PUBLIC HEALTH PROMOTION AND MEDICAL EDUCATION REFORM

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PUBLIC HEALTH PROMOTION AND MEDICAL EDUCATION REFORM

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EDITORIAL
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Editorial: Public Health Promotion and Medical Education Reform

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Editorial on the Research Topic

Public Health Promotion and Medical Education Reform

Due to population aging and growing awareness of health-related issues, the demand for health services is increasing (1, 2). On the other hand, the shortage of healthcare workers prevails in most health care occupations, as demand outstrips supply. This problem may be particularly acute in local healthcare institutions where healthcare resources are limited (3). To address the supply-demand imbalance, various reforms of education and training of healthcare workers are underway in many parts of the world. Otherwise, the medical field has come to recognize the critical role of public health in prevention and control of diseases. The availability of early interventions would effectively reduce preventable illness, minimize complications, and lower health care cost burdens, with a corresponding reduction in demand for health workers (4). Consequently, many medical schools are engaged in incorporating public health and epidemiology courses into existing curricula. In this editorial, we provide a platform for most recent advances in teaching and learning innovations, along with issues relating to public health. The Research Topic represents a collection of 17 original research articles, two review articles and one opinion article ranging from theory to applications in both fields of medical education and public health.

To create a self-motivated learning environment, there has been a shift from teacher-centered to student-centered learning. This student-centered learning approach engages students to shape their own learning, where the teachers act as guides, helpers and facilitators of learning (5). A key result of this shift is the formation of "blended learning" that implement a student-centered approach to learning by using Internet technology and multimedia tools (6). One popular format to realize blended learning is the flipped classroom (FC). Application of FC in higher medical education is becoming more and more accepted because of its advantages over traditional learning (7). Ji et al. implemented FC in the whole course of physiology, and investigated both short- and long-term effects of FC on students' learning outcomes. Students were asked to get familiar with the basic learning objectives through pre-class learning using reading materials (e.g., videos and courseware) from Chinese biggest MOOC platform "iCourse." The pre-class self-learning helps students to free up classroom time for higher-level thinking, and gives them more opportunity to discuss and interact with others. FC not only increased students' learning effectiveness but positively affect their long-term learning outcomes, indicating that FC enable students to acquire the skills of lifelong learning. As for students' preferences for online materials, Xu et al. found that students in the FC had a significant preference for mini-video with clear knowledge focus, but quite a few students did express positive attitudes to complete videos that may better illustrate the connection between different knowledge items. Likewise, Wu et al. applied FC based on micro-video class in pharmacology courses. This learning model significantly improved students' enthusiasm for learning, learning efficiency, self-directed learning ability, and problem solving skills, thus leading to improved learning performance. It can be concluded that success of blended learning depends

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not only on the quality of the course and the virtual environment, but also on whether there is individualized instruction of each student. In addition to flipped classroom, educators also implemented other types of blended learning according to their unique characteristics. Wang D. et al. combined massive open online courses (MOOCs) with case based learning (CBL) in teaching pathophysiology in a local medical university. They hope that the open online courses could offset the lack of qualified teachers and instructional materials in local medical institutions. Both students and teachers had positive attitude toward blended learning because students' achievement and motivation was greatly enhanced.

As the COVID-19 outbreak continues to evolve, it has brought tremendous changes in our daily life. For example, face-to-face education has been damaged in many countries, especially at the early stage of the COVID-19 pandemic (8). In such a case, online education is adopted on a large scale around the world for the first time. As review by Su et al. existing online course platforms in China such as MOOCs, Rain Classroom, WeChat, Moodle, QQ, and DingTalk have been further developed and implemented into online teaching (9). Accordingly, educators have developed more effective pedagogies for online learning, by which students have greater access to online medical resources and they can study on their own pace (10). Additionally, students' multiple abilities were improved, such as self-learning, independent thinking, communication and collaboration. Unexpectedly, this online teaching mode is more popular in Chinese postgraduate medical education during the COVID-19 pandemic. Postgraduates become even more active in online teaching than in traditional teaching. They are willing to communicate with teachers online in a relaxed atmosphere, and there appears to be more interaction between teachers and students. Another noteworthy phenomenon is that postgraduates could get more feedback from the educator in an online course. So it is evident that the online education is beneficial for most medical students in spite of the educational backgrounds.

COVID-19 is global health emergency, and has had a major impact on international higher education, which is to some extent caused by strict international border closures and irregular international flights at high cost (11). Liang et al. reviewed the most common difficulties faced by medical education based on the outcome-based education (OBE) concept for Bachelor of Medicine and Bachelor of Surgery (MBBS) in Chinese regional medical schools, as well as the solutions to overcome these difficulties. In the OBE model, ability training is integrated into professional education and provide support for the training of advanced applied medical talents. After the COVID-19 outbreak, MBBS education suffers from shortage of experienced teachers with good English proficiency and integrated online teaching platforms, and students may not be able to participate in internships. In response to these difficulties, teachers in these regional schools are encouraged to improve their online teaching competencies, including foreign language proficiency and teaching skills. The blended learning mode is integrated into MBBS education, while school supervision is adopted as strategies for quality assurance in medical education.

Before the COVID-19 pandemic, online learning did not account for the major modality for medical education, while now many medical institutions have established and strengthened their online learning and training programs (12, 13). Naidoo et al. designed a distance learning (DL) framework in anatomy teaching using the exemplar of the Head and Neck (H&N) course. The process of developing the framework was guided by the Analyse, Design, Develop, Implement, and Evaluate (ADDIE) model. They demonstrate that the DL-framework is an efficient learning approach and positively received by the students. This framework also developed students' cognitive ability such as communication, problem solving, and critical thinking.

Subsequent to the COVID-19 outbreak, the importance of public health education in addressing the pandemic has been highlighted (14). Since the health science students are future health care providers, their proper education regarding healthy lifestyle is necessary. Alotaibi et al. proved that the utilization of an online interactive educational workshop promoted acquisition of knowledge relevant to healthy lifestyle promotion. Meanwhile, the COVID-19 pandemic has exposed the urgent need for well-educated and appropriately trained public health leaders and managers to cope with public health challenges (15). Then a Chinese medical school established a special educational program for doctors of public health—the Doctoral Training Program of Public Health-Crisis Management (Cai et al.). The program meets the need of advanced public health practitioners in national emergencies by infusing public health content into foundation and advanced social service courses. The Program's graduate students developed their theoretical and communication abilities required for the management of national emergencies. In addition, their experiences working with experts from Disease Control and Prevention (CDC) greatly improved the practical and leadership-related capacity of public health crisis management. It may support the development of advanced public health policy and health care education in China. The COVID-19 crisis also poses unique challenges for clinical training. With the aim of developing effective and sound training models for epidemic prevention and control, a conceive-design-implement-operate (CDIO) mode was adopted to improve the theoretical knowledge and practical skills of obstetrics and gynecology (O&G) residents in COVID-19 epidemic prevention protocols (Wang X. et al.). This timely training is beneficial in alleviating work pressure and improving professional identity of residents.

More importantly, the COVID-19 has pried our eyes open to the importance of public health. The primary prevention interventions lead to reduction in incidence of diseases, and a healthier population would have lower health care spending (16). As is known, the nation's future health will be greatly determined by the health status and future health risk among children and young people (17). Peng et al. found that the overweight of teenagers was positively related to the proportion of biochemical abnormalities in their blood, while the healthy behavior helped to improve biochemical indexes and control overweight, and from here it is necessary to bring health education into the national education system. And a school health education program should be established to let teenagers take physical exercise as a way

of life. However, in many developing countries, there is the lack of health education, which may lead to severe public health problems. It was found that Chinese college students in Henan had preliminary understanding of HIV knowledge, but they did not know enough about sexual transmission of HIV (Zhang et al.). Notably, the college students' attitude toward HIV-infected patients was generally negative. This may be alleviated by raising awareness of AIDS health education knowledge. That is, the adequate health knowledge can create positive attitude toward health care. Similarly, a cross sectional community-based study about blood donation in India demonstrated that most participants had favorable attitudes toward blood donation, among who most were knowledgeable (Samreen et al.).

The WHO defines health as a state of complete physical, mental, and social wellbeing and not merely the absence of disease and infirmity (18). Mental health is also an integral component of general health. Yet, mental health is neglected more as compared to physical health. Although many national governments have paid increasingly close attention to the field of mental health, the COVID-19 pandemic also had enormous impact on mental health (19). Individuals affected in the pandemic may have many mental health problems such as depression, anxiety, stress, panic attack, and sleep disorders (20). Therefore, it is essential to provide mental health services to the public, whereas access to mental health services should be increased. In this case, Mat Ruzlin et al. held a campaign called "Mind your Mental Health Carnival"—a hybrid carnival which consists of in-person and virtual attendants. They delivered mental health content and health interventions using web-based platforms. As a result, this hybrid approach that combined face-to-face interactions and virtual learning improved mental health literacy among participants. Meanwhile, free online therapy sessions were offered to identify highly vulnerable individuals during the screening process. The study proved the feasibility of this digital approach in providing mental health support and treatment during the COVID-19 pandemic.

Another public health issue is how to effectively disseminate health knowledge to the public. Given the fact that much people are willing to seek out information and interact with others via social media, most medical institutions have run an official account for professional health knowledge dissemination (21). Through analyzing readers experiences of reading articles published by the official WeChat account of a hospital in China, Bian et al. demonstrated that the modern science and technology made it much easier for people to learn about the health information of various diseases, contributing to effective prevention and treatment of chronic diseases. Hence, healthcare workers should pay more attention to the use of social media so as to popularize the concept of health. There is no doubt that physicians are responsible for dissemination of health information and education. Regardless of education level, the patients were more likely to report attempted behavior change according physician advice for lifestyle change, while compliance with advice was affected by health education on physical activity (Chen et al.).

When it comes to public health, we can not ignore the effects of economic issues on health care. Economic conditions would influence personal health, health care services and population health. At personal level, the costs of medical services has been identified to be a large factor in patients' decision-making (22). On the other hand, the consumption of drugs, a major source of medical cost, is on the rapid rise with advanced healthcare (23). Although the therapeutic effectiveness of generic drugs are similar to their brands, the attitudes of practicing pharmacists and pharmacy students are ambivalent due to the different knowledge level regarding generic medicines. The better awareness of the generic medicines, the more liable the practicing pharmacists and pharmacy students have positive attitudes to generic drugs (Al-Arifi et al.). As future pharmacist, pharmacy students need to grasp adequate information regarding generic medicines. More severely, economic conditions influences personal protection of frontline workers in the COVID-19 pandemic. Compared with general population, frontline workers have a higher risk of COVID-19 virus infection, and thus personal protective equipment is widely used to avoid virus infection (24). Nevertheless, elevated cost negatively influences workers' intention to use personal protective equipment, though they have adequate knowledge about this pandemic and possess a greater propensity to use the equipment (Irfan et al.).

Medical students, as special frontline healthcare workers, seems to be more susceptible to the virus because of the lack of skills and experience in managing emergencies. Feng et al. focused on the performance of medical post-graduates during the COVID-19 pandemic. Indeed, this pandemic had an impact on student clinical internships, and they became more aware of personal protection. Students took different protective measures against COVID-19 infection, but they still worry about the insufficient personal protective measures and the possibility of cross-infection in the hospital.

Overall, the articles outlined above in this Research Topic provide insights into better understanding of medical education reform and public health, and analyses the impact of COVID-19 pandemic on the education and training of healthcare workers and public health activity. This global emergency would lead to improved healthcare delivery and health systems development.

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All authors contributed to the article and approved it for publication.

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Design, Implementation, and Evaluation of a Distance Learning Framework to Adapt to the Changing Landscape of Anatomy Instruction in Medical Education During COVID-19 Pandemic: A Proof-of-Concept Study

Nerissa Naidoo[1†], Aida J. Azar[1], Amar Hassan Khamis[1], Mandana Gholami[1], Marjam Lindsbro[1], Alawi Alsheikh-Ali[1,2] and Yajnavalka Banerjee[1,3†]*

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This study presents the design of a DL-framework to deliver anatomy teaching that provides a microfiche of the onsite anatomy learning experience during the mandated COVID-19 lockdown. First, using nominal-group technique, we identified the DL learning theories to be employed in blueprinting the DL-framework. Effectiveness of the designed DL-framework in anatomy teaching was demonstrated using the exemplar of the Head and Neck (H&N) course during COVID-19 lockdown, in the pre-clerkship curriculum at our medical school. The dissemination of the DL-framework in the anatomy course was informed by the Analyse, Design, Develop, Implement, and Evaluate (ADDIE) model. The efficiency of the DL-framework was evaluated using the first two levels of Kirkpatrick's model. Versatility of the DL-framework was demonstrated by aligning its precepts with individual domains of key learning outcomes framework. The framework's blueprint was designed amalgamating principles of: Garrison's community inquiry, Siemens' connectivism and Harasim's online-collaborative-learning; and improved using Anderson's DL-model. Following the implementation of the DL-framework in the H&N course informed by ADDIE, the framework's efficiency was evaluated. In total, 70% students responded to the survey assessing perception toward DL (Kirkpatrick's Level: 1). Descriptive analysis of the survey results showed that the DL-framework was positively received by students and attested that students had an enriched learning experience, which promoted collaborative-learning and student-autonomy. For, Kirkpatrick's Level: 2 i.e., cognitive development, we compared the summative assessment performance in the H&N course across three cohort of students. The results show that the scores of the cohort, which experienced the course entirely through DL modality was statistically higher ($P < 0.01$) than both the other cohorts, indicating that shift to DL did not have an adverse effect on students' learning. Using Bourdieu's Theory of Practice, we showed that the DL-framework is an efficient pedagogical approach, pertinent for medical schools

to adopt; and is versatile as it attests to the key domains of students' learning outcomes in the different learning outcomes framework. To our knowledge this is the first-study of its kind where a rationale and theory-guided approach has been availed not only to blueprint a DL framework, but also to implement it in the MBBS curriculum.

Keywords: anatomy teaching, COVID-19, ADDIE model, Bourdieu's concept, competency framework, distance learning, instructional design and application, medical education

INTRODUCTION

In the past decade, medical schools around the globe have been endeavoring to renovate pedagogy by reducing didactic delivery of content; exploiting technology to supplant/augment anatomy teaching both during didactic and laboratory sessions; effecting team-expedited, active, and self-directed learning; and encouraging personalized and interprofessional education (1, 2). The expansion of entrustable professional activities (EPA) and competency-based learning, with recognized mileposts for accomplishment, have metamorphosed assessment. As a result of this so-called "renaissance in medical education," several leading medical schools have reduced the basic science curriculum to 12 or 18 months, while amalgamating clinical medicine within this timeframe, and revisiting/reassessing the basic sciences later in medical school (3, 4).

At present, in most medical schools, students convene onsite during the first 12–18 months for collaborative problem-solving or discussions in small groups; their physical attendance at both inpatient and outpatient sites has been an undisputed precept of early clinical engagement experiences and the clerkship curriculum. The last 18 months of medical school may be customized, with students contributing to patient-care through advanced clinical rotations, sub internships preceding residency, or scholarly projects. The COVID-19 pandemic has affected this educational continuum.

Social distancing is the effectual preventive strategy since the emergence of COVID-19, pending completion of vaccination, treatment, or both (5, 6). By characterization, social distancing precludes students from gathering in learning ateliers, lecture halls, or small-group rooms. If one carefully follows the pedagogical trend in medical education over the past few years, one would observe that many faculty have already been "flipping" the classroom to provide individualized tutoring/instruction for asynchronous learning "anytime/anywhere" (7–9). However, students still convened for small-group interactions, laboratory sessions, simulations, and technology sessions [e.g., learning bedside medicine (10, 11)], as well as for clinical instruction with standardized patients and in realistic patient care environments (12).

In response to the pandemic, medical education faculty around the globe have rapidly and successfully transitioned the entire pre-clerkship curriculum to distance-learning (DL) formats that comprise content in the basic sciences, health systems sciences, and even in behavioral sciences (13–15). Small-group designs assemble online in virtual team settings (16), and clinical skills sessions may occur online employing the precepts of telemedicine (17) or, in some cases, may be deferred (18). Examinations have also migrated to online settings through the use of specific online proctoring modules (19). Even objectively structured practical examination (OSPE) have transitioned online in the form if electronic OSPE (20). Similarly, Web-Objective Structured Clinical Examination (OSCEs) have been piloted for the clinical skills assessment (21, 22). In summary, the pandemic has stimulated innovative, constructive and beneficial changes in medical education.

Anatomy education is an essential stipulation for medical students in the pre-clerkship curriculum. At heart, anatomy is a three-dimensional subject that necessitates understanding of body structures and their relationships. This aspect is often tackled using cadaveric specimens, access to which has been limited during the COVID-19 pandemic (23). Furthermore, organizing dissection of cadaveric specimens in small-group teaching milieus, often categorized as dissection sessions, have not been possible during the pandemic as the pre-clerkship curriculum delivery in most medical schools transitioned to the DL modality (24). In fact, this issue has added to the numerous challenges that are disadvantageously impacting anatomy education in current times as indicated above. These challenges include, a drastic reduction in anatomy teaching hours and its context, decrease in the number of trained anatomists, and an increase in the costs of human cadaveric dissections and the related ethical uncertainties surrounding the use of human cadavers (25). As there has been significant reduction in anatomy teaching hours, instructors often find it difficult to elaborate on the clinical relevancy of disseminated anatomical facts. This has initiated a new challenge in the form of "integration-gap" (26), whereby many students are of the opinion that learning anatomy largely involves rote-memorization as disseminated facts rarely inform their clinical practice in the clerkship years (27–29). Research by Patel and Moxham indicates that in order to address the aspect of "integration-gap," majority of

Abbreviations: EPA, Entrustable Professional Activities; DL, Distance Learning; OSPE, Objectively Structured Practical Examination; OSCE, Objective Structured Clinical Examination; H&N, Head and Neck course; CBMC, Competency-Based Medical Curriculum; ADDIE, Analyse, Design, Develop, Implement, and Evaluate; MBRU, Mohammed Bin Rashid University of Medicine and Health Science or in Latin, Medicinae Baccalaureus Baccalaureus Chirurgiae; MBBS, Bachelor of Medicine, Bachelor of Surgery; LMS, Learning Management System; MS, Microsoft; KMO, Kaiser-Meyer-Olkin; MSA, Measure of Sample Adequacy; EFA, Exploratory Factor Analysis; ANOVA, Analysis of Variance; GWAS, Genome-Wide Analysis Study; RPM, Remote Patient Monitoring; MOOC, Massive Open Online Course; ACGME, Accreditation Council for Graduate Medical Education; GMC, General Medical Council; GMER, Global Minimum Essential Requirements; SPSS, Statistical Package For The Social Sciences; SD, Standard Deviation.

anatomists favor the use of human cadaveric dissection above other teaching methods, and that this preference is evident for both "traditionalist" and "modernist" anatomists (30, 31), which has also been confirmed by Ghosh (32). However, with the current pandemic, it is not possible to integrate onsite dissection sessions in anatomy teaching. Also, such onsite sessions are essential as such sessions not only provide students with haptic understanding and promote discussion of anatomical variation and pathologies, but also demonstrate aspects of professionalism, including empathy and respect for future patients. In fact, these relate directly to competency-based training in the surgery rotations of the clerkship curriculum, which rely on defined EPAs to assess and document competence (33). One of the alternate strategies to address 'integration gap' is to integrate simulation-based anatomy teaching (34), however, this pedagogical approach also demands onsite sessions in the in the simulation laboratory, not possible during the current pandemic.

