these systems to meet the preexisting healthcare needs of the population (61). Before the pandemic, there have been underfunding for the public healthcare systems in MENA, particularly in countries with middle-income, even though the share of the public sector had grown as a portion of GDP (61). The pandemic revealed inadequacy of core elements of public health resilience which reflects the ability of healthcare systems to absorb the attacks of health emergencies, mainly the surveillance and absorptive capacity (61). Some countries such as the high-income GCC countries adapted and responded quickly to the pandemic and managed successful responses both on the policy and pandemic containment efforts (61). While many other countries failed to achieve such prompt responses or to make adequate emergency investments in their public healthcare systems (61). The COVID-19 will have a significant implication on the MENA

health systems, both directly and indirectly by affecting care-seeking for other essential health services (27). This will augment the pre-existing limitations of the health systems such as the low and inequitable financing levels, fragmented and inflexible care delivery, limited and poorly distributed human and physical resources, and inadequate surveillance and health information systems (27).

It has been postulated that lack of data and data use may have contributed to the limited ability to provide a realistic assessment of the preparedness of the healthcare systems prior the pandemic in the MENA region (61). This has highlighted the value of effective use of data for public health policy making (61). The progress made in this aspect during the pandemic combined with a strong focus on building essential public health functions can be the basis for deeper health reforms and for constructing resilient healthcare systems in the region (61). Moreover, collaborative efforts are needed to support the necessary reforms to improve the level and distribution of health financing and to strengthen physical and human resources (27).

Discussion

This review article provides an overview of the health systems organization, health patterns, disease burden and population dynamics in the MENA region. It also outlines the challenges that have been facing these systems and provides examples of health system reform experiences that were achieved in the countries of the region. Some of the reported reform experiences in these countries impacted the different elements of the Flagship Framework (16, 17). Some reform initiatives were directed to the fine-tuning of the control knobs of the framework including the financing (5, 23), organization (38, 39, 41), payment (23, 35), and behavior (5) knobs, or they evaluated the ultimate performance goals of the health systems (7, 15).

The challenges facing the MENA health systems are multifaceted at various levels and scope. These include health transition-related challenges such as the increasing pressure on health systems to keep pace with demographic and epidemiological transitions affecting the region including the rapidly growing population, rising prevalence of NCDs, increasing aging population and refugees' crises (4, 5). Other set of challenges are health-system related challenges which include challenges related to service delivery, financing, health workforce, medical technologies, information and leadership (3, 4). The governments of the MENA countries must engage all key stakeholders in the design, implementation and management of the health systems and in adopting adequate reforms to effectively and efficiently address these challenges (4).

In order to overcome the growing complex health and security challenges facing the MENA region, there must be a focus on developing effective health systems with effective health financing mechanisms to provide health services that are affordable, equitable and of adequate quality to all citizens, residents, refugees and displaced individuals (3). The aim of the financial policy reform in the MENA region must be directed toward increasing public revenues for the health sector to achieve UHC (11). To achieve this goal, governments must prioritize health on their agenda and allocate governmental budget to support healthcare services despite any financial constraints (62). In view of the growing population and high unemployment rate in many countries of the MENA region, government health budgets must be directed to supporting the needs of the most vulnerable populations to provide financial protection to these disadvantaged groups (4). To achieve reforms in healthcare financing systems, governments must adopt risk pooling mechanisms and the prepayment method for healthcare financial contributions as a means for increasing population coverage (36). Raising new taxes and improving the tax administration strategies can help increase the fiscal space for health (63). Moreover, governments must ensure appropriate and fair distribution of healthcare systems of good quality for the population and maintain sustainable funds of health programs or activities (36). External funding can be another important source of public funding for health particularly in lower middle-income countries and upper middle-income countries that are hosting huge numbers of refugees, but efforts are needed to ensure their predictability (11, 64).

To meet the increased demands for healthcare services and the needed development in the delivery of certain types of services, countries of the MENA region must develop clear policies and strategies to strengthen the role of the private health care sector (13). The governments of these countries must thoughtfully use the private sector facilities and fully regulate them to serve the population health needs and to complement the overstretched public health sectors (3, 4). Indeed, the private sector is expected to play a key role in providing health care in both high- and low-income courtiers in the region, as well as in conflict and post conflict settings as it can provide health care for refugees (3, 13, 16).

Reconfiguring the MENA health systems is needed to effectively integrate the provision of promotional and preventative services with curative and support services (4). This would require development and adoption of suitable policies and good management of human resources (4). Efforts are also needed to mitigate the risk factors underlying the development of NCDs to limit the disease burden and direct and indirect healthcare costs (4, 13). There must be a focus on developing innovative paradigms and methods to re-organize the health care delivery system (4). This can include good collaboration between different providers and stakeholders, maximizing skills mix and improving the training of health professionals, effective use of primary and acute care services, and rationale use of available medical and pharmaceutical technologies and the adequate integration of new ones (4). Evidence has shown that the investment in the delivery and

quality of basic health services such as preventative and primary care can result in improvements in health outcomes and equitable access to care (22). Therefore, shifting investment to ensuring basic, primary care can assist low-income countries, as well as sub-national territories that are challenged by resources constraints (22). On the other hand, it would be beneficial for middle-income countries that apply a combination of governmental subsidies and social health insurance such as Egypt, Tunisia and Morocco to ensure the effective functioning of the targeting mechanisms and availability of awareness programs for eligible beneficiaries (22). Middle to upper middle-income countries which implement social health insurance schemes are advised to continue fine-tuning systems in place to address institutional-level issues and optimize the outcomes (22).