In summary, keeping in line with COVID-forced challenges, the landscape of anatomy teaching needs to metamorphose, whereby there is an ardent requirement to design a "student-centered teaching framework" (easily implementable for both face-to-face and DL modalities), such that anatomy can be delivered effectively: (1) within a limited and fixed time frame [in line with recent the transformations in pre-clerkship curriculum (stated above)]; (2) employing a small team of trained anatomists; (3) using a small number of cadaveric specimens; (4) by integrating principles of active learning, collaborative learning, feedback, and student autonomy; and (5) in a cost-effective approach.

Although, the literature provides a corpus of information on DL strategies that have been designed and implemented during the COVID-19 pandemic for the delivery of courses in the pre-clerkship phase of the curriculum, none of these strategies provide a theory-guided approach, such that these DL strategies can be adopted for the delivery of any course in a competency based medical curriculum. Moreover, most of the reported DL strategies rarely integrate an instructional design model to facilitate the delivery of a course. The purpose of this study is to address these gaps. Therefore, in this study, we have designed a DL-framework to deliver anatomy teaching that provides a microfiche of the onsite anatomy learning experience during the mandated COVID-19 lockdown. First, through a dedicated needs-assessment using nominal-group technique (35), we identified the DL learning theories that should be employed in blueprinting the DL-framework. The framework's blueprint was designed amalgamating principles of:

Garrison's community inquiry (36, 37), Siemens' connectivism (38) and Harasim's online-collaborative-learning (39); and improved using Anderson's DL-model (40). Effectiveness of the DL-framework in anatomy teaching and course delivery was demonstrated using the exemplar of the Head and Neck (H&N) course during the COVID-19 lockdown in the pre-clerkship phase of the competency-based medical curriculum (CBMC) at our medical school. Instructional strategy integrated in the H&N course to disseminate the DL-framework were informed by the Analyse, Design, Develop, Implement, and Evaluate (ADDIE) instructional design model (41). The efficiency of the DL-framework was evaluated using the first two levels of Kirkpatrick's model (42) as part of ADDIE. Additionally, using Bourdieu's Theory of Practice (43), we demonstrate that the DL-framework is an efficient pedagogical approach, pertinent for medical schools to adopt; and is robust and versatile, as it attests to the key domains of different learning outcomes framework. In summary, the strategized DL-framework presents an adaptable approach for medical education faculty to efficiently and effectively deliver anatomy courses in the pre-clerkship curriculum in the changing landscape of anatomy instruction, especially during unprecedented circumstances as presented by the COVID-19 pandemic.

METHODS

Study Landscape

Mohammed Bin Rashid University of Medicine and Health Science (MBRU) is medical school located in Dubai, where the curriculum is founded on a competency-based educational model (44), in line with the tenets of Epstein and Hundert (45), and spans over 6 years. The undergraduate entry medical curriculum provides a milieu for a highly adaptive learning process rather than the traditional "one-size-fits-all curriculum." Furthermore, the MBRU curriculum aims to foster an erudition environment, where peer-assisted learning and learning supported by social learning theories are facilitated (46).

The MBRU curriculum is divided into 3 phases (**Figure 1**). The pre-clerkship curriculum is divided into two phases: Phase -I and Phase -II and spans over 3 years. The clerkship curriculum consists of Phase–III courses, which focus on clinical training. Each phase of the curriculum includes integrated courses and builds on the preceding one, such that the curriculum is "spiral" and the students repeat concepts pertaining to a subject, where with each successive encounter, concepts build on the previous one (47) (**Figure 1**).

Participants

The study participant were selected according to a defined inclusion criteria. Only students in the second semester of Phase – I (**Figure 1**), registered for the H&N anatomy course were eligible to participate in the study. A total of 56 students who had successfully completed all the courses in semester – 1 of Phase – I registered for the course.

Participation in this study was entirely voluntary. Of the total 56 students registered, only 39 (70%) students opted to participate in this study. Gender distribution was represented by 26 (67%) females and 13 (33%) males, with the female to male respondent ratio representative of that of the entire cohort. The mean age of the study participants was 19.2 (3.2) years.

Dissemination of the DL Framework

The incorporation of the ADDIE Model (41) (refer below for details) enabled us to implement the pedagogical approach of flipped learning in the DL delivery of the H&N course. The cloud-based software, Brightspace learning management system

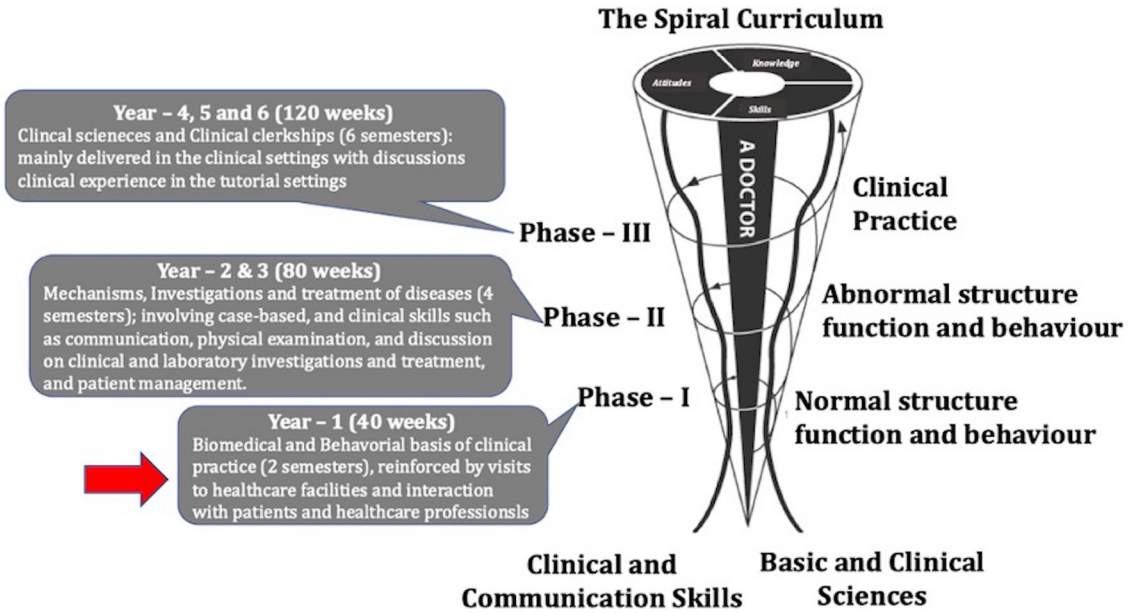

FIGURE 1 | The undergraduate medical curriculum at Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU). The curriculum is divided into three phases and spans over 6 years. Note: Each phase of the undergraduate medical curriculum includes integrated courses and builds on the preceding one, such that the curriculum is a "spiral," and the students repeat the study of a subject, each time at a higher level of difficulty and in greater depth. The phase in which the teaching framework was implemented is indicated with a red arrow.

(LMS) by D2L (Kitchener, ON, Canada) was employed for dissemination of the course content, and formative assessments.

Instructional materials in the form of the study-guide, pre-recorded PowerPoint presentations [which an initial survey indicated was the mode of content delivery preferred by the students (*data not shown*)], data sets and clinical cases to be discussed and formative assessments were uploaded on the LMS by the concerned instructor(s) at least 1-week prior to the delivery of a given session. The LMS was linked to an intelligent timetabling module by Wise Technologies Ltd (Ljubljana, Slovenia), which allowed students to simultaneously view the weekly schedule of the course-sessions with the intended learning outcomes for each session.

Due to the mandated COVID-19 lockdown and social-distancing, all on-campus sessions were substituted with virtual off-campus live sessions, organized using Microsoft (MS) Teams (MS Corporation, USA) application compatible with Windows, Linux, macOS, iOS and Android operating systems. Prior to each live session, a reminder email was sent to all students registered for the course to ensure their participation. Discussion groups were conducted using WhatsApp (Facebook, Inc.).

Design of the Framework for Course Dissemination

Identifying the Learning Theories for the Framework Using Nominal Group Technique

The blueprint of the pedagogical framework was designed amalgamating principles of: Garrison's community inquiry (36), Siemens' connectivism (38) and Harasim's online-collaborative-learning (39); and improved using Anderson's DL-model (40) (**Figure 2**). These learning theories were identified using keywords collated employing nominal group technique (48) (**Figure 2**). Briefly,

- In the *Orientation phase* (∼10 min), the director of Phase – I of the curriculum along with the course coordinator and lead instructor of the H&N course formed a team; where the Phase – I director informed the team members to individually identify keywords using principles of Schon's "Reflection in action and Reflection on Action model" (49, 50); that they believed best attested to the "learning needs" of the students and would facilitate a rapid transition of the H&N course from on-site face-to-face teaching to the DL modality. A list of questions, identified by Menard et al. (51), was also circulated among the team members to trigger guided reflection.
- Team members wrote their responses on 3 in × 5 in post-it notes independently and silently (*Idea generation phase*), following which each member read their responses to others in the team *(Idea sharing phase*). The total process took ∼15 min.
- In the *Group discussion phase* (∼25 min), members explained to the team the rationale for selecting a specific keyword. A final list of keywords was collated, and any duplicates were removed.
- In the *Voting and Ranking phase* (∼10 min), the team members voted on the ranking of keywords according to their importance.

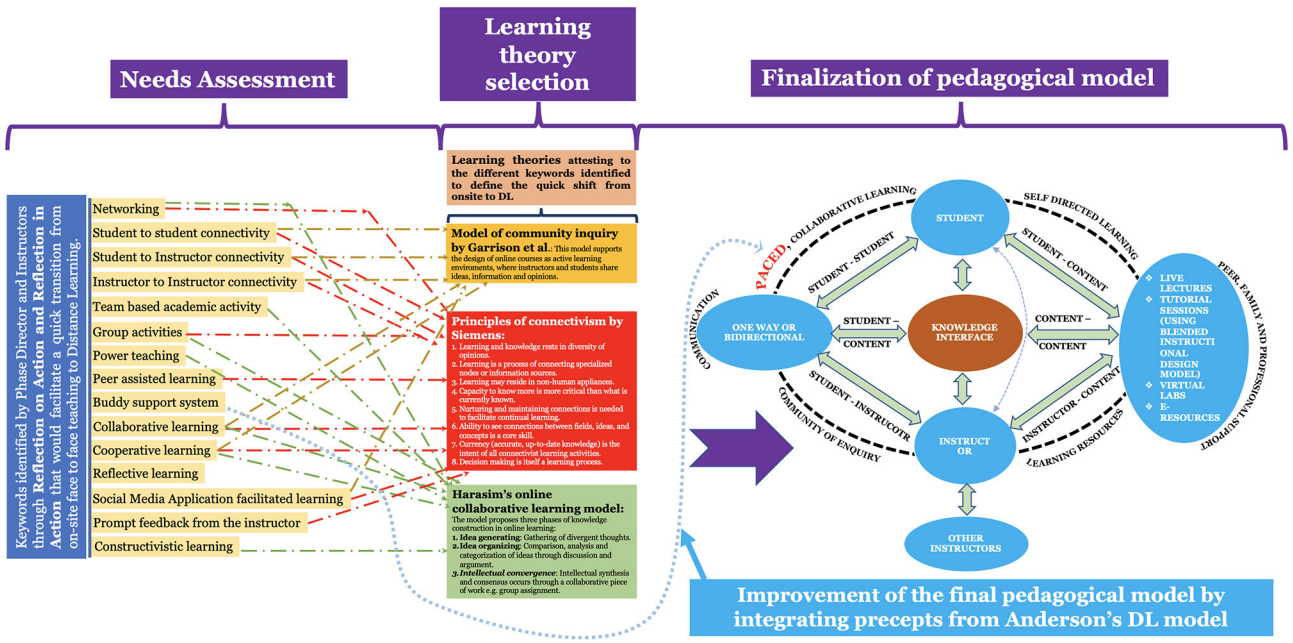

FIGURE 2 | Identification of the DL theories using nominal group technique, and their use in blueprinting the DL-framework. The framework's blueprint was designed amalgamating principles of: Garrison's community inquiry, Siemens' connectivism and Harasim's online-collaborative-learning; and improved using Anderson's DL-model. Note: The need for the incorporation of the "Buddy support system" required us to integrate the Anderson's DL-model (refer to the text for details).

Selection of the Learning Theories

The Phase – I director and the course coordinator used the ranked keywords to search for learning theories. Four education-relevant databases: ERIC (https://eric.ed.gov); PubMed (https://pubmed.ncbi.nlm.nih.gov); PsychINFO (https://search.proquest.com/psycinfo/advanced); and Web of Science (https://webofknowledge.com) were searched for publications associated with DL theories using the list of ranked keywords obtained using nominal group technique (**Figure 2**).

Three DL theories were identified from 21 publications, which were later vetted by the team for eligibility: Garrison's community inquiry (36), Siemens' connectivism (38), and Harasim's online-collaborative-learning (39) (Refer to **Figure 2** for the key principles of individual theory). These three DL theories were used to construct the initial pedagogical model. However, in order to integrate the aspect of "Buddy support system" (**Figure 2**), which essentially focuses on collaborative learning (52), we decided to integrate principles of Anderson's DL-model (40), to obtain the final pedagogical model (**Figure 2**). The final pedagogical model was vetted and reviewed by the team. This model was used to derive the teaching principles. The teaching principles were further employed to blue-print the guide-plan for the DL course (**Figure 3**). Based on the derived teaching principles, there was a consensus to adopt ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (41) to deliver the H&N course (**Figure 3**).

Rationale Behind the Selection of the ADDIE Model to Design the Dissemination Framework for the Course

One of the essential aspects to be considered when designing a framework for the dissemination of a course is that the instructors must ensure that the framework provides a coherent and favorable learning milieu for all students. The ADDIE model is one such framework, and has been used to design and blueprint curriculum delivery in diverse fields such as online continuing education (53).

Also, in light of the unprecedented circumstances, brought about by the COVID-19 pandemic, as well as the evolving response in governmental and institutional measures, it was important to adopt an instructional model which offers instructors considerable flexibility. ADDIE's inherent characteristics of flexibility and non-linearity allow instructors to easily adapt and combine it, and the information and elements can be adjusted and modified to meet the needs of the course and its learning objectives (54). Based on the above, we decided to incorporate the ADDIE model in the instructional delivery of the H&N course.

Furthermore, the ADDIE model can be rapidly implemented in the delivery of a course due to its simplicity (55). This is evident from the fact that the model has been extensively used by the United States army, especially during World War II, when the armed forces had to swiftly conduct technical

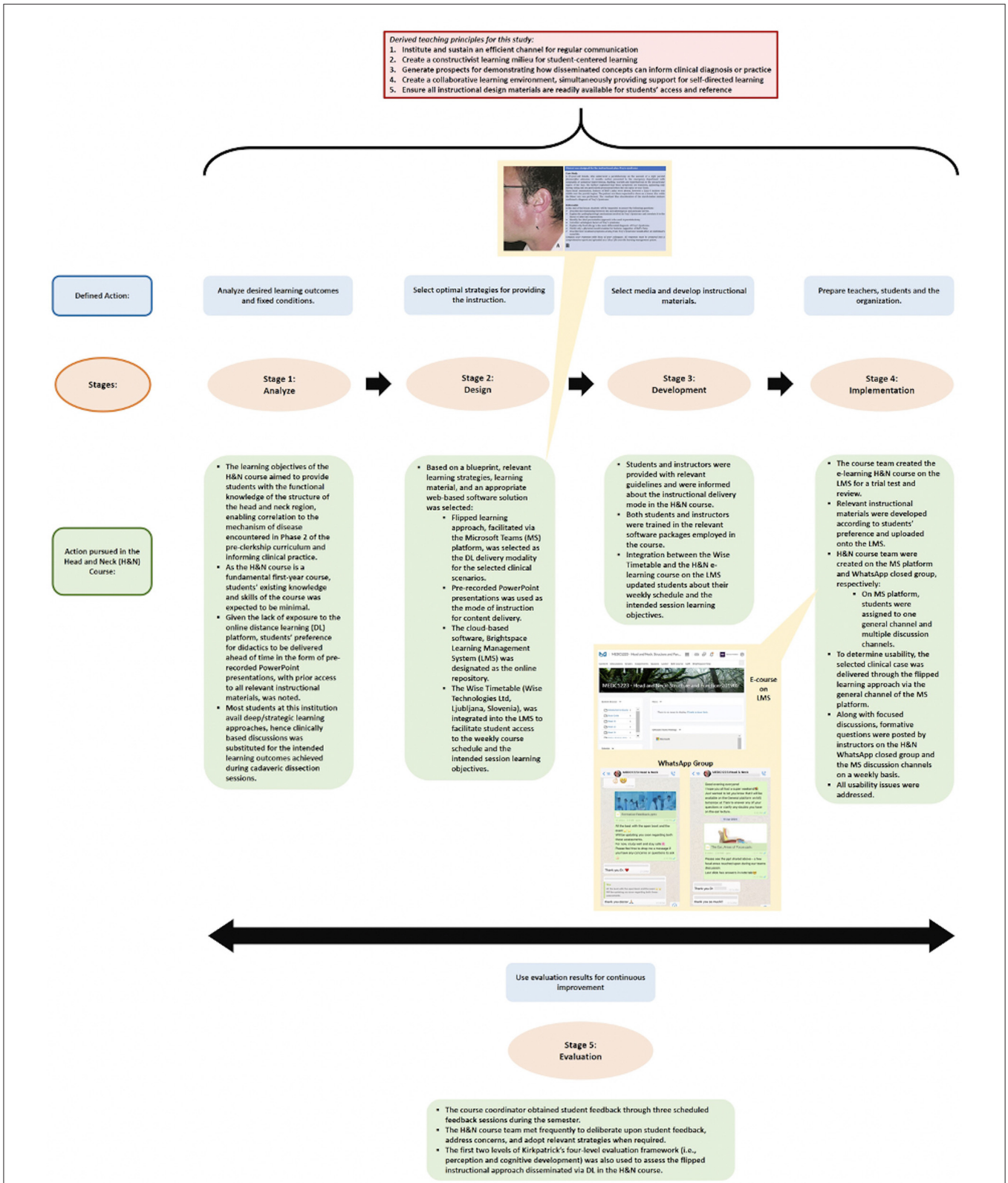

FIGURE 3 | Defined activities pertaining to each stage of the ADDIE instructional design model through which the flipped classroom approach was delivered in the H&N course during the mandated COVID−19 period, where the designed DL pedagogical strategy was implemented. Note: the flipped learning approach was

(Continued)

FIGURE 3 | employed in the instruction of selected clinical cases (shown using the exemplar of Frey's Syndrome in figure) that was delivered through the general channel of the MS teams platform. Formative questions and interesting facts pertaining to the selected clinical cases were posted weekly by instructors on the H&N WhatsApp closed group (snippets of this shown in the figure) and the MS teams discussion channels, allowing students to self-evaluate their understanding of the delivered concepts and establish a community of learning through focused discussions.

training for a large group of new recruits who were expected to uphold various specialized military roles (56). Our situation was somewhat similar. We had little time to transition from onsite to the DL modality, and also our delivery strategy required to facilitate the integration between basic science and clinical concepts. To address both these requirements the ADDIE model was considered to be best-suited for designing the framework for the delivery of the H&N course (57).

Blueprint of the Course Dissemination Framework Designed Using ADDIE

Stage 1: Analysis

This stage was considered to be integral to the framework as it inadvertently posed questions that acted as an investigative prelude to the implementation process (54). Thus, through this stage, the instructional problem was elucidated, instructional goals and objectives were established, and the students' learning environment, existing knowledge, and skills were ascertained (54). The H&N course team and the Phase I Director, engaged in a discussion to identify the instructional challenges associated with course delivery in the context of setting and modality and determined the expectations for performance after course completion (**Figure 3**).

As a fundamental 1st-year course, the H&N course is designed to provide students with the functional knowledge of the structure of the head and neck region, thereby enabling correlation to the mechanism of disease encountered in Phase 2 of the pre-clerkship curricular phase, so as to inform clinical practice. In this regard, it was expected that students' existing knowledge and skills of the H&N course would be minimal.

In view of the learning context and target group, institutional instructional delivery was transferred to the online DL platform due to the mandated COVID-19 lockdown. Since this particular student cohort did not have previous exposure to the DL modality, an informal survey, enquiring about preferred mode of DL delivery, was conducted to address the transition to the DL platform. The majority of students indicated that they preferred the didactics to be delivered ahead of time in the form of pre-recorded PowerPoint presentations (*data not shown*), with prior access to all relevant instructional materials. Moreover, one of our earlier studies, indicated that most students at MBRU avail deep/strategic learning approaches. Therefore, we decided to incorporate "*clinical case discussions*" as a substitute for the intended learning outcomes achieved during *cadaveric dissection sessions* (25, 58). Further, it was decided that precepts pertaining to aspects of "Balint groups" (59) and "Schwartz rounds" (60) will be integrated in the clinical case discussions to promote collaborative learning and discussions.

Stage 2: Design

This phase entailed the creation of a blueprint which was based on the feedback generated from the discussion of the analysis stage (54). This led to the selection of relevant learning strategies, learning material, and a web-based software solution to support the instructional process (**Figure 3**).

Accordingly, the flipped learning approach, facilitated via the MS Teams platform was selected as the DL strategy to deliver the dedicated selected clinical case discussions. An exemplar of a clinical case pertaining to Frey's Syndrome is shown in **Figure 3**. LMS was designated as the online repository through which students accessed instructional material. In addition, integration of the scheduling assistant, Wise Timetable, assisted students to keep a record of their learning progress.

Stage 3: Development

In this phase, the course team evaluated the designed material (54) (**Figure 3**). In accordance with the blueprint, the course team created the e-learning H&N course on the LMS for a trial test and review. The relevant instructional materials, developed in line with students' preference as stated in Stage 1, were uploaded onto the LMS.

A H&N course team with one general channel and multiple discussion channels were created on the MS Teams platform. The entire student cohort, assigned to the general channel on MS Teams platform, was then divided into two large groups, each of which were further sub-divided into smaller teams and assigned to the respective discussion channels for the purpose of clinical case discussions.

In effort to determine usability in the initial demonstration phase, the flipped learning approach was employed in the instruction of the selected clinical case that was delivered through the general channel of the MS Teams platform. After a thorough discussion with the course team, a H&N WhatsApp closed group was created. Formative questions and interesting facts pertaining to the selected clinical cases were posted weekly by instructors on the H&N WhatsApp group and the MS Teams discussion channels, allowing students to self-evaluate their understanding of the delivered concepts and establish a community of learning through focused discussions (**Figure 3**).

Once all usability issues were addressed, the instructional design framework progressed to Stage 4 (i.e., implementation) (**Figure 3**).

Stage 4: Implementation

This phase entailed the preparation of students and instructors by providing relevant guidelines and informing them about the particulars pertaining to the instructional delivery mode in the H&N course (**Figure 3**). Both students and instructors were trained in the relevant software packages employed in the course. Integration between the Wise Timetable and the H&N e-learning

course on the LMS ensured that the students were regularly informed about their weekly schedule and the intended session learning objectives.

Stage 5: Evaluation

This phase ensured that the H&N course underwent continuous improvement as the course progressed through the semester (**Figure 3**). Accordingly, student feedback was obtained thrice during the course through scheduled feedback sessions organized by the course coordinator. The H&N course team, which was chaired by the course coordinator, met frequently to deliberate upon this student feedback, address concerns, and adopt relevant strategies when required. In addition, the flipped instructional approach disseminated via DL, was also assessed using the first two levels of Kirkpatrick's four-level evaluation framework (42), i.e., perception and cognitive development (*Refer below for details*).

Evaluation of the DL Framework

DL in the H&N course was evaluated using the first two levels of Kirkpatrick's four-level evaluation framework (42). Level – 1 of the framework evaluates reaction/perception, i.e., "*Did the student/learners enjoy the learning process?*" Level – 2 of Kirkpatrick's framework evaluates cognitive development, i.e., "*Did the learning occur?*"

Kirkpatrick's Level 1 Evaluation

(a) Survey tool: A 19-item 5-point Likert scale (1 = strongly disagree; through 5 = strongly agree) survey, adopted from one of our previous studies with minor modifications (61), was used to evaluate Kirkpatrick's Level 1 (*Refer to supplementary information for the questionnaire*) i.e., students' perception regarding the DL delivery of the H&N course during the mandated COVID-19 pandemic lockdown. As this was the first time the students experienced anatomy instruction through the DL modality, we perceived that it was imperative to appraise "Anxiety associated with the use of DL" (one question item) (*Refer to supplementary information for details*). The remaining 18-question items were further grouped into four principal categories: *Computer expertise* (four question items); *Flexibility of DL* (four question items); *Usefulness of DL* (five question items); and *DL Satisfaction* (five question items) (*Refer to supplementary information for details*).

(b) Validation of the survey: The survey tool was assessed for both validity and reliability. The statistical package, SPSS (V25, IBM Corp, NY, USA) was used to analyze the data.

According to Tabachnick and Fidell (62), sample sizes of 50 and 100 are considered to range between very poor and poor. As we had 56 participants in this study, we decided to employ the Kaiser-Meyer-Olkin (KMO) test to measure sample adequacy (MSA) (63). The KMO test, which correlates pairs of variables and the magnitude of the partial correlations among variables, ideally yields an overall measure within the range of 0.6 and 1. A high (1.0) KMO index indicates that the Principal Components Analysis may be conducted, while a low (∼0.0) KMO index states otherwise (63).

Intercorrelations between variables (i.e., interrelation of each question item in a specific category) were determined through the statistical method of exploratory factor analysis (EFA) (64) and, the Bartlett test of sphericity (65).

EFA explores previously unknown groupings of variables to seek underlying patterns, clustering and groups. Loading values below 0.5 indicate that the specific item has a weak influence on that category, values between 0.5 and 0.6 indicate that the specific item has a fair influence, values between 0.6 and 0.7 have a sufficient factor loading influence, values between 0.7 and 0.8 have a good loading influence, and those above 0.8 have a high loading influence on that category (66).

The Bartlett test, which investigates the correlations between variables, should reveal statistical significance ($P < 0.05$) (especially used when the number of cases per variable is five or fewer).

The internal consistency (reliability) of the questionnaire was validated using the Cronbach's alpha (α). This measures the extent to which the question items within each category consistently measure what is intended to be measured. Values of α below 0.6 indicate low internal consistency, values between 0.6. and 0.7 indicate acceptable consistency levels, good levels are those values between 0.7 and 0.8, and high reliability levels are those above 0.8 (67).

Kirkpatrick's Level 2 Evaluation

Level 2 of Kirkpatrick's framework evaluated students' cognitive development in the H&N course. This was addressed by comparing the summative assessment performance across three cohort of students.

Cohort 1 – experienced the course through traditional teaching modality (with onsite teaching and dissection sessions) without the presence of a pedagogical framework; Cohort 2 – experienced the course through traditional teaching modality with presence of a defined instructional design framework, which was applied in a blended learning milieu in one of our earlier studies (25), and Cohort 3 (*current cohort*) – experienced the course entirely through DL modality.

The summative assessment content and structure was similar for all the three cohorts, and was standard set by a panel of content experts assigned by the student assessment and progression committee (SAPC) at our medical school. The summative assessment was designed according to the principles of Miller's pyramid of professional competence (68) and employed different types of assessment tools, which is summarized in **Figure 4**. However, we could not include practical assessment in the cohort which was exposed to the DL-framework (Cohort 3), due to mandated social distancing protocols in line with the pandemic. The summative assessment scores across the different cohorts (indicated above) was compared using the Analysis of Variance (ANOVA) (69). The software package of Stata (StataCorp V16, CA, USA) was used for this analysis. A $p < 0.05$ was considered statistically significant (70).

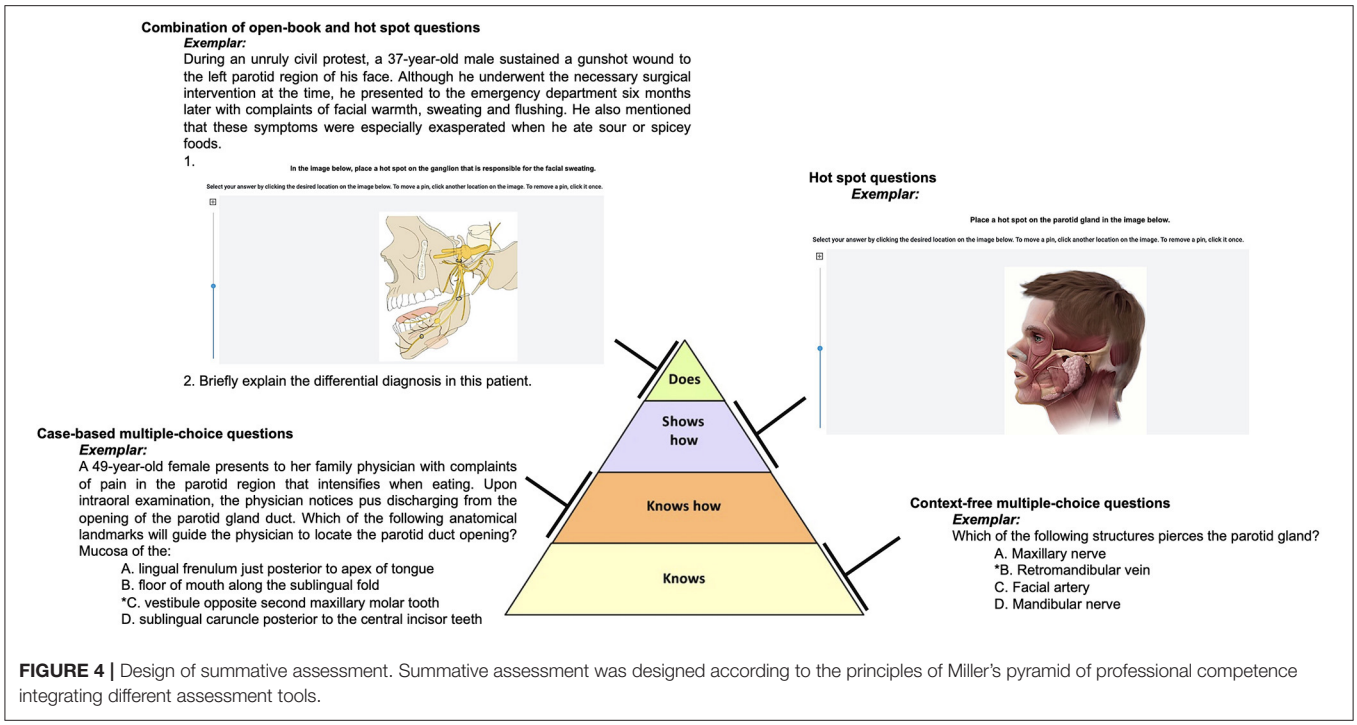

FIGURE 4 | Design of summative assessment. Summative assessment was designed according to the principles of Miller's pyramid of professional competence integrating different assessment tools.

RESULTS

Validation of the Survey Tool

In this study, the validity and reliability of the questionnaire is shown in **Table 1**.

Sample adequacy was confirmed by KMO values yielded within the range of 0.6 and 1.0 for categories "Computer expertise," "Usefulness of distance learning" and "Distance learning satisfaction" (**Table 1**). However, the category "Flexibility of distance learning" yielded a KMO value of 0.54, which may be attributed to the low sample size that was restricted to only 56 students within the cohort who registered for the H&N course (**Table 1**). This category was not removed from the analysis as the KMO value is close to 0.6. More relevantly, the Bartlett test was statistically significant for all categories, revealing a strong correlation between the items in each category (**Table 1**).

As indicated by the EFA values (0.60–1.0), most question items (i.e., 16 items) were noted to have either a sufficient, good or high influence on their respective categories (**Table 1**). Two questionnaire items emanating from the categories "Usefulness of distance learning" and "Distance learning satisfaction" yielded EFA values that were <0.40, indicating weak and fair influences, respectively (**Table 1**). Cronbach Alpha values were >0.6 for all categories in this study, revealing acceptable to good levels of internal consistency between question items, thereby validating the reliability of the questionnaire employed (**Table 1**).

Kirkpatrick's Level 1 Evaluation: Evaluation of a Student's Perception

Level 1 of Kirkpatrick's framework (i.e., perception) was evaluated using a validated 18-item 5-point Likert scale questionnaire, grouped into four categories (*Refer to methods for details*) preceded by an item appraising the association of anxiety with the use of DL. The results obtained with students' perception are presented and discussed below in detail.

Anxiety and the Use of Distance Learning (DL)

In the survey tool, one of the items appraised student anxiety associated with the use of DL. This item specifically enquired about the anxiety associated with the transition of onsite face-to-face teaching to the DL modality.

With the precipitous shift from onsite face-to-face teaching to DL, majority (49%) of students expressed that they felt anxious (**Figure 5**). Anxiety is a fundamental human emotion that consists of fear and indecision and typically occurs when an individual believes that the event is a threat to self or self-esteem. Findings suggest that students, as well as the general population, may be experiencing negative psychological effects from the outbreak of COVID-19, such as anxiety, fear, and worry, among others (71). Also, students feel more anxiety in DL due to the distance as they are unable to discuss or share problems with instructors on a daily basis (72). Additionally, collaborative learning associated with DL often becomes difficult giving rise to anxiety (73).

For the instructor, the indication of understanding, or lack thereof, that is observed from the general facial expressions and body language of students in the class, is also absent, thereby requiring students to vocalize their feedback via the DL platform, which further adds to the anxiety as students are often shy to voice their opinions and feedback (74). Moreover, students with socially anxious tendencies may not be comfortable to approach instructors for clarification on content, creating "gap

TABLE 1 | Validity and reliability analyses of the questionnaire administered to 1st-year medical students ($N = 39$) undertaking the Head and Neck Course during the mandated COVID-19 lockdown[a].

Category	Items in each category	Exploratory factor analysis		KMO[b] & Bartlett	Cronbach's Alpha[c] (%)
		Factor loading value	Item influence		
Computer expertise	This course helps me use the internet source more efficiently	0.68	Sufficient	0.70[d]	77.9
	My use of computers increases after taking this course	0.74	Good		
	My computer knowledge increases with the course assignments and projects	0.81	High		
	This course contributes to my knowledge of searching on the internet	0.89			
Flexibility of distance learning	In terms of use of time and location, distance learning is flexible	0.63	Sufficient	0.54[d]	73.0
	Distance learning is appropriate to students with different learning capacities	0.66			
	Distance learning allows me to allocate my time better	0.76	Good		
	Distance learning allows me to work at home comfortably	0.93	High		
Usefulness of distance learning	Evaluation of the success in distance learning is quite objective	0.48	Weak	0.73[d]	77.4
	Distance learning provides me with a valuable learning experience	0.76	Good		
	A degree in distance learning is as valuable as a degree in traditional education	0.79			
	I believe distance learning is useful	0.83	High		
	Distance learning minimizes the inequalities in education	0.85			
Distance learning satisfaction	In this course, I am pleased with the timely responses to my questions	0.57	Fair	0.75[d]	68.1
	The content of this course meets my expectations	0.61	Sufficient		
	I advise other students to take this course	0.63			
	I like the content of the course which draws examples from real life	0.65			
	The student-centred instruction offered in this course through distance learning is enjoyable	0.92	High		

[a] *First-year medical students enrolled in the Bachelor of Medicine, Bachelor of Surgery (MBBS), College of Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU), Dubai, United Arab Emirates.*
[b] *KMO, Kaiser-Meyer-Olkin.*
[c] *Shows the internal consistency.*
[d] *$P < 0.0001$.*

in knowledge," which may further add to the anxiety of students experiencing a course through DL. This aspect is supported by the observed direct proportionality reported between academic underperformance and academic anxiety.

To resolve these concerns, it is recommended that positive instructor-student relationships be developed along with the integration of regular instructor feedback and counseling initiatives into the DL approach, thus helping students adapt to this new modality. In fact, at MBRU we have initiated sessions involving progressive muscle relaxation (PMR) to counter anxiety in students pursuing medical education [Naidoo et al., manuscript under consideration (refer to supplementary information for the manuscript file)].

It is to be noted that 28% of the students conveyed that they did not experience emotions of anxiety with the transition to DL (**Figure 5**). This may be attributed to the fact that MBRU draws medical students from diverse high school curricula locally and internationally, coming from different socio-economic standings and perhaps with previous exposure to the DL modality. It is also likely that the respondent group is representative of adult learners, who were able to quickly adapt to the transition to DL (75).

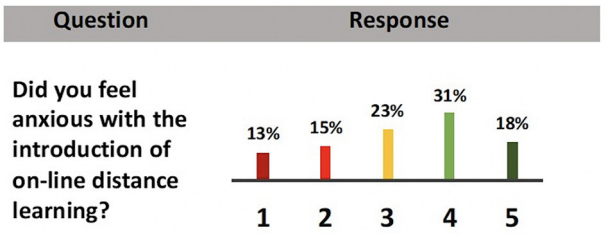

FIGURE 5 | Bar graph showing respondents' levels of agreement about anxiety and the use of DL in the H&N course following the implementation of the blueprinted DL framework. (5-point Likert scale: 1 = strongly disagree through 5 = strongly agree) (refer to the text for details).

Anxiety also has direct bearing on the mental health and learning ability of a medical student (76–78). However, one key aspect of anxiety often not elaborated upon in the medical education literature is that it also has a genetic predisposition (79). This issue of genetic predisposition is important in the current study, given the fact that MBRU medical student population is multi-ethnic, which alludes to the fact that different genetic makeup may be an underlying factor when it comes to the aspect of coping with anxiety related stress. In a study by Hill et al., a genome-wide analysis study (GWAS) showed the direct influence of 30 different loci on socio-economic status of an individual; indicating the effect of environmental and genetic factors on brain structure and neuronal function, which in turn affects education, intelligence, income and the ability to handle stress (80). This is also supported by the studies of Zhou et al., where genetic variation in human neuropeptide Y expression affects psychobiology and molecular aspects of stress response and resilience (81, 82). In line, the observed difference in the ability to handle stress may have a underlying genetic causality, which of course needs to be explored further using a relatively genetically homogenous population of students, as available in some of the countries in the region (83).

Computer Expertise and the Use of Distance Learning

Category 1 or Computer Expertise comprised of four items that focused primarily on the effect of DL on computer expertise. Computer expertise can be defined "*as the abilities of the students to work efficiently with a computer.*" For the first three items under this category, 59–72% of responses were in the agree-strongly agree continuum, with 8–11% of responses ranging between strongly disagree and disagree (**Table 2**). Majority of responses within the agree-strongly agree continuum, indicates that the DL modality augmented the computer expertise of the course participants. We believe this has long-term benefits.