Development of new model of care such as decentralized and flexible healthcare services, and providing support for patients to move from provider-centric care to patient-, primary-, and community-centric care are among the strategies that can help overcome issues such as the increased aging population and the disproportionate concentrations of resources between urban and rural areas (10). Integration of healthcare services such as formation of multidisciplinary team and developing initiatives that aim for a greater involvement of the community can be a key step to coordinate health care delivery and decrease the burden on the health systems (10). Another important element that must be considered involves encouraging patient-based care and developing approaches to the education and empowerment of patients to help them play an active role in their own care (4, 10).

Health staff development has been fundamental to the improvement of quality of health care (10). A well-trained health workforce is also needed to strengthen the public health infrastructures in the MENA region (5). This would require development of health school curricula to link health workforce education and training with the health needs of the population (4, 5). Health systems must ensure that the health practitioners are kept up to date with medical advances and technological developments (10). This would require careful consideration to workforce education and training, recruitment, professional development and establishment of leadership roles (10).

Addressing the challenges facing MENA health systems will require creating comprehensive health information systems to provide accessible information for planning, managing and implementing services (4). Health IT solutions are essential for modern health systems and can be useful assists for health system reform (39, 40). Adopting e-health technology has been improving patient-centered care by enhancing electronic data storage, management and capacity, while providing readily available information to clinicians, patients and healthcare providers (10).

To overcome health-system related challenges, resources, political commitment and management capacity must be invested to support the available public health measures and functions or to create new ones if they are absent (4). Perhaps the most crucial of these functions would be public information and education, intersectoral policy making, and quality assurance and improvement, which require transparent governance structures and good coordination between the various entities beyond the health sector (4). Benchmarking of the health systems within the region can be a useful tool to guide the internal health reform of the individual countries (15). It can identify the objectives that must be accomplished in terms of the health sector development and the areas that the reform process must address to overcome low performance in health outcomes (15).

Braithwaite et al. (18, 19) outlined the common factors that are linked to the success in their overview of 60 country case studies on health reforms. These included starting a small scale initiatives that can result in system-wide reforms, supporting the role of data and IT in the delivery of efficient and appropriate care, stakeholders concrete action and collaboration to mediate the reform and situating the patients at the center of reform process (18, 19). Starting small and modest scale projects and piloting or testing the reform initiatives can prepare the setting to implement larger scale reforms over time (18, 19). Attention must be directed toward the integrated use of IT, operational data storage and transmission, and existence of accessible decision support tools and databases to enable communication and information exchange among decision makers and stakeholders in a timely, effective way (18, 19). System improvements can be mediated through coordinating collaborative relationships among multiple stakeholders, applying evidence-based decisions and implementing clear principles of reform design (18, 19). Centering the patients, their wellbeing, needs and experiences at the heart of the reform process is perhaps the most vital factor to ensure the success of the reform enterprise (18, 19).

The future health systems are shaped by universal trends (10, 65). These include the genomics revolution that will result in development of new system of care, evolution of emerging technologies such as e-health capacities, global demographical dynamics due to increasing and mobilization of population which constantly alter demands for health services, and the development of new model of care in response to issues such as increased aging population (10). This would necessitate the development of sustainable health systems that can overcome the evolving challenges and respond to the stressors resulting from accelerated changes (10). Countries in the MENA region are advised to develop their health systems to keep pace with these universal trends.

Conclusion

The MENA region is among the highly dynamic areas in the world, full of both opportunities and challenges (16). The evidence describing health system reforms in the MENA region has been scarce and underrepresented in the literature. This review article attempts to add to the existing published literature and to provide examples on improvements made on the performance of the health systems in the MENA countries. It also highlights the plethora of challenges facing the health systems of the region. As challenges continue to advance, the methods of health reform will continually evolve to overcome these challenges (19). Accordingly, health systems of the MENA region must develop their adaptability and responsiveness to meet the increasing demands for health care by the population while overcoming the financial shortages and increasing challenges.

Author contributions

MK reviewed the literature to collect the relevant evidence, evaluated the evidence, organized the findings and wrote the first draft of the review article. MJ, AC, and LG contributed to the development of the outline of the review article and evaluation of the collected evidence, revised the manuscript and provided suggestions for expansion and improvement. All authors read and approved the final version submitted for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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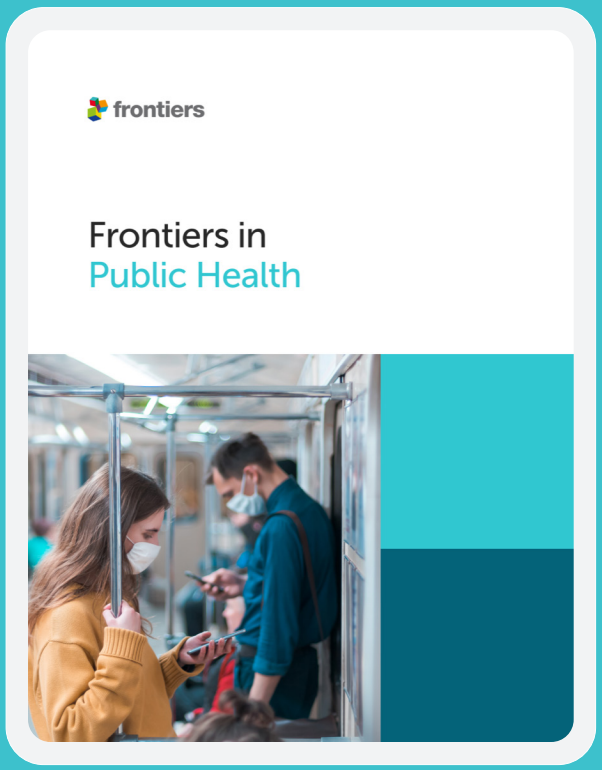

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