With the pandemic, telehealth has become an essential need for the general populace. Health care providers, and patients with COVID-19, especially when patients are in quarantine, telemedicine has enabled patients to contact the health care provider in real-time for advice on their health issues (84–86). Several technologies have been deployed for telehealth, including mHealth (mobile health), video and audio technologies, digital photography, remote patient monitoring (RPM), and store and forward technologies. In fact, one needs to replicate the entire health system in the "microcosm" of telehealth through information technology (87). Clinicians are an essential part of this microcosm, where they are involved in efficient management of patients and eliminating gaps in knowledge. Additionally, telehealth allows increased satisfaction of delivering superior patient care, and also grants decreased risk of burnout by providing a more manageable workload and improved patient communication processes. In line, it is imperative that medical education integrates aspects, whereby computer expertise of future clinicians are augmented and they are suitably prepared to address needs of patients through telehealth. Computer skills are essential for the effective implementation of telehealth strategies (88). As our DL learning framework strengthens and enhances computer expertise (**Table 2**), it demonstrates that it will allow medical students to be better prepared to integrate the precepts of telehealth in their clinical practice as well as during their clerkship years.

Furthermore, respondents' rate of 64% within the range of agree-strongly agree was recorded in the present study for the item regarding efficiency in internet usage gained through the online DL experience (**Table 2**). Also, 46% of respondents agreed that course assignments and projects augmented their computer skills (**Table 2**). The H&N course employed rubric-based assessments tailored employing Miller's model of competency. Hence, it can be safely concluded that incorporation of computer and internet as study tools in this course assisted students to improve their internet-searching/browsing skills, as well as develop their abilities to think critically and evaluate the credibility of the information sourced. Again, we believe this has long-term ramifications. Bhatia et al. showed that providing training for improvement of internet-searching skills for obtaining up-to-date medical information, and evidence-based medicine from the internet improves the practice of medicine (89); based on which one can conclude that our DL framework trains students in the conscientious, explicit, and judicious use of the current best evidence to inform decisions about the care of individual patients.

The last item in category 1 also yielded a significant response of 21% for the strongly disagree-disagree continuum (**Table 2**). Factoring in the aspect that the H&N course was delivered solely through DL, it involved considerable self-directed learning, which is based on the premise that learners are capable of determining their personal learning needs and set appropriate steps to achieve their personal learning goals (90). In contrast, in face-to-face delivery of a course, instructors often set the task for their students who are metacognitively, motivationally, and behaviourally active participants in their own learning process (91). The H&N course is delivered in the 1st year of the medical curriculum, and at this stage students may lack the academic maturity to address their learning needs entirely through self-directed learning [reflected in the significant disagreement observed (**Table 2**)].The integration of blended sessions (92), may address this aspect, and therefore requires future investigation.

TABLE 2 | Levels of agreement for different categories.

		Likert scale, levels of agreement in %				
Category	**Item**	**SD**	**D**	**N**	**A**	**SA**
Computer expertise	This course helps me use the internet source more efficiently	0	8	28	59	5
	My use of computers increases after taking this course	3	8	18	36	36
	My computer knowledge increases with the course assignments and projects	3	18	33	46	0
	This course contributes to my knowledge of searching on the internet	0	8	33	49	10
Flexibility of distance learning	In terms of use of time and location, distance learning is flexible	0	0	87	10	3
	Distance learning is appropriate to students with different learning capacities	3	33	23	26	15
	Distance learning allows me to allocate my time better	18	18	18	33	13
	Distance learning allows me to work at home comfortably	3	13	23	36	26
Usefulness of distance learning	Evaluation of the success in distance learning is quite objective	8	13	33	44	3
	Distance learning provides me with a valuable learning experience	3	8	33	51	5
	A degree in distance learning is as valuable as a degree in traditional education	15	21	33	18	13
	I believe distance learning is useful	3	15	31	31	21
	Distance learning minimizes the inequalities in education	15	15	46	21	3
Distance learning satisfaction	In this course, I am pleased with the timely responses to my questions	0	5	18	44	33
	The content of this course meets my expectations	0	3	33	59	5
	I advise other students to take this course	0	0	23	67	10
	I like the content of the course which draws examples from real life	0	3	18	59	21
	The student-centred instruction offered in this course through distance learning is enjoyable	0	15	36	46	3

SD, Strongly Disagree; D, Disagree; N, Neutral; A, Agree; SA, Strongly Agree.

One word of caution, as the framework integrates the use of social media application (for the discussion of relevant clinical cases) (**Figure 3**) and the internet, it is imperative that students are suitably informed regarding the ethical implications that surround internet use and patient data confidentiality (93). To address this aspect, students who registered for the H&N course had to complete two courses in semester – 1 (**Figure 1**): A. Principles of Bioethics and B. Foundation in Clinical Medicine, which informed them about ethical considerations regarding medical practice and patient data confidentiality.

Flexibility of Distance Learning

In light of productive learning experiences, the concept of flexibility and its influence on three key dimensions of DL (i.e., learner engagement with the learning environment, learner-content engagement and learning experience design) were investigated through four items in category 2 i.e., flexibility of DL.

Item 1, which was reflective of the dimension "*learning experience design,*" addressed the effect of DL on students' time management skills (**Table 2**). Respondent rates for agree-strongly agree and strongly disagree-disagree continua were 46 and 36%, respectively (**Table 2**), with the former owing to the realistically achievable learning objectives outlined in the ADDIE model of instructional delivery (**Figure 3**). Since the ADDIE model is best known for its flexibility and cyclic nature (94), the well-structured content and organized workload may have enabled students to direct focused protected time to their fundamental learning needs. Moreover, the integration of both asynchronous and synchronous DL (95) components in the

instructional delivery may have fostered students' self-regulation in multitasking behaviors. However, despite its specificity and flexibility, the ADDIE model is also scalable (96), and may necessitate that the individual dedicates more time to particular steps and actions. This may account for the 36% of respondents who were unable to allocate their time accordingly (**Table 2**).

Items 2 and 3, which were indicative of the DL dimension "*Learner engagement with learning environment,*" enquired about the conduciveness of the student's learning environment, and the flexibility of the DL modality in terms of time and location, respectively. With the number of COVID-19 cases rising exponentially at the commencement of the lockdown, social distancing measures became the most effective means of prevention (97). Hence, it is not surprising that the majority of respondents (62%) (**Table 2**), felt psychologically safe and physically comfortable to learn via the online DL platform during this time. Yet, DL may not prove advantageous for every student due to the apprehension associated with the use of technology and the physical separation between the instructor and student (98). It is also a possibility that collaborative learning and networking suffer at the expense of DL, leading to student frustration, uneasiness and confusion—all of which may impede the learning process (99). This may provide a plausible justification for 16% of respondent rates which were localized within the scale of strongly disagree and disagree (**Table 2**).

Despite the dispersion of responses across the strongly disagree-disagree and strongly agree-agree ranges for the conduciveness of the DL environment, 87% of students expressed a neutral response regarding DL flexibility in terms of time and location (**Table 2**). In fact, Dhawan stated that the flexibility of time and location in DL may be considered to be both strengths and weaknesses, the excessiveness of which may be beneficial or problematic (99). In this study, the preponderance toward this neutral opinion may imply that students were not comfortable to express themselves acquiescently. The rationale behind this selection may be explicated from the perspectives of the institutional DL platform and the home learning environment. In addition to the integration of the ADDIE model, the online delivery of the H&N course also adhered to the institutional teaching schedule using the WISE scheduling module (*Refer to methods for details*). While schedule adherence ensured that all required concepts were delivered timeously, it may have compromised the flexibility and time allocation of the DL modality.

It is notable that the predictability of the course schedule forms a pivotal component of the online syllabus in DL, as it instills routine, assists students to transition from one lesson to another, and encourages student productivity and enhanced learning (100, 101). Given the immense pressure faced in the transition to the DL modality, the online course schedule also allows instructors to distribute their time between teaching and scholarly duties, with sufficient time devoted to the design, development and implementation of online instructional approaches (102). However, the integration of more asynchronous learning components may present as a potential future improvement that paves the way for further flexibility in the DL framework.

Of course, the home learning environment also plays a role in the student's academic and social development (103). For many families, the mandatory shift to the home environment was viewed as a dynamic process, rather than an event because it entailed adjusting to a common workspace, thus requiring individuals of especially larger families to occupy designated workstations within the confines of their homes. It also meant that these individuals had to simultaneously develop a degree of tolerance and build a mental forbearance to overcome distractions. With quarantine becoming a normal part of life, boundaries of time and location were eventually invisible as individuals diverted their focus to achieving study goals and work deadlines, all at the cost of unbalanced circadian rhythms and mental well-being. In some communities, female students experienced challenges to juggle household chores and their studies, leading to poor academic performance and low morale (104). This highlights the cultural and societal disparities with which DL must contend. Indeed, respecting personal boundaries and priorities may allow families to work and study efficiently from the home environment, but motivating one and another to adhere to a daily routine may be the answer to mimic a typical day outside of quarantine.

The DL dimension "learning-content engagement," which described how the student applied his/her learning style to engage with the H&N course content, was represented by item 4 in category 2. Respondent rates regarding the appropriateness of the DL modality to students' learning capacity were relatively similar for the strongly disagree-disagree (36%) and agree-strongly agree (41%) continua (**Table 2**). This observation alludes to several aspects, which we believe warrants further investigation.

Firstly, this observed dichotomy may be because of different learning methods availed by medical students. Visual, auditory, read, and kinetics (VARK) learning styles are adopted by students, but majority have been found to embrace the aural style (105). Therefore, it may be a possibility that the dichotomous distribution of responses alludes to contrasting learning styles present in the student cohort.

Secondly, the educational veracity of the medical curriculum is acutely susceptible to the effects of COVID-19. An early emphasis on clinical teaching has been an essential element of medical education reform in recent years (106). Medical curricula, including ours, now observe to abide by a strict guide-plan: an abridged preclinical period where students are educated within the medical school, and a subsequent clinical component during which students operate externally to their medical school and within the healthcare environment (107). This shift in pedagogy necessitates that preclinical students convene in groups for tutorials, problem-based learning, anatomy laboratory sessions and simulated patient interactions and for that clinical students have to access patient care centers. Although lecture-based teaching is easily transitioned to an online format, interactive small-group sessions and clinical exposure are not as easily replicated [*which we addressed through the integration of clinical case discussions and incorporation of WhatsApp discussion groups* (**Figure 3**)]. Given these reforms to curricular structure through the integration of the DL framework, the COVID-19 pandemic may have birthed an exasperating dichotomy for

medical students (**Table 2**). A virus that exploits human contact for survival is encumbering an educational ecosystem that also necessitates human interaction.

Lastly, in designing the framework we employed the ADDIE model (**Figure 3**). ADDIE uses a behavioral approach in designing instruction (108). Behaviorism, cognitivism, and constructivism are the three primary learning theories (109). In behaviorism, information is transferred from instructors to learners from a response to the right stimulus. Students are a passive participant in behavioral learning— "instructors are giving them the information as an element of stimulus-response" e.g., through the discussion of a clinical case where the instructors elaborate to the students how the information that is gained through the didactic sessions is applied in addressing specific questions related to the clinical case. Instructors use behaviorism to show students how they should react and respond to certain stimuli. This needs to be done in a repetitive way to regularly remind students what behavior an instructor is looking for, as in the current study it was the through the repetitive discussion of relevant clinical cases in the WhatsApp group (**Figure 3**). Therefore, through ADDIE, although we were able to achieve the desirable outcomes in a DL learning environment, it also restricted us from applying reflective thinking (cognitivism), such as that which is done during active dissection sessions in the anatomy laboratory; and reflection in action (constructivism), which happens through collaborative construction of knowledge during group discussions following an active dissection session. The above may be responsible for the observed dichotomy of responses (**Table 2**). A blended approach may address these issues, but during the mandated lockdown integrating such sessions in the DL framework were not possible.

Usefulness of Distance Learning

Category 3 investigated the usefulness of the DL modality through five items. For items 1 (52%) and 3 (56%), students agreed that the DL framework was useful in the delivery of the H&N course, providing them with a valuable learning experience (**Table 2**). This is most likely because the DL framework allowed students to manage their time, better enabling them to effectively address the learning outcomes of multiple courses. Also, the DL framework employed the ADDIE model, which was disseminated using a published social media application interactome, that embodied aspects of peer-assisted learning and social constructivism (25). Thus, use of this instructional framework promoted and ensured active student participation and engagement, as observed in other similar studies (96).

On the contrary, as the H&N course was the inaugural structure-function course to be delivered via DL, students' responses within the strongly disagree-disagree continuum for items 1 and 3 (**Table 2**), may have stemmed from the questionable development of psychomotor skills in the absence of practical sessions.

Students' learning style is also considered to play an integral role in the usefulness and value of a DL ecosystem. As a result, learning style was recognized to be a possible inequality in education and was addressed through item 4. Although Mohr et al. argued that online DL enables students to capitalize on all four stages of Kolb's learning styles and experiential learning cycle (110), only 24% of respondents agreed that online DL abates such inequalities in education, with nearly 50% of respondents expressing a neutral opinion, which implied uneasiness and reluctance of students to share their views **Table 2**) (111). The latter may be justified by the ambiguity of the phrase "inequalities in education" as students may have misinterpreted it as access to online resources or components of social inequality.

With the establishment of massive open online courses (MOOCs) on the rise, obtaining a degree through distance education has gained considerable popularity as it promotes lifelong learning by extending beyond the boundaries of age, time and geographic location. Two types—Connectivistic Massive Open Online Course (cMOOC) and Extended Massive Open Online Course (xMOOC) have distinctly emerged. cMOOC promotes creativity and interaction among participants, while xMOOC is used merely for knowledge dispersion (112). However, the usual societal belief that on-campus degrees are more accepted and respected than those obtained through DL/MOOCs, tend to influence one's willingness to enroll in the latter (113). In the same vein, item 2 enquired about the comparable value of obtaining a degree through the traditional route vs. DL. The responses to this question were met with much skepticism as they were almost equally distributed across the strongly disagree-disagree, neutral and agree-strongly agree continua (**Table 2**). It is inevitable that the diversity of these responses hint at a multifactorial origin. Respondents' neutral opinion may be linked to the uncertainty of institutional reputation, employability, and duration of program. Further to the substantially high internet usage in the UAE, the recent multinational study of Fidalgo et al. reported that the inability of UAE undergraduate students to appraise the credibility of online DL programs was attributed to the lack of accreditation provided by the UAE Ministry of Education (114–117). Feelings of isolation, missing out on campus life, financial uncertainties, capricious internet connectivity, lack of immediate feedback and the communication gap between instructor and student may explain the negative stigma attached to obtaining a degree through DL (117). Given that medicine is a profession that entails the practice of hands-on skills, studying it through DL may have been viewed as a disadvantage to respondents. On the other hand, respondents' levels of agreement (**Table 2**), were most likely swayed by the global availability of numerous course and program offerings, autonomy to work independently and manage class- and study-time, opportunity to develop leadership skills, cost-effectiveness of the program and the eradication of traveling (118).

Of course, the success of DL also depends on the delivery and outcome of student assessment, and not merely on the delivery of instruction as it provides the opportunity to improve the modality. In item 5 of this study, 47% of respondents concurred that the success of DL in the H&N course was objectively evaluated (**Table 2**). The timely online delivery of both formative and summative proctored assessments through the ExamSoft platform in this course, as well as review of the item analysis by the course team, ensured that exam integrity was maintained. Through participation in formative assessment, students also had

the opportunity to familiarize themselves with the assessment software and were provided with step-by-step troubleshooting guidelines in the event of technical hurdles.

Distance Learning Satisfaction

Students' satisfaction regarding online DL in the H&N course was explored in entirety through five question items that focused on enjoyment of student-centric instruction, expectations met by content, applicability of real-life examples through the discussion of relevant clinical cases (exemplar shown in **Figure 3**), course recommendation to other students, and provision of timely feedback disseminated using a previously applied strategy (7). Respondent rates of 49–80% were recorded within the agree-strongly agree continuum for all five items (**Table 2**), indicating that the DL delivery mode of this course was positively received by the students. This may be because of the application of pedagogical theories of Harasim's online collaborative learning, Garrison's community inquiry and Siemen's connectivism for blueprinting the DL framework and the subsequent integration of the ADDIE model of instructional design for the dissemination of the framework (**Figures 2**, **3**). Interestingly, while the students in this study were exposed to dissection in previous structure-function courses, 80% of respondents agreed that the content of the course drew from examples of real-life (**Table 2**), proving that the course team succeeded in supplementing aspects of clinical and living anatomy through incorporation of a pedagogical framework in DL.

Preferred Mode of Distance Learning Delivery

In this study, the order of respondents' preferred mode of instructional DL delivery was noted to be hybrid/blended (i.e., combination of online and face-to-face instruction) (72%), on-site face-to-face (56%) and online/internet (26%) classes (data not shown). The preference of hybrid classes alluded to the existence of diverse learning styles and capacities within the respondent group and may suggest a potential recommendation for future direction. In fact, Hoch and Dougher documented an increasing trend of preference for hybrid classes over the years that was correlated to improved student attitude and overall class satisfaction (119). According to Marquis and Ghosh, hybrid classes are more attractive to the current generation of students as the flexibility enables them to maintain work-life balance and gain a greater sense of community (120).

Kirkpatrick's Level 2: Cognitive Development

For cognitive development we compared the summative assessment performance in the H&N course across three cohort of students *(refer to methods for details on the different cohorts*) using ANOVA (**Figure 6**). The summative assessment was designed according to the principles of Miller's pyramid of professional competence (68), and employed different types of assessment tools (**Figure 4**) As observed in **Figure 5**, the median of summative assessments across three cohorts do not overlap with one another, highlighting that the presence of an instructional design model and/or pedagogical strategy has an effect on student performance in summative assessment i.e., cognitive development, where the presence of both instructional design model and pedagogical strategy, as is the case for the current cohort, which experienced the course through the DL framework, advantageously affects cognitive growth (*refer to the median of cohort−3 which has the highest value*). A $P < 0.05$ was observed when the mean of summative assessment was compared between: cohort−1 vs. cohort – 2; cohort – 2 vs cohort – 3; and cohort – 1 vs cohort – 3 (values are indicated in **Figure 6**) indicating statistical significance.

In summary, the implementation of a defined instructional design model along with a defined pedagogical framework augments cognitive growth. This observation is not unique to this study. Ogrnic et al. showed that pedagogical frameworks integrating practice-based learning, improved learning in medical students and residents ultimately augmenting patient care (121). Ross and his colleagues designed a pedagogical framework focusing on four domains of teaching: "Facilitating," "Managing," and "Learning and Community Building." Students found the designed framework of learning and teaching not only helpful, but felt it adequately represented the place of teaching activities within the wider context of undergraduate medical education (122). Similarly, integration of instructional design models in course dissemination have also been shown to be advantageous for student learning (123). 25.

DISCUSSION

In this study, we designed a DL-framework, employing the DL theories of Garrison's community inquiry (36), Siemens' connectivism (38), Harasim's online-collaborative-learning (39); and Anderson's DL-model (40). The blueprinted framework was successfully used in the delivery of H&N anatomy course in the pre-clerkship phase of the competency based medical curriculum at MBRU. In order, for course dissemination we integrated the ADDIE instructional model in the framework (41). The efficiency of the framework was evaluated using first two levels of Kirkpatrick's framework (42).

Although in the literature there are numerous exemplars and instances of DL modes of course delivery specifically relating to course delivery during the pandemic (124–128); to our knowledge this is the first-study of its kind where a rationale and theory-guided approach has been availed not only to blueprint the framework, but also to implement it in the undergraduate medical curriculum.

Case in point, the study by Maggipinto et al. although provides the readers with valuable video resources that can be effectively used to deliver courses in medical genetics in the pre-clerkship phase of the curriculum, but unlike our study, falls short on informing the readers regarding how these video resources can be used to create a framework to effectively deliver a course in medical genetics through DL modality (128). Hence, it is safe to conclude that the outcome of the present study is a DL-framework that is highly versatile and robust; and although in the present study we have employed the framework to deliver a course in anatomy, the designed framework can be easily adapted for the delivery of any course in undergraduate medical

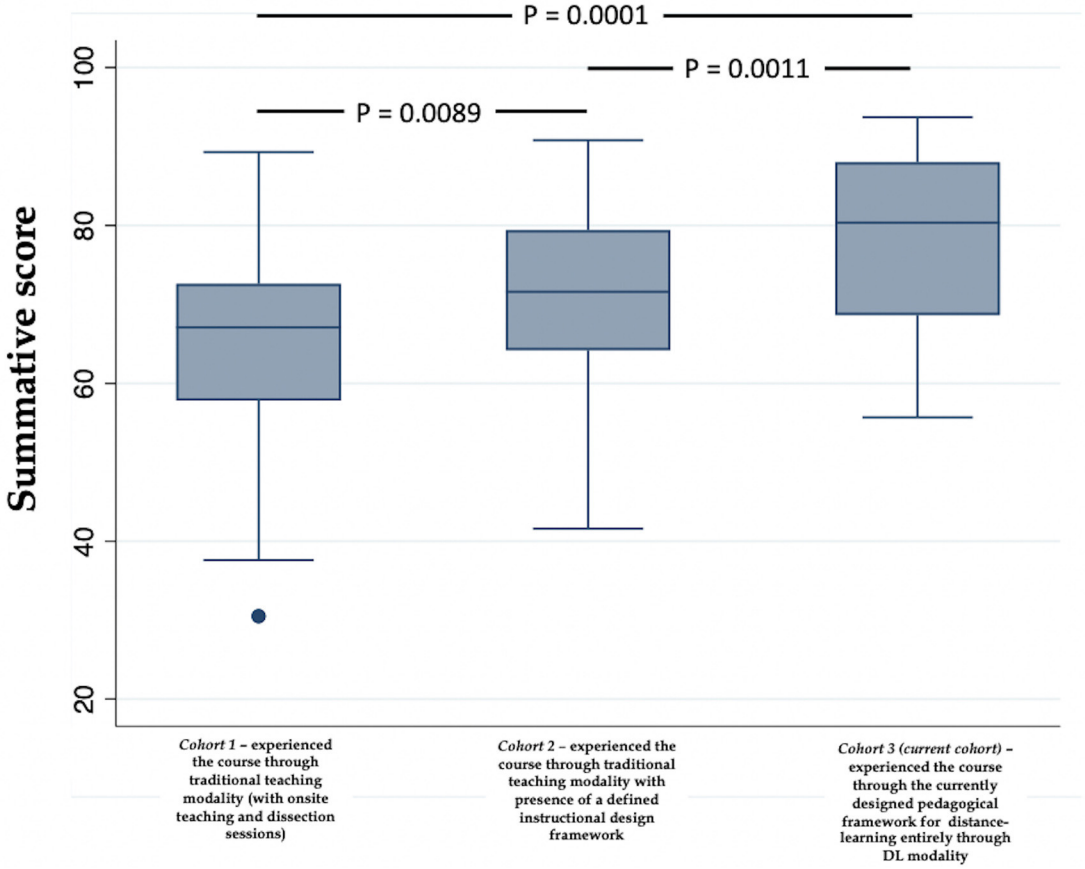

FIGURE 6 | Comparison of the summative assessment performance in the H&N course across three cohort of students using ANOVA. Note: The implementation of a defined instructional design model along with a defined pedagogical framework (cohort−3) beneficially affects students' performance.

curricula with minor tweaks. In fact, in a recent study by our research group, precepts of the framework were adopted with minor modifications in delivering a course in epidemiology and biostatistics. Readers are referred to the article by Azar et al. for details (61).

Robustness of our DL-framework is explicated by the fact that it integrates diverse student-centred educational strategies (**Figure 7**). Unfortunately, because of the mandated COVID-19 lockdown in place, we couldn't integrate aspects of "blended learning" in our DL-framework (129), which would have further augmented the framework's cogency. In line, it is warranted that practitioners of health professions education who are interested in using/adopting this framework for course delivery should also incorporate principles of "blended learning" into the framework which we believe would further augment the benefits of the framework.

The integration of student-centred educational strategies allows our DL-framework to attest to the CRISIS model of Harden (**Figure 7**) (130). The CRISIS model is widely used in medical education and has been extensively employed in designing and delivering continuing medical education activities at the University of Dundee (131). The model has also been utilized in course design and delivery, in areas other than medicine, which attests to CRISIS' versatility and ease of adoption according to the need of the situation. For example, Dunn & Hamilton applied a modified version of CRISIS to an assessment of continuing education for pharmacists (132). Additionally, the rationale of the CRISIS model has also been investigated, and is related to Brookfield's six principles of effective practice (133), in harbingering adult learning (134). The fact that our DL-framework attests to the CRISIS model further highlights its robustness and easy adaptability.

Furthermore, the ingenuity and versatility of our DL-framework is demonstrated by the fact that it endorses several of the key domains of the different learning outcomes framework (**Figure 8**). As shown in **Figure 8**, the designed framework aligns well with several of the key domains of: the Scottish Doctor framework (**Figure 8A**) (135); the CanMEDS physician competency framework (**Figure 8B**) (136); the Accreditation Council for Graduate Medical Education (ACGME) competency framework (**Figure 8C**) (137); the General Medical Council (GMC) UK competency framework

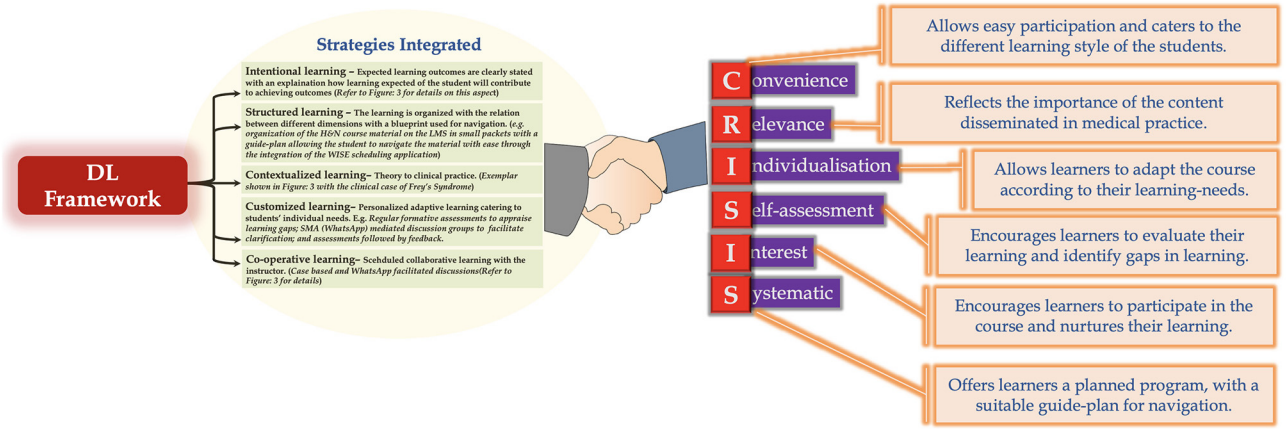

FIGURE 7 | Strategies integrated in DL framework and how they align with CRISIS framework of Harden. Note: All learner-centric strategies could be integrated in the DL framework except blended learning.

(**Figure 8D**) (138); the Global Minimum Essential Requirements (GMER) competency framework (**Figure 8E**) (139); and the Brown abilities competency framework (**Figure 8F**) (140).

Based on the above observations, the DL-framework presents an excellent pedagogical approach, which, when adopted by any medical school, will have long-term plusses and advantages. This aspect is important as a recent study indicated that temperature and latitude do not appear to be associated with the spread of COVID-19, instead school closures and other public health measures seem to have a positive effect (141, 142). Also, significant degree of vaccine hesitancy observed in medical students (143). These reflect that it is pertinent that medical schools avail DL modality to address students' learning needs, indicating the need for a robust and versatile DL-framework. This can be further elaborated using Pierre Bourdieu's Theory of Practice (144–146). Bourdieu developed three intimately related concepts: field, capital, habitus (Refer to **Figure 9** for details of the individual concepts). By applying Bourdieu's Theory of Practice, the designed framework, when executed and integrated in a competency-based medical curriculum, will allow any medical school to function effectively to deliver medical education, even during unprecedented times as presented by the current COVID-19 pandemic, to attract high achieving students (*academic capital*), as well as allow a more effective delivery of courses with access to limited infrastructure and human resources (*economic capital*). This will augment the ranking of the medical school, which has adopted the DL-framework (*symbolic capital*), as well as facilitate the school in applying and receiving more funding or emoluments (*economic capital*) in the field of medical education and health professions education research. These aspects will impact the medical school's values, primacies and curricula (*habitus*). Furthermore, all the above will be reflected in students the medical school will attract and train (*habitus*).

Although our DL pedagogical framework has overarching and specific benefits (discussed extensively in RESULTS and DISCUSSION sections), there are specific limitations that need to be addressed:

(1) In this study we have evaluated only the first two levels of Kirkpatrick's framework. However, levels – 3 and 4 of the framework, corresponding to "Did the intervention bring about a change in behavior?" and "Did the intervention influence performance?" respectively, still need to be evaluated. To pursue these evaluations, long-term studies are warranted, where the DL framework needs to be adopted across courses in both pre-clerkship and clerkship phases of curriculum, following which the effect of this intervention has to be assessed using suitable tools. For assessment of level – 3 of Kirkpatrick's framework, behavioral analysis of the ward rounds of students, exposed to the DL framework across different courses in the curriculum, is required. In this regard, the methodology of Sanson-Fisher et al. can be employed (147). Evaluation of level – 4 can be pursued using a strategy analogous to Seeley and Harding (148). Here, one group of students (the experimental group) will be exposed to the DL pedagogical approach in different courses in the curriculum. A second group of students (the control group) will attend courses delivered using traditional teaching methods. Dedicated multiple-choice question assessments and objective structured clinical examinations (OSCE) will be used to evaluate knowledge and skills. Results will indicate if the experimental group shows improved post-intervention clinical practice compared with the control group.

(2) One of the key limitations of this study is the small sample size. The small size of the sample is justified by the following factors: (A) As per the guidelines of the Commission of Academic Accreditation (CAA) in the United Arab Emirates (UAE), and given that MBRU is a newly established institution, it is limited to an intake of 70 students per year until the first cohort of students has graduated, which will be in 2022; (B) In the transition from semester 1 to semester 2 of year 1, there is notable attrition (∼20 students) in the year 1 cohort, with ∼50 first-year students successfully progressing from semester 1 to semester 2; and (C) In light of the diverse high school curricula in the UAE, many hopeful high school students may not satisfy

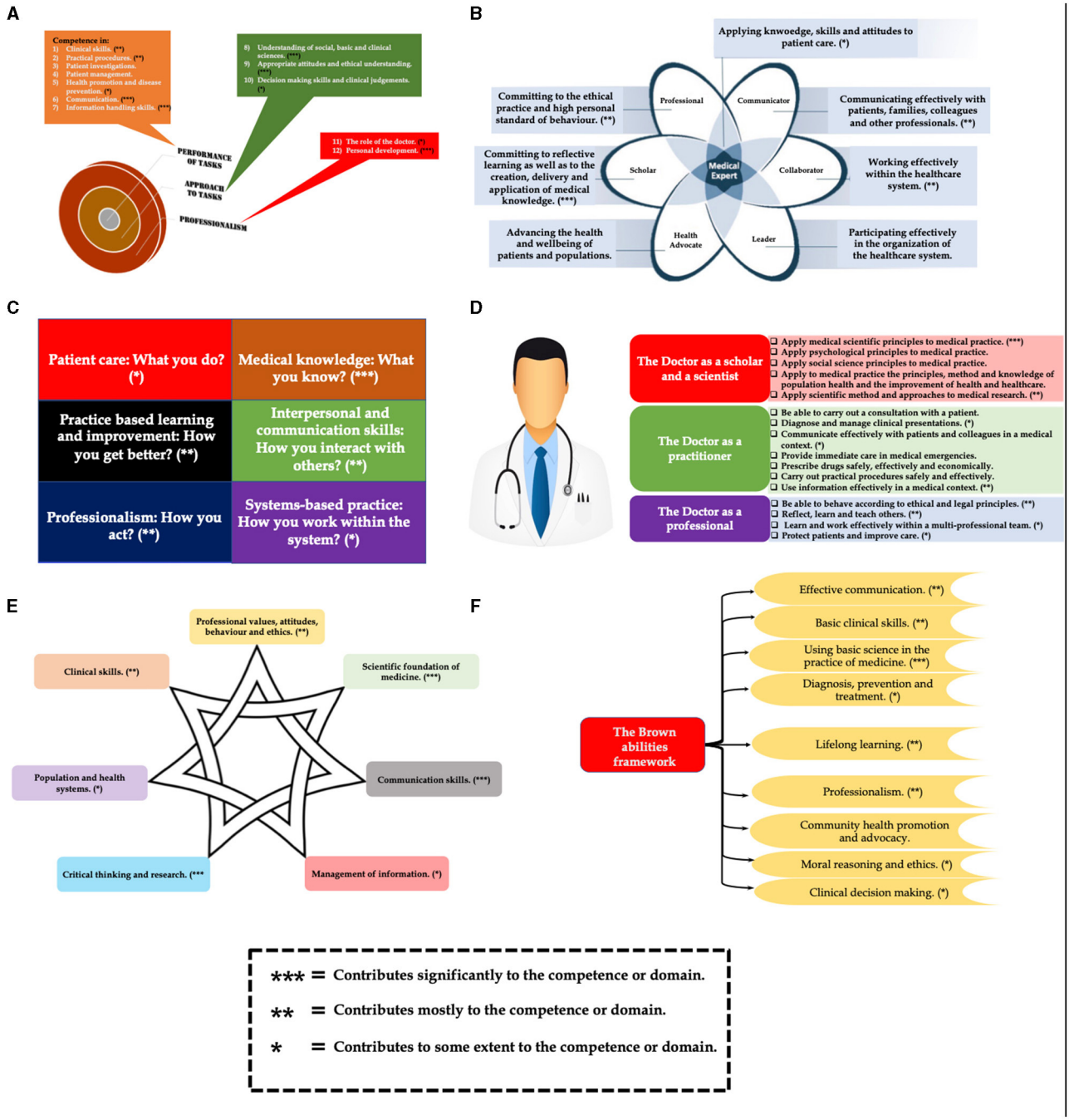

FIGURE 8 | Alignment of the designed DL framework with several of the key domains of: **(A)** the Scottish Doctor framework; **(B)** the CanMEDS physician competency framework; **(C)** the Accreditation Council for Graduate Medical Education (ACGME) competency framework; **(D)** the General Medical Council (GMC) UK competency framework; **(E)** the Global Minimum Essential Requirements (GMER) competency framework; and **(F)** the Brown abilities competency framework.

the basic entry requirements outlined by MBRU, resulting in the receipt of fewer applications.

The authors also attempted to detect a simple correlation between DL modality and academic performance using a 2-sided test of 5% significance level (alpha = 0.05) with 80% power ($\beta = 0.20$) with correlation coefficient $r = 0.20$ of N observations. The required sample size was then estimated to be 194 (**Table 3**). However, as per the mandated guidelines of the CAA, a sample size of this magnitude is not possible. Consequently, this shortcoming will be addressed using a multi-centric approach in the future, where the DL strategy is applied to disseminate content pertaining to the regional

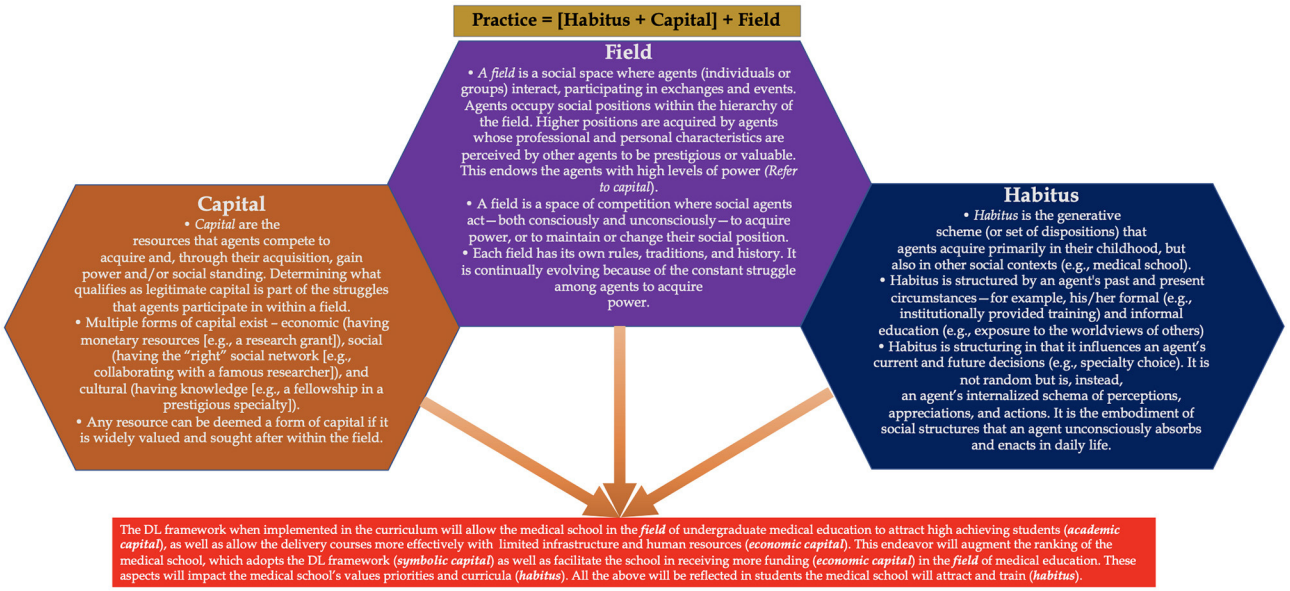

FIGURE 9 | Bourdieu's Theory of Practice. The figure elaborates on three intimately related concepts: field, capital, and habitus. The text box in RED elaborates how Bourdieu's Theory of Practice when applied to the current context demonstrates the benefit of the DL framework being adopted by a medical school.

TABLE 3 | Power calculation table [Significance level (α) = 0.05; N is indicated by the italicized numerical in the table].

	Sample correlation (r)							
Power of the study (1-β)	0.2	0.3	0.4	0.5	0.6	0.7	0.8	
	0.9	259	113	62	38	25	17	12
	0.8	194	85	47	29	19	13	10
	0.7	153	67	37	23	16	11	8
	0.6	122	54	30	19	13	10	7

Note: for association of DL modality to academic performance, with a range of power values (0.6–0.9) (shaded region), indicates that the number of participants will be suitable for statistical correlations. In line with the table, if one wishes to detect a simple correlation between DL modality to academic performance, where correlation co-efficient (r) = 0.2 of N observations, then using a two sided test, of 5% significance level (α = 0.05) with power 80% power (β = 0.2), the required sample size is ~194 (n = 194).

anatomy of the H&N across different medical schools in the UAE, thereby establishing one of the most important goals of our future investigations.

(3) Anatomy as a discipline in a typical competency based undergraduate medical curricula, necessitates that the students are exposed to dedicated hands on sessions either through the use cadaveric dissection (149), or through the dedicated utilization of virtual reality modules (150). In other words, the dissemination of anatomy courses require the judicious use of manipulative activities especially dissection sessions. Manipulatives are concrete or virtual objects generally used in the elementary mathematics curriculum to disseminate fundamental concepts, thereby promoting hands-on learning. The major use of manipulatives in college education has been in chemistry classes, where students learned to construct molecules with model kits. Their use in medical education has been so far limited. Case in point, Krontiris-Litowitz employed manipulatives to enhance learning of neurophysiology in the medical curriculum (151).

Manipulative activities augment student-engagement. Such activities also build on a concept, taking it from the simplistic to the complex, thus facilitating horizontal and vertical integration. Additionally, manipulative activities address different learning styles, addressing the needs of visual, auditory, and kinaesthetic learners (152). In our study, we integrated manipulatives through a two-pronged approach which consisted of the use of: (A) 3D visualization module (BioDigital Interactive 3D Anatomy application), and (B) alternative assessments (Formative quizzes comprising of open-ended questions). An exemplar of such a quiz where an instructor discussed a long-case based on the case report of Williams et al. (153) is shown below:

> *"A 5-year-old girl presented to her GP with a history of an erythematous rash that appeared on her left cheek associated with eating certain foods including strawberries, apples, and sweets. The rash would appear immediately on mastication and would entirely disappear within 30 min of ingestion.*

Her medical history was unremarkable apart from a road traffic accident at 3 years of age when she suffered facial and chest trauma leading to a mandibular fracture and right lower lobe collapse. The patient required intubation and ventilation for 9 days on the pediatric intensive care unit and underwent maxillofacial surgery for the mandibular fracture.

Physical examination revealed a well-grown child with no systemic abnormalities or eczema. Within a few seconds of eating candy a facial flushing appeared on her left cheek, stretching from her the temporal region to the corner of her mouth. This faded within a few minutes.

(i) Based on the above clinical presentation what is the most likely diagnosis that the GP will make?

(ii) What is the differential diagnosis for this patient?"

Such formative quizzes were discussed in detail via the social interactome model (more specially in the WhatsApp groups) (**Figure 3**). To stimulate discussion in the groups, an array of probes in line with those identified and typified by Brown and Atkins (154) were employed. The key aim of such discussions were to address the fact that when making a diagnosis of Frey's syndrome one should keep an open mind.

As our DL-framework was specifically tailored for the delivery of courses during the mandated lockdown period associated with COVID-19 pandemic, manipulative activities in the form of hands-on or dissection sessions couldn't be integrated into the framework. Although, we have tried to assuage this shortcoming through the integration of the two-pronged approach presented above, which was positively received by students; we perceive that students may feel less confident to pursue specific tasks specifically during their surgical rotation especially in the operating room. Cadaveric dissection integrated in anatomy courses aim to close the gap between the anatomic knowledge and surgical practice. Students gain knowledge and strengthen theoretical data through visualization of real anatomic structures. Additionally, by practicing on cadavers they touch and feel the anatomic relations more efficiently (155). This aspect requires further investigation.

(4) Although our DL-framework has been able to provide an enriched learning experience to students in the H&N course, will it be able to do the same across all the courses in the pre-clerkship phase of the curriculum?, specifically in those courses where there is a relative dearth of clinical scenarios/cases/vignettes. such as courses associated with research methodology and ethics. To address this issue, we are in the process of implementing precepts of the DL-framework in the delivery of courses such as Research Methods and Principle of Bioethics. Results from these studies are awaited and will form the basis of future scholarly communications.

One of the reasons we were able to successfully implement our teaching approach within a limited frame of time can be attributed to the presence of well-structured e-learning and cyber resources at our university, which we have alluded to, in the methodology. However, "Can our framework be adopted effectively by medical schools with limited access to such resources?," is a question that still needs to be addressed especially for medical schools in developing countries (156). One of the cost-effective strategies for medical schools with limited access to e-learning and cyber resources, will be to implement social media applications (SMA) such as YouTube channels and WhatsApp discussion groups (*which we have also integrated into the framework*) in the delivery of courses through DL modality. In fact, our previous study indicates that these two SMA are regularly used by medical students in their learning process (46). Additionally, instructors with limited access to e-learning resources can employ virtual classroom modules such as WizIQ (https://www.wiziq.com) (104), which provide flexibility of pricing.

Lastly, it needs to be assessed if our teaching framework will be effective in the delivery of courses involving patient exposure. One of the ways to address this aspect will be to integrate the principles of telemedicine in our framework. A fundamental strategy for healthcare surge control is "forward triage" or the sorting of patients prior to their arrival in the emergency department (84). Direct-to-consumer (or on-demand) telemedicine, a 21st-century tactic to forward triage that permits patients to be competently screened, is equally patient-centred and advantageous to self-quarantine, and it safeguards patients, clinicians, medical students and the community from exposure. It allows physicians and patients to connect 24/7 using smart devices. Respiratory symptoms, which may be initial signs of COVID-19 infection are among the complaints generally appraised with this approach. Health care providers can effortlessly obtain complete travel and exposure histories. Automated screening algorithms are usually built into the intake process, and local epidemiologic information can be used to standardize screening and practice patterns across providers. In line, if precepts of telemedicine are integrated into our framework, especially in our virtual live online sessions, students will be able to interact safely with patients, even during the COVID-19 pandemic. However, this requires further investigation.

CONCLUSION

In conclusion, in this study we have designed a student-centric and versatile DL-framework integrating precepts of ADDIE instructional model. The framework was used for the delivery of H&N anatomy structure-function course, and was not only received positively by the students, but also contributed successfully to their cognitive development. One of our future courses of action, will be to implement this framework in the delivery of other courses in the pre-clerkship phase of the curriculum. To this effect, we have designed a change-management strategy using Mento's change-management model (157). The strategy aims to facilitate a change in pedagogy such that instructors integrate the precepts of the DL-framework in their course delivery. In fact, the change-management strategy has been successful as precepts of the framework were integrated by instructors in the delivery of fundamentals epidemiology and

biostatistics course during the mandated COVID-19 lockdown period (61).

Additionally, one our future aims will be to fine-tune and revise the DL-framework by integrating aspects of resilience and stress-coping. With regards to the latter currently a study is in progress to determine the relationship between resilience, learning approaches, and stress-coping strategies and how they can collectively predict achievement in undergraduate medical students (158). Specifically, the indicated study addresses: What is the correlation between the psychoeducational variables; resilience, learning approaches, and stress-coping strategies? Can academic performance of undergraduate medical students be predicted through the construction of linear relationships between defined variables employing the principles of empirical modeling? (158). Fine-tuning of the DL-framework, using data obtained from this study will further enhance the adaptability of DL-framework better addressing students' learning trajectories during unprecedented times such as that created by the current COVID-19 pandemic.

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 Written consent was obtained from all individual respondents included in this study as the pursued survey was an essential part of the feedback process pertaining to the H&N course. The study was considered as a quality control project. Therefore, according to the policy and guidelines, of The Mohammed Bin Rashid University of Medicine and Health Sciences-Institutional Review board (MBRU-IRB), this project doesn't necessitate appraisal by MBRU-IRB or an exempt status. Further clarification can be obtained from the MBRU-IRB at irb@mbru.ac.ae. The study protocol is in line with the MBRU-IRB guidelines. The study spanned between January and September of 2020 during the mandated lockdown period because of the COVID−19 pandemic. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

NN was involved in the delivery of the H&N course in the semester−1 of Phase–I (in the pre-clerkship phase of the MBRU curriculum) referred to in this study and drafted significant sections of the manuscript. AA and AK were responsible for the statical analysis. MG and ML were responsible for data collection and curation. AA-A assisted in data analysis pertaining to the section pertaining to Kirkpatrick's Level−2 and YB as the director of Phase−1, designed the study in order to implement change in teaching in Phase–I of the curricula at MBRU during the COVID-19 mandated lockdown, drafted the final version of the manuscript along with NN, and oversaw the general organization and logistics of the study. All authors have read and approved the manuscript.

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Promoting Mental Health During the COVID-19 Pandemic: A Hybrid, Innovative Approach in Malaysia

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Background: The COVID-19 pandemic has had monumental effects on the mental health of populations worldwide. Previous research indicated that programs and interventions using social networks can play a positive role in promoting mental health. Nevertheless, current evidence is largely derived from high-income regions, reflecting an urgent need for more studies in low- and middle-income settings.

Objectives: This paper aims to (a) describe the potential value of a hybrid health carnival in promoting mental health and increasing access to screening services; (b) assess the level of community engagement with the digital platform.

Methods: A mental health carnival was conducted with the theme of "Mind Your Mental Health" *(Cakna Kesihatan Mental)* in conjunction with the World Mental Health Day in Malaysia. This was a hybrid carnival that combined elements of face-to-face interactions and virtual learning. Free online therapy sessions were offered to high-risk groups identified during the screening process. Social media metrics were utilized to report the levels of community engagement and participants completed pre-and post-assessments to measure the program's impact on their knowledge.

Results: The carnival was attended by 515 participants (78.8% virtual participants). Social media metrics reported more than 5,585 reaches on Facebook for all the activities held throughout the event. Results from pre-and post-assessments showed significant improvement in the mean knowledge scores ($p < 0.05$).

Conclusion: This digital approach will continue to evolve by releasing new features and tools as a new frontier for high-risk populations and all individuals seeking mental health support and treatment.

Keywords: health education, mental health, community health promotion, COVID-19, pandemic

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INTRODUCTION

Mental health is an integral and fundamental component of health, which can be defined as "a state of well-being in which every individual realizes his or her potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community" (1). The increasing magnitude and burden of mental health problems today are becoming a global public health concern. At the global level, depression affects more than 264 million people and is currently

the leading cause of disability (2). From the total number of people living with this condition, nearly half reside in the Southeast Asian and Western Pacific regions (3). On the other hand, suicide accounts for 1.5% of all deaths worldwide, with more than 50% occurring in low- and middle-income countries (3).

Mental health promotion often refers to positive mental health, which is the desired outcome of mental health promotion interventions (4, 5). The fundamental aspects of mental health promotion include empowerment, competence, resilience, and supportive environments (6). Empowerment is a fundamental component of health promotion, and its main concept is to educate and enable individuals so they can have the knowledge (health literacy) and self-efficacy in maintaining good mental health and ensuring appropriate help-seeking behavior (7). Our program also provided learning opportunities to enhance personal competencies such as improving their coping strategies and develop emotional resilience which revolves around having a positive attitude toward mental health and mental health promotion as well as toward individuals (8). Supportive environments such as facilitating early access to professional psychological help and mental health services are actions that will also improve psychological well-being (9, 10).

Previous literature from social, biological, and neurological sciences highlighted the role of protective factors in the developmental pathways associated with poor mental health (4). Identifying and enhancing protective factors such as knowledge, literacy, beliefs and self-esteem, problem-solving and social skills are potential targets for mental health promotion with the explicit goal of promoting positive mental health and developing competence to promote well-being rather than preventing symptoms or the onset of disorders (11). The lack of protective factors may predispose a person to move from a mentally healthy condition to greater susceptibility to mental illnesses. According to a systematic review, mental health interventions also yielded significant and positive short-term and long-term effects on formal help-seeking behavior as well as mental health literacy and stigma especially if delivered to people with or at risk of mental health problems (12).

Mental health literacy refers to the ability to obtain and maintain positive mental health, understand mental health problems and their treatments, avoid stigma related to mental health problems, and enhance help-seeking efficacy (13). The low literacy and awareness could be attributed to many factors, among which are the stigma attached to mental disorders and the often perceived "intangible" nature of mental health. Empirical evidence emphasizes the importance of mental health awareness and literacy and shows that properly designed interventions can have tremendous and positive impacts. For example, an educational program to boost mental health awareness among university students in the Texas city of the United States demonstrated an increase in knowledge of, and reduction in stigma against, schizophrenia (14). Similarly, The Compass Strategy—a mental health literacy awareness campaign in Australia—was found to facilitate self-identified depression and awareness of suicide risk, improve the estimation of the prevalence of mental health problems, and reduce perceived barriers to help-seeking (15). Higher mental health awareness and literacy can empower people to act upon their knowledge and enable them to take charge of their well-being (16).

Given the rapid digital revolution in recent years, online mental health interventions have been increasingly used and recognized as effective in treating, preventing, and educating people with regards to mental health problems (17). A meta-analysis by Andrews et al. suggested that online interventions are comparable to traditional, face-to-face delivery of mental health treatments in terms of effectiveness (18). In addition, virtual mental health programs are said to offer various advantages including greater convenience (accessibility and flexibility), capacity to reach wider populations especially individuals who are socially isolated or are not able to be physically present, and provision of a cheaper and non-threatening avenue for psychological help (17, 19). Interestingly, the social networking sites (SNS) which are often associated with negative effects on mental health such as depression, loneliness, and self-esteem, are said to have opposite effects when used in a "healthy and mindful" manner, and with the right techniques (5, 20). For instance, Peek et al. corroborated the role of social media and blogging in mental health education and advocacy (21), while Kayrouz et al. highlighted the use of Facebook to engage with hard-to-reach populations for mental health programs and research (22).

Beyond mortality and morbidity, the impact of the COVID-19 pandemic across the globe has been unprecedented. The risks of transmissions and the counter-measures adopted have not only led to movement restrictions that resulted in economic shutdowns but caused a sharp rise in psychological distress, anxiety disorders, post-traumatic stress disorders, and other forms of negative feelings—such as excessive fear of death and paranoia—that could easily predispose individuals to mental illnesses (23–27). Due to the social distancing measures, forced closures of educational institutions, and reallocation of health resources to fight the pandemic, the demand for mental health literacy and services is unlikely to be met using conventional modes. In this context, digital or virtual platforms are the most practical alternative to compensate for the drawbacks of traditional mental health education and service delivery.

Despite the various proven benefits of online- and SNS-based mental health interventions, evidence on their use, level of engagement, and effectiveness in the context of low- and middle-income countries (LMIC) have been scarce. A systematic review on SNS-based mental health interventions for young people included nine studies in their final analysis, all of which were conducted in high-income countries (Australia, Hong Kong, and USA) (28). Similarly, another systematic review on online mental health interventions for depression among youths found 15 eligible studies, all of which were from high-income settings (29). This "geographical gap" was corroborated by Arjadi et al. in a 2015 review on online mental health interventions in LMICs, where the authors found only three studies; two from China and one from Romania (30). While we have witnessed a gradual burgeoning interest among LMIC academics and researchers in this field—especially with the advent of COVID-19—the body of evidence in this region remains low. Our study thus attempts to fill in this gap, and contribute to the existing knowledge

on online-based mental health programs and interventions by providing a Malaysian perspective.

In this paper, we described a mental health program called the "Mind your Mental Health Carnival," which was a hybrid form of mental health awareness campaign that combined face-to-face and online platforms, targeting mainly youths and university students: (a) describe the potential value of the hybrid health carnival approach in promoting positive mental health and increasing access to screening services; (b) assess the level of community engagement with the digital platform, and (c) evaluate the impact of the hybrid carnival on mental health literacy.

METHODS/CONTEXT

This study was a descriptive research which used quantitative methods to outline the potential benefits of the hybrid health carnival, to promote mental health in the midst of COVID-19 pandemic.

"Mind Your Mental Health *(Cakna Kesihatan Mental)*" Hybrid Carnival

In conjunction with the World Mental Health Day, the "Mind Your Mental Health" Carnival was held from 9 to 11 October 2020. The project began with the development of educational materials as a strategy for mental health promotion and education. Posters were designed based on the Health Belief Model (HBM), a well-established theoretical approach that has been employed in various studies to explore the perception and belief of mental illness and mental health service utilization (31, 32). Examples of mental health issues and their corresponding HBM constructs, as well as health education messages to address these issues, are presented in **Table 1**. These messages were formulated by mental health experts and included the following principal constructs of HBM: (i) perceived susceptibility (what is mental health and who are at-risk); (ii) perceived severity (the seriousness of poor mental health effects); (iii) perceived benefits (of having good mental health), (iv) perceived barriers (to obtain good mental health and challenges in seeking social support), (v) perceived threat (of not having good mental health), and (vi) cues to action.

For perceived susceptibility, the public was informed regarding the risk factors of developing mental illness through various health education materials and provided screening by using the DASS-21 questionnaire (33). As for perceived severity, people are likely to engage in a given health-related behavior if they believe that the problem has serious consequences or will interfere with their daily functioning. Therefore, the varying levels of severity and symptoms of mental illness were elaborated to enable the audience to fully grasp the severity of certain mental health conditions. As for perceived benefits, we delivered insight on the benefits of good mental health. To overcome the barriers in accessibility, the availability of mental health services within the faculty and other related NGOs such as Befrienders was highlighted. Individuals with higher health consciousness have greater motivation to adopt health-seeking behaviors such as obtaining health-related information from the internet as the significant local information source. However, social media platforms provide access to unprecedented amounts of information and the use of social media as the main source has caused significant concerns given the reliability of this information. Therefore, the use of the HBM in creating educational health materials and incorporating scientific evidence from multiple perspectives is an effective tailored communication strategy in tackling current info-demics and unconventional health claims (34).

The carnival aimed to (i) create an accessible digital platform that provides learning materials for mental health awareness, and (ii) to provide appropriate screening tools for early identification of mental health issues and psychological support for high-risk groups.

TABLE 1 | Examples of mental health messages based on the HBM constructs.

Constructs	Mental health issue related to constructs	Message examples for health educational materials to address construct issues
Perceived susceptibility	Belief that one most likely will not be at risk of the health problem	End the stigma! Mental illness knows no boundaries and affects all walks of life adolescents, youth and adults.
Perceived severity	Belief that mental health is not a serious health problem	Mental Health is a "silent killer"! Mental health affects physical health and academic performance!
Perceived benefits	Belief that preventative action will be effective in reducing symptoms and improve mental health	With good mental health you can work productively and contribute to the society!
Perceived barriers	In denial that there is a problem and reluctant to talk to a counselor	It's OK to ask for help! Speak up for your needs and find support!

Advertisement of the Carnival

The target population for this event is adolescents, youths, and young adults who comprise the majority of SNS users in Malaysia. We chose this population because the onset of mental disorders peaks between adolescence and young adulthood (28). The 4th-year undergraduate medical students undergoing their public health medicine rotational posting were involved in preparing and hosting the health carnival as part of their curriculum. One month prior to the event, the students advertised the program by posting creative visual content on social media platforms and started customizing a countdown campaign to build momentum toward the event. Updated daily news and headlines were delivered automatically through the university's email system for faculty staff, undergraduate and graduate students. Given the role of social media as powerful marketing tools, the organizers used all successful media brands—Facebook, Instagram and Twitter—to promote the event. Diverse social

media platforms would increase the opportunities to engage with more diverse groups of people in terms of age groups and preferences. Photography and short video competitions with the theme of "Mind Your Mental Health" *(Cakna Kesihatan Mental)* were opened to all Malaysian citizens. A poster describing a step-by-step neck and shoulder massage therapy was designed and posted on social media. This was followed by a video contest entitled "massage challenge" to encourage more users to learn the neck and shoulder massage techniques, to reduce muscular tensions, improve mood and relax the body.

To ensure that the event was a crowd-puller, the organizing team uploaded a total of 34 daily contents within the social media to increase public's awareness and educate the online community about mental illnesses such as anxiety disorders, hallucinations, depressions, panic disorders, obsessive-compulsive disorders and many more. Unique hashtags were adopted to gain likability and popularity on the trending list (i.e., #mindyourmentalhealth, #caknakesihatanmental, #mentalhealthawareness, #stopthestigma, and #loveyourself etc.).

Activities of the "Mind Your Mental Health" Hybrid Carnival

Upon arrival at the carnival site, participants were required to comply with Standard Operating Procedures (SOPs) related to COVID-19, including registering themselves through the *My Sejahtera* application developed by the Government of Malaysia, checking their body temperature, and maintaining physical distancing of one-meter. The program of the events included the following:

(i) The hybrid carnival began with an opening ceremony, which took place within the faculty and was broadcasted live through Facebook and Instagram.
(ii) Subsequently, a "Chairobic" session was conducted which featured a simple set of gentle exercises performed while seated on a chair for 20 min. This activity was aimed to educate the public on regular exercises at home and/or at work, as a way which was essential to inculcate a healthy lifestyle through exercise as one of the measures to reduce stress and relax the mind. The steps were simple and included fist-clenching, arm-stretching, seated side bend stretching, and leg raising.
(iii) The program continued with a motivational forum entitled "Busting the Myth" featuring a mental health professional and a Muslim scholar, *Ustaz*, to expose the audience to a more holistic perspective of mental health. The question-and-answer sessions were opened to both on-site and virtual attendants.
(iv) "Posteria" corner exhibited educational materials, which were developed based on the HBM. These posters were displayed in the faculty and posted digitally on social media. Facebook live streaming video sessions were held to further elaborate on mental health education.
(v) Online mental health trivia quizzes were created using Instagram Story to raise public awareness on mental health issues and to fully grasp the topic of mental health.
(vi) Two short videos were uploaded to social media. The first video demonstrated a step-by-step guide on deep and rhythmic breathing techniques to reduce symptoms of anxiety disorders such as general anxiety, social anxiety, and panic attacks. The second video was a learning tool that demonstrated simple neck and shoulder massage therapy as a form of stress relief.
(vii) Counseling and mental health services were made available to assist those in need of mental health support. Participants were encouraged to have their mental health screened and/or meet up with the professional counselors for assistance. The screening was done among 88 respondents using the DASS-21 questionnaire to assess symptoms of depression, anxiety, and stress.
(viii) The closing ceremony was broadcasted to the virtual audience with an estimated 1,400 views on multiple social media platforms. A closing speech was delivered by the university's Deputy Dean of Academic and Student Affairs, highlighting the importance of raising awareness on mental health issues, fighting stigma related to mental illnesses, and seeking help early.

Research Tools

Participants were encouraged to have their mental health screened and/or meet up with the professional counselors for assistance. Mental health screening was performed using the Depression, Anxiety, and Stress Scale (DASS-21) (33). The depression scale in DASS-21 assesses a range of depressive syndromes including dysphoria, hopelessness, and lack of interest/involvement. A higher score indicates a higher level of depression. The anxiety scale assesses the subjective experience of the anxiety effect, autonomic arousal, skeletal muscle effects, and situational anxiety. The stress scale assesses difficulty relaxing, being irritable/- overreactive and impatient, and being easily upset/agitated. The Malay version of DASS-21 was used, as its reliability (Cronbach's alpha = 0.95) and construct validity have been well-established (33).

Apart from that, the pre-and-post self-assessment forms were distributed during the event to detect any change in mental health awareness among the participants. Mental health knowledge was measured using the Mental Health Knowledge Questionnaire (MHKQ) (35).

Analysis

This social media-based intervention which was promoted using multiple SNSs such as Facebook, Instagram, and Twitter included evaluation metrics that were commonly reported for digital campaigns. Relevant key performance indicators (KPIs) such as measures of campaign awareness and proximal impact measures of engagement (i.e., responses) were adopted to reflect and measure the effectiveness and performance of the campaigns. Social media metrics measuring campaign awareness were used to quantify the total number of reaches that represent the number of people that have viewed the campaign by social media. Proximal impact measures of engagement represent engagement on social media and are comprised of the total number of likes, shares, followers, or comments on social platforms (36).

Therefore, there were two main measures of social media KPIs that were evaluated in this hybrid health carnival program:

a) Awareness social media metrics (e.g., reach: number of viewers that a unique post has reached)
b) Engagement social media metrics (e.g., likes, shares, followers, and comments)

Data obtained from the DASS-21 Questionnaire was exported to SPSS version 23 for analysis. Respondents with a depression score of 10 and more were considered to have depression, those with an anxiety score of eight and more were considered to have anxiety, and those with a stress score of 15 and more were classified as having stress (33). Pre-and-post assessment scores were recorded and summarized by calculating the means and standard deviation (SD). Paired *t*-tests were used to compare the means of the two samples. Statistical significance was set a priori at $p < 0.05$.

Ethical Considerations

Participants attending the carnival were informed about the voluntary nature of having their mental health screened and their information would be kept confidential. The form did not contain personal identifiers, and participants were given a choice of whether they would like to be referred to a professional counselor if they were found to be at-risk. Aggregate data analysis was performed to protect respondents' anonymity and confidentiality. This project was granted ethical approval from the ethical review board of the institute where the carnival was held.

RESULTS

The hybrid carnival had a total of 515 participants, whereby 78.8% participated virtually. The event recruited 1,104 followers through Instagram, 370 likes through Facebook, and 88 followers on Twitter. All the available online campaigns used different modes of health promotion and educational interventions. According to the objectives of the campaigns, different content-based communication strategies were adopted.

Most participants obtained information regarding the event through online communication in social media (43.2%), followed by WhatsApp (29.79%), and peers (25.2%). To summarize the social media metrics for all the daily contents during the preparation, Instagram metrics tracked a total of 1,150 likes and 15 comments, Facebook metrics tracked a total of 5,236 reaches, 401 likes, and 116 shares, while Twitter metrics tracked 160 retweet and 158 likes. As per social media metrics traced for a single post, it was revealed that the number of reaches in Facebook ranged from 38 to 704 in a single post and up to 457 views on Instagram. The virtual countdown posts had a high number of reaches and engagement with a total of 901 on Instagram and Facebook.

The two health educational videos received good response rates. The first video demonstrating breathing techniques successfully achieved 457 views, 101 likes, and 29 comments on Instagram; 489 reaches, 188 views, and 15 likes on Facebook; 137 views, 12 likes, and 12 retweets on Twitter. Meanwhile, the second educational video on massage therapy had 188 plays on Facebook; and 261 views, 66 likes, and three comments on Instagram.

TABLE 2 | Social media metrics of each activity conducted in hybrid health carnival.

Activities	Facebook	Instagram
Live session presenting the poster	342 people reached 155 plays	215 views 36 likes
"Chairobic" session	918 people reached 345 views 36 likes 31 comments 21 shares	564 views 50 likes 15 comments
Forum "Busting the myths"	3,488 people reached 1,219 views 88 likes 70 comments 30 shares	902 views 88 likes 20 comments
Closing ceremony	837 people reached 368 plays	5,000 likes 1,000 views 95 comments

Participants were asked to complete a baseline self-assessment of their mental health knowledge before and after the 2-day event. Overall, results revealed a significant improvement and performance in the mean knowledge scores ($p = 0.001$), whereby the mean paired difference was 2.56 (1.90, 3.23). The mean (SD) knowledge scores post-carnival, reported at 18.27 (1.761), was significantly higher than the mean (SD) knowledge scores pre-carnival that stood at 15.70 (3.407).

Table 2 shows the social media metrics KPIs for each of the activities held during the hybrid health carnival. Results indicate a high combination of reach and engagement metrics for both social media platforms with high follower growth in the health carnival's Instagram page (1,104 followers). Overall, Facebook had the highest engagement reach of all the activities held during the carnival.

From the mental health screening based on DASS-21, the prevalence of depression was 25%, anxiety was 33%, and stress was 37%. These figures are illustrated in **Figure 1**. Those who had severe or extremely severe levels of depression, anxiety, and/or stress (a total of 16%) were categorized as high-risk groups and referred to a licensed professional counselor for a counseling session.

DISCUSSION

The overarching aim of this study was to describe the potential value of a hybrid health carnival approach in promoting positive mental health and increasing access to mental health screening services for the community. Based on the sizable number of participants, social media metrics, screening uptake, and pre- and post-assessment of mental health knowledge, a hybrid health carnival approach to mental health promotion is demonstrably and evidently an effective modality to engage communities and increase mental health literacy.

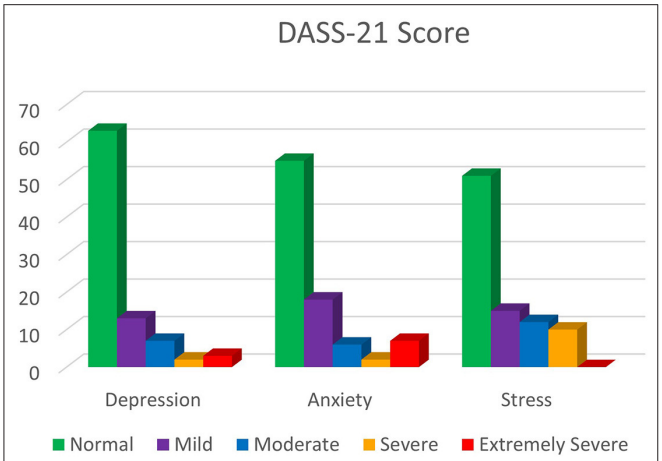

FIGURE 1 | Bar Graph of DASS-21 scores according to severity among participants attending mental health screening.

The hybrid health carnival, which was grounded by the principles of mental health promotion (6), used a blended approach to health promotion and education delivery, by utilizing physical-based and web-based platforms to deliver mental health content. Traditional face-to-face interventions continue to be successful in health promotion initiatives (37), and thus all components of the hybrid health carnival were delivered to participants attending the carnival on-site. Concurrently, social media was adopted as a tool to deliver mental health promotion materials *via* web-based platforms. The use of social media as a tool to deliver health interventions is fitting in this day and age where the nature of interpersonal interactions has evolved in line with advancing digital technology. Social media platforms are progressively developing as a rich source of mass communication as they offer easy, cost-effective access to a large number of people across geographic distances in a short time frame (38). Furthermore, interventions using social media platforms address some of the limitations observed by traditional health communication strategies by increasing the potential for interaction, customization, and participation (39).

Indeed, widespread public engagement with social media creates a ready platform for its application in the health field (40) and health promotion professionals have begun to recognize the potential of social media for enabling and empowering consumers in health and healthcare-related interactions (41). Previous studies have shown that the use of mobile technology and social media in delivering health promotion interventions produces successful outcomes. Various mobile phone interventions to address various health concerns such as reducing obesity, increasing physical activity, and reducing HIV risk behaviors have demonstrated measurable beneficial impacts on participants (42, 43). Similarly, interventions using social networking sites were reported to be effective in promoting changes in health-related behaviors (44).

In the hybrid health carnival, various communication strategies including social media were employed to create awareness and gain the interest of the target audience. Social media metrics were used to gauge participants' interest and acceptance of the hybrid health carnival, as they provide valuable information about reach and usability (40). As shown in this study, by utilizing popular social media platforms including Facebook, Instagram, and Twitter to publicize the hybrid health carnival, the reach for the hybrid health carnival was enhanced. This was evident from our findings, where the majority of virtual carnival participants (43.2%) had become aware of the hybrid health carnival *via* social media platforms. Indeed, according to event statistics, 76% of event organizers use Twitter to promote their events, and 88% of companies use social media to create awareness before an event, the most popular being Facebook, Twitter, and Instagram (45). Besides social media, several other modalities were utilized to promote the hybrid health carnival, including flyers, daily news *via* university email, WhatsApp, and word-of-mouth communication. This multimodal approach is the most effective method to reach audiences about health issues (46).

In addition, as part of the promotion strategy, the organizers of the hybrid health carnival provided daily news on the event *via* university email and social media platforms as well as conducting a countdown campaign, which helped generate momentum toward the event and kept it in the spotlight for longer. This is in line with the marketing tactics advocated by marketing strategists to help build excitement, sustain interest, and get some last-minute sign-ups from the target audience (45). Similarly, unique hashtags were also used to gain likability and popularity. As a result, the organizers were able to pull quite a number of crowds to attend the virtual session and the live event physically, despite the short period of time allocated to conduct the hybrid health carnival.

In terms of community engagement, live broadcasting *via* Facebook and Instagram was able to generate a respectable level of engagement among participants. These platforms allow not only a wider reach, but also improve participants' engagement as followers are able to ask questions and have them answered in real-time (45). As in previous studies, interactive communication is more effective than linear, i.e., one-way, communication (39), and multidimensional interventions and participant interactivity are pivotal toward successfully reaching diverse audiences (47). Moreover, the interactive and participative nature of content delivery such as the short video contest and photography competition which combined interpersonal and mass media communication has been argued to be more impactful on health behavior (48). On the whole, the social media metrics for each of the activities conducted and the numbers of participants being screened and referred for counseling suggest that a fair level of engagement from the attendees was achieved throughout the carnival.

One of the outcomes assessed during the hybrid carnival was mental health literacy, in keeping with the notion of promoting positive mental health by empowering communities (6). Improved mental health literacy was observed among study participants as evidenced by the significant increase in mental health knowledge among participants who attended the hybrid

health carnival ($p = 0.001$). This is highly encouraging given that mental health literacy is fundamental toward empowering whole communities to take action for better mental health (16). Moreover, mental health literacy curbs the current phenomenon of infodemic and misinformation pertaining to mental health that may be associated with it as more and more people become reliant on social media as a means to keep up to date with current information (49).

Other carnival components aimed at improving communities' competence and resiliency included the health educational videos demonstrating breathing techniques and massage therapy. The ultimate aim of these videos was to improve one's coping skills and ability to cope with mental distress, thereby increasing the options available to individuals to exercise more control over their health and their environment to make choices conducive to health (50). Though the efficacy of these videos on enhancing personal skills was not assessed, the social media metrics suggested that participants received them favorably and may be more inclined to practice the stress-reducing techniques in daily life. Finally, the hybrid health carnival also aimed to enable supportive environments, in keeping with the principles of mental health promotion. Though this was again not assessed directly, the screening uptake and subsequent referrals to counselors for those at-risk suggests that participants were comfortable enough to undergo screening despite the stigmatization of mental health disorders. The creation of supportive environments is imperative to the success of any mental health promotion interventions, as mental health is mediated by the interaction between the individual, the environment, and wider social forces, underscoring the need for mediating structures such as home, schools, workplaces and community settings to be accommodative (50).

In relation to evidence pertaining to the value of hybrid health carnivals within the local context, at present, there is scarce evidence to support this modality in delivering mental health promotion interventions within the Malaysian setting. However, studies published elsewhere have indicated encouraging results from health promotion campaigns using social media platforms for mental health advocacy. In India, a mental health promotion campaign on suicide prevention, tobacco cessation, and migraine reported satisfactory reach and level of engagement from social media users (38). Similarly, a social media intervention conducted in Canada to raise awareness and improve attitudes toward mental health issues among youths and young adults demonstrated increased mental health literacy outcomes (51). With regards to treatment, a systematic review explored the effectiveness of blended interventions for the treatment of mental health disorders and reported that blended therapy may save clinician time, lead to lower dropout rates, and help maintain initially achieved changes within psychotherapy in the long-term effects of inpatient therapy (52).

To give further credence to the potential of hybrid health carnivals in delivering mental health promotion initiatives, comparisons between online interventions and conventional interventions have shown that online interventions are generally at least as effective as traditional face-to-face interventions (37). Thus, a blended intervention combining face-to-face and internet-based approaches for addressing health issues is appropriate, especially in the COVID-19 pandemic era where social distancing is the norm. As both face-to-face and online interventions have their respective advantages and disadvantages and functions, this form of intervention may be the best method of facilitating health promotion initiatives, as suggested by previous studies (37). In the post-COVID-19 era, this is especially pertinent given the psychological distress associated with the COVID-19 pandemic as well as the need to accommodate COVID-19 control measures.

There are some limitations to this study. Recruitment of study participants was conducted *via* university emails and advertisements on social media platforms, which may have limited participant demographics. This is because some segments of the community especially youths from low socioeconomic or marginalized backgrounds may have been excluded, thus our study participants are not representative of the overall population. Another limitation stems from the use of social media metrics to gauge the response to the hybrid health carnival. These indices may not have reflected the true impact of the carnival, as the application of metrics to track and evaluate social media is still in its infancy, and there is currently limited understanding on how to measure social media impacts most effectively (40). Furthermore, the study was not able to determine whether the meaningful engagement was achieved from the use of social media, as the metrics do not indicate whether participants were "just stopping by" or actually engaging with the content as intended (40). In addition, the approach to measure this carnival's impact lacked a qualitative perspective (e.g., verbal, or written feedback from students or audience), which could have been more relevant to assess "meaningful engagement." With regards to the change in scores said to indicate the impact of the program on mental health literacy, post-event measurement was conducted once. Whether or not such an immediate impact (increase in mental health literacy) is sustainable and prolonged cannot be determined.

CONCLUSIONS

The hybrid mental health carnival using social media is a new approach for delivering engaging health messages and promoting mental health in Malaysia. Despite the multiple limitations of virtual communications and online platforms, the current digital transformations occurring at the global level—accelerated by the COVID-19 pandemic—provide numerous "windows of opportunities" for innovation and creativity to flourish with regards to health intervention deliveries. The role of digital platforms in the health field is increasingly recognized, therefore health care providers and policymakers have no choice but to keep up with these changes and make the most out of them. For future research, it is recommended that a more robust method is designed to measure the impact or effectiveness of similar virtual health campaigns.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because dataset request is subjected to approval by the Research Ethics Committee. Requests to access the datasets should be directed to pjimedic@uitm.edu.my.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Universiti Teknologi MARA (UiTM) Research Ethics Committee [REC/05/2020(MR/101)]. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization and writing of this 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.2021.747953/full#supplementary-material

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Investigation of the Cognitive Attitudes and Behaviors of Medical Post-graduates in Clinical Practice During the COVID-19 Pandemic in China

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The cognitive attitudes and behaviors of medical post-graduates may be influenced by the coronavirus disease 2019 (COVID-19) pandemic. A cross-sectional study was used from a questionnaire survey in hospitals affiliated with the Zhejiang University School of Medicine. Questionnaire was distributed online including demographic information, cognitive attitudes, and personal protective behaviors. Moreover, personal protective behaviors such as wearing protective equipment were compared between different academic major and gender, respectively. A total of 176 valid questionnaires were obtained. Of the medical post-graduates in this study, (1) 89.67% believed that the COVID-19 pandemic had an impact on their clinical internships, and 40.34% expressed concerns about their infection on inadequate personal protection; (2) 91.48% took personal protection in hospital and 86.36% enhanced personal hygiene; (3) There were no statistically differences in the personal protection by academic major and gender ($p > 0.05$). This study suggests that the COVID-19 pandemic had an impact on the medical post-graduates' clinical practice, and affected their cognitive attitudes and behaviors. As such, universities and hospitals should increase pandemic prevention training and investment, provide more psychological counseling to their medical post-graduates to reduce their psychological burden, and take measures to reduce the influence of the COVID-19 pandemic on their medical post-graduates' clinical practice.

Keywords: COVID-19 pandemic, medical post-graduates, clinical practice, attitudes and behaviors, investigation

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INTRODUCTION

Since the World Health Organization announced in January 2020 that the coronavirus disease 2019 (COVID-19) pandemic is a public health emergency of international concern (1), the Chinese medical staff have demonstrated outstanding skill and dedication in striving to save lives across the country. COVID-19 has caused unprecedented damage to the medical education system worldwide (2). It is difficult to continue teaching as usual, thus affecting the lecture and patient-based clinical practice (3). The COVID-19 pandemic puts people at risk, which poses a major challenge to medical education, because teachers must teach safely while at the same time ensuring the integrity and continuity of the medical education system. Due to the focus on patients with COVID-19, these challenges have resulted in limited patient care, which limits the opportunities for medical students

to teach at the bedside (4). Clinical practice through rotation has been suspended for a long time (5). Other challenges include concerns that medical students may contract the virus during their clinical practice and need to wear personal protection (6). Passing on their skill and dedication to the future medical practitioners is the most important task of medical education. In consequence, COVID-19 may cause great impact on the medical students' attitude and behaviors during the clinical practice (7, 8).

As of this writing, as the COVID-19 pandemic is under control in China, clinical medical post-graduates have returned to the hospital to carry out their internships. However, due to the normalization of the pandemic prevention, the medical post-graduates who are preparing for medical practice are not only striving to learn what they should but are also enduring the long-term challenges posed by the COVID-19 pandemic. There is a growing literature on how medical educators and students adapted to the COVID-19 pandemic (9–13). However, the studies from China are limited. In this study, the cognitive attitudes and behaviors of medical post-graduates conducting internship during the COVID-19 pandemic in China were investigated through a questionnaire survey. Our research questions are:

1. What are the clinical medical post-graduates' cognitive attitudes toward the COVID-19 pandemic?
2. What are the personal protective measures taken by the clinical medical post-graduates in response to the COVID-19 pandemic?
3. What are the difference of prevention and control measures taken by clinical medical post-graduates with different majors?
4. What are the difference of prevention and control measures taken by clinical medical post-graduates with different genders?

METHODS

Participants

The subjects of this study were clinical medical post-graduates of the Zhejiang University School of Medicine. We conducted a cross-sectional survey from March to April, 2021.

Data Collection From the Questionnaire Survey

The questionnaires had 3 parts. The first part asked about the basic demographic information of the respondents (such as gender, age, grade, academic major, and health status). The second part was the questionnaire addressed their experience with cognitive attitudes during the COVID-19 pandemic, including the impact of COVID-19 on clinical practice, reasons for anxiety and fear during clinical practice, worry in clinical practice during the COVID-19 pandemic, the most desirable COVID-19 prevention and training mode, most desired COVID-19-related training content, vaccination, and most gratified thing about the current pandemic prevention and control. The third part was the investigation of personal protective measures of the clinical medical post-graduates. They were asked about which kinds of personal protective measures to take, such as wearing protective articles in the hospital, strengthening one's personal hygiene, reducing access to patients, and exercising more to improve one's immunity.

We developed the questionnaire in Chinese. We tested its internal consistency in a pilot study comprising 50 students. All the questionnaires had high level of internal consistency among our study population, with a Cronbach's alpha over 0.9 (0.91, 0.94, 0.96, respectively). An electronic survey questionnaire was formulated and randomly sent out through the Questionnaire Star survey program (https://www.wjx.cn/) on WeChat. A total of 195 questionnaires were sent out. Nineteen of the retrieved questionnaires were invalid and were thus excluded from the study, and 176 were valid. The effective survey questionnaire retrieval rate was thus 90.26%.

Statistical Analysis

The data from the retrieved electronic survey questionnaires were gathered by Questionnaire Star. We described categorical variables as frequencies and percentages. The data were analyzed using chi-square tests (χ^2) to compare the differences between groups and p-values were two-sided and considered significant at $p < 0.05$. All data were analyzed by SPSS version 22.0 software.

Ethical Approval

Ethical approval was obtained from the ethics committee of the Second Affiliated Hospital, School of Medicine, Zhejiang University in China. All participants provided written informed consent prior to participating in the study, without identifiable data.

RESULTS

Demographic Characteristics

A total of 176 medical post-graduates completed the survey, and most of them (57.95%) were female. **Table 1** shows the distribution of the study participants. Most of those who completed the survey were post-graduate students of ophthalmology, otorhinolaryngology, and stomatology (43.75%). The current health status of the students was basically good, and the proportion of students with a poor health status was only 1.7% based on self-assessment.

Cognitive Attitudes of Medical Post-graduates in Clinical Practice During the COVID-19 Pandemic

Of the medical post-graduates who participated in this study, 89.77% believed that the COVID-19 pandemic had affected their clinical practice in different ways (**Table 2**). Among these was the fact that they developed nervousness and fear due to their knowledge that the virus causing COVID-19 could be transmitted in various ways and was highly infectious. Their biggest worries in relation to their clinical practice were self-infection, cross-infection, and large-scale infection due to inadequate personal protection, the presence of too many patients in the hospital, and the patients' concealment of their illness. For pandemic prevention and training mode, most of the students hope to obtain is the unified arrangement of the

TABLE 1 | Demographic characteristics of the study subjects.

Essential information	Classification	No. of people	Percentage (%)
Gender	Male	74	42.05
	Female	102	57.95
Grade level	First year, master's program	45	25.57
	Second year, master's program	47	26.70
	Third year, master's program	36	20.45
	First year, doctoral program	15	8.52
	Second year, doctoral program	14	7.95
	Third year, doctoral program	11	6.25
	Fourth year, doctoral program	8	4.55
Major	Ophthalmology, otorhinolaryngology, stomatology	77	43.75
	Internal medicine	63	35.80
	Surgery	20	11.36
	Laboratory science, medical imaging	13	7.39
	Nursing	3	1.70
Home location	Town	101	57.39
	Countryside	75	42.61
Current health status	Very good	62	35.23
	Good	76	43.18
	General	35	19.89
	Poor	3	1.70

medical school and the hospital. Most of the students (63.64%) thought that the COVID-19 vaccines were effective, and 66.5% thought that being vaccinated is the best way to gradually return to original clinical work.

Personal Protective Measures and Behaviors of Clinical Medical Post-graduates During the COVID-19 Pandemic

Of the medical post-graduates who participated in this study, 161 (91.48%) took protective measures against COVID-19 infection in the hospital during their internship (**Table 3**). One hundred fifty-two medical post-graduates (86.36%) chose to strengthen their personal hygiene, and 61 (34.66%) chose to reduce their contact with the patients. The number of medical post-graduates who exercised more to improve their immunity was basically the same as the number of those who did not take such measure. Seven medical post-graduates (3.98%) did not take any measure to prevent themselves from acquiring COVID-19.

Prevention and Measures Taken by Clinical Medical Post-graduates With Different Majors and Genders

Table 4 shows that there was no statistically significant difference in taking various prevention and measures among the medical post-graduates in this study by academic major ($p > 0.05$). **Table 5** shows that the proportion of male and female medical post-graduates who wear protective items in hospitals exceeds 90%. Interestingly, in terms of strengthening personal hygiene, the percentage of males who did so (83.78%) was slightly lower than the percentage of females who did the same (88.24%). There was no significant difference in the prevention and measures taken by gender ($p > 0.05$).

DISCUSSION

The COVID-19 pandemic has swept the world, and the pandemic prevention and control work has become a norm (14). As they serve as the backup force of clinicians, medical post-graduates consider clinical practice the main content of their study. However, due to the large number of patients in hospitals and the high work intensity, their occupational exposure risk from the doctor–patient ratio imbalance is much higher than that of students in other academic majors (15). The changeable clinical situation will create tremendous pressure on clinical medical students who are still in the growth stage, and this is likely to affect their clinical study and practice (16). During the COVID-19 pandemic, especially in the stage of normalization of the pandemic prevention and control work, medical post-graduates in clinical practice are faced with clinical risks and thus belong to the high-risk groups. This study focused on the cognitive attitudes and prevention and control behaviors of clinical medical students during the COVID-19 pandemic. According to the survey, the pandemic has had an impact on the medical post-graduates' clinical practice, but the students have a relatively positive attitude toward the pandemic situation. They are also doing a good job of protecting themselves in their clinical practice. For hospitals and schools, they should strengthen their personal protection training, encourage active participation in vaccination, and strengthen the teaching of infectious-disease prevention and control. At the same time, they should actively cultivate the professional quality and identity of medical post-graduates.

The survey showed that 89.77% of the medical post-graduates thought that the COVID-19 pandemic has had an impact on them. Among these, 15.34% thought that the pandemic has had a great influence and 3.41% thought that the pandemic has had a major influence on their clinical practice. The reasons for these can be roughly divided into two points. First, in early 2020, when the domestic pandemic situation was relatively severe, almost all the medical students in clinical practice were required to stop their practice for their own protection (17). They resumed their clinical practice after several months, and no measures were put in place to make up for their lack of practice time. Second, some clinical frontline doctors were transferred to pandemic prevention and control teams, leading to a decrease in the number of clinical teachers (18). As each of the remaining clinical teachers was then put in charge of more students to make up for the shortage of clinical teachers, the teaching effect was bound to be affected (19). With the emergence of COVID-19 vaccines and vaccination, 66.5% of the medical students were glad to see that life was getting back to the old normal, which showed that most of the students were eager to return to normal life after experiencing

TABLE 2 | Results of the questionnaire survey on the clinical medical post-graduates' cognitive attitudes toward the COVID-19 pandemic.

Questionnaire content	No. of people	Percentage (%)
Impact of COVID-19 on your clinical practice:		
Slightly affected	81	46.02
Moderately affected	44	25.00
Greatly affected	27	15.34
Not affected	18	10.23
Very much affected	6	3.41
Reasons for anxiety and fear during clinical practice:		
COVID-19 can be transmitted in many ways.	51	28.98
No fear	40	22.72
The virus is too infectious.	39	22.16
Lack of effective treatment for COVID-19	32	18.18
There are more severe pneumonia patients and there is a higher mortality rate during the pandemic.	14	7.95
The family burden is increased by COVID-19 infection.	3	1.70
What makes you worry in clinical practice during the COVID-19 pandemic (only can choose one answer):		
Self-infection may occur when one is not wearing personal protective gear.	71	40.34
Cross-infection can easily occur as there are too many floating personnel in the hospital.	52	29.55
Large-scale infection may be caused by the patients' concealment of their condition.	46	26.13
The COVID-19 pandemic complicates the original clinical work.	7	3.98
The most desirable COVID-19 prevention and control training mode is:		
Unified arrangement of study in the school and the hospital	153	86.93
Autonomous online learning	23	13.07
Most desired COVID-19-related training content:		
Related operation process	77	43.75
Personal protection	66	37.50
Disinfection and isolation	33	18.75
Do you think vaccination has a preventive effect?		
Yes	112	63.64
Usually	62	35.23
No	2	1.14
What makes you gratified about the current pandemic prevention and control (only can choose one answer)?		
Life is gradually getting back on track.	117	66.48
The public awareness of the need for personal protection has been strengthened.	19	10.80
The number of new cases has decreased.	15	8.52
The government has taken effective measures to control the spread of the virus causing COVID-19.	11	6.25
There is progress in the new-drug research and development.	10	5.68
The number of cured cases has increased.	3	1.70
Other	1	0.57

the pandemic. Schools need to encourage their students to take part in the pandemic prevention and control training and work and to strive to cut off the COVID-19 transmission routes and to get back to the old normal as soon as possible.

A previous study found that the COVID-19 pandemic has had a negative psychological impact on post-graduate trainees (20). Among Chinese college students, 0.9% suffer from severe anxiety, and 2.7% have moderate anxiety symptoms during the outbreak of COVID-19 pandemic (21). We found that in spite of the pandemic, the post-graduates in all the academic departments and grades in our University are basically in good

TABLE 3 | Survey questionnaire items on the personal protective measures taken by the clinical medical post-graduates in this study during the COVID-19 pandemic.

Personal protective measures	No. of executors	Percentage (%)
Wearing protective articles in the hospital	161	91.48
Strengthening one's personal hygiene	152	86.36
Reducing access to patients	61	34.66
Exercising more to improve one's immunity	82	46.59
None	7	3.98

TABLE 4 | Comparison of the prevention and control measures taken by academic major.

Protective measures taken	Academic major					χ^2	*p*
	Ophthalmology, otorhinolaryngology, stomatology (*n*/%)	Internal medicine (*n*/%)	Surgery (*n*/%)	Nursing (*n*/%)	Medical imaging (*n*/%)		
Wearing protective articles in the hospital	74/96.10	54/85.71	18/90	3/100	12/92.31	5.145	0.273
Strengthening personal hygiene	72/93.51	52/82.54	14/70	3/100	11/84.62	9.173	0.057
Reducing access to patients	23/29.87	24/38.10	7/35	0	7/53.85	4.814	0.307
Exercising more to improve immunity	35/45.45	25/39.68	10/50	1/33.3	11/84.62	9.107	0.058
None	1/1.30	6/9.52	0	0	0	–	–

TABLE 5 | Comparison of differences in the prevention and control measures taken by gender.

Protective measures taken	Gender		Total (*n*/%)	χ^2	*p*
	Male (*n*/%)	Female (*n*/%)			
Wearing protective articles in the hospital	67/90.54	94/92.16	161/91.48	0.144	0.705
Strengthening personal hygiene	62/83.78	90/88.24	152/86.36	0.722	0.396
Reducing access to patients	28/37.84	33/32.35	61/34.66	0.570	0.450
Exercising more to improve immunity	37/50.00	45/44.12	82/46.59	0.596	0.440
None	4/5.41	3/2.94	7/3.98	0.682	0.409

health. A high 78.41% of the students said that they were in good health, which shows that the pandemic prevention and control work in our University has yielded relatively satisfactory outcomes. COVID-19 has had little influence on the health status of the University's medical clinical post-graduates. This study also investigated the infection prevention measures that could be taken by clinical post-graduates. It was found that medical students are more conscious of their personal protection in the face of the pandemic. Only 3.98% of the students said that they had not taken any preventive measure during the pandemic, and the remaining students said that they had taken different protective measures against COVID-19 infection. Moreover, there were no significant differences in the prevention and control measures taken by the medical post-graduates by gender and academic major. The results showed that 91.48% of the medical post-graduates chose to strengthen their personal protection against COVID-19 and 86.34% chose to strengthen their personal hygiene. Previous studies have demonstrated that the hands are an important medium for virus transmission, and hand hygiene is thus the simplest and most cost-effective measure for reducing the occurrence of hospital infection (22). Hand hygiene is also listed in the guidelines issued by China to protect the public against COVID-19 as one of the important measures that can be taken to prevent COVID-19 infection (23). However, only 46.59% of the students chose to exercise more to improve their immunity and to reduce their risk of infection. Zhu et al. found that it is safe to exercise during the COVID-19 outbreak (24). Proper physical exercise is also a scientific protective measure to strengthen one's resistance. Our study results also showed that most of the students had a positive attitude toward the COVID-19 vaccine, and only 1.14% of them thought that the vaccine had no effect on the prevention of COVID-19 infection. The existing literature also confirmed that the vaccine used in China has good immunogenicity (25). In the follow-up pandemic prevention and control work, accelerating the maturity and popularization of the existing vaccines and increasing the COVID-19 vaccination will play a relatively positive role in combatting the COVID-19 pandemic. Thus, medical schools and hospitals can also strengthen their training programs on and investments in personal protection and personal hygiene for the medical post-graduates, encourage the medical post-graduates to actively engage in physical exercise, provide safe exercise spaces for them, and actively promote COVID-19 vaccination among them to reduce the impact of the pandemic on their clinical practice and to better protect them against COVID-19 infection.

COVID-19 is a new infectious respiratory disease. Due to its multiple transmission routes and strong contagion effect (25), the biggest worry of the medical post-graduates in this study was their COVID-19 infection due to their inadequate personal protection and the possibility of cross-infection in the hospital. The survey also found that 86.93% of the students hope that unified arrangement of pandemic prevention and control training mode can be achieved. There have been three major disease outbreaks in the 21st century: China's severe acute respiratory syndrome outbreak (26) in 2003, the Middle East respiratory syndrome (MERS) outbreak in 2012 (27), and the West African Ebola epidemic in 2014 (28). Thus, it is possible that every medical post-graduate student in clinical practice will face a new infectious-disease outbreak. Therefore, knowledge regarding pandemic prevention and control and the related training are necessary in hospitals and medical schools. It is also one of the most recognized forms of training for medical post-graduates.

In recent years, with the advances in the field of medicine, the spectrum of infectious diseases has changed significantly; for instance, the incidence rates of plague, cholera, and encephalitis B have dropped significantly (29). The COVID-19 pandemic has shown the need to teach infectious-disease outbreak control as new infectious diseases may emerge at any time. Every clinical worker should thus be alert to the emergence of new infectious diseases. For the teaching of infectious-disease treatment and control for medical post-graduates, what is most important is to update the information in real time and to add the concept, types, characteristics, causes, and influencing factors of new infectious diseases to the medical syllabus on infectious diseases. Second, it is necessary to increase the exercises in coping with the outbreak of infectious diseases in the teaching of the said matter so that the students will be able to understand all the aspects of the prevention and control of infectious diseases through actual participation. Combined with the existing resident standardized training, hospitals can also increase the training contents related to infectious diseases and pandemic response.

In early 2020, the COVID-19 pandemic raged around the world (30, 31). Tens of thousands of Chinese medical staff rushed to Wuhan, China, to help treat the patients there, bravely facing the risk of infection and demonstrating the resolve to "respect life, save the dead, and heal the wounded" (32). As the reserve army of clinicians, medical students have the mission not only to safeguard human health but also to inherit the spirit of medical practice. Therefore, besides medical skills, moral education should be placed at the core of medical education (32). Before medical students start their clinical practice, teachers should make them feel the suffering of patients at close range, experience the race against death, and actively cultivate their professionalism and professional identity. The results of this survey showed that most of the medical post-graduates in this study were not willing to reduce their risk of contracting COVID-19 by reducing their contact with patients. The medical education curriculum can regard pandemics as a teaching material and can mandate the discussion of these in class, along with medical skills and medical ethics education (33).

CONCLUSIONS

In conclusion, our study found that the COVID-19 pandemic had an impact on the medical post-graduates' clinical practice, and affected their cognitive attitudes and behaviors. There were no statistically differences in the personal protection by academic major and gender. Medical schools and hospitals should therefore increase their targeted measures against the medical post-graduates' COVID-19 infection, offer psychological counseling to them to lighten their psychological burden, and strive to reduce the impact of outbreaks on their clinical practice.

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 the Ethics Committee of the Second Affiliated Hospital, School of Medicine, Zhejiang University, and conducted in accordance with the Declaration of Helsinki principles. Informed consent from all participants was included at the start of the questionnaire, and all participants voluntarily participated or withdrew from the questionnaire. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

LF and JS: conceptualization and formal analysis, funding acquisition, and writing—review and editing. ZX: data curation. LF, ZX, and JS: methodology. LF and ZX: writing—original draft. All authors contributed to the article and approved the submitted version.

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Investigation of Health Science Students' Knowledge Regarding Healthy Lifestyle Promotion During the Spread of COVID-19 Pandemic: A Randomized Controlled Trial

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Background: Health sciences students as future health care providers, can play a valuable role in protecting societies against the spread of COVID-19 through health promotion and lifestyle modification education. Therefore, proper education of these students is essential.

Objective: This study sought to assess and measure the change of knowledge of health sciences students regarding healthy lifestyle promotion strategies during the spread of the Covid-19 pandemic, after participation in different types of online and social media educational programs.

Methods: In order to serve the purpose of the study, a methodological research design was first used to ensure the validation of the developed scale; the COVID-19 Healthy Lifestyle Promotion Scale (COVID-19 HLPS). The study utilized a four-arm randomized control research design in which the participants were randomly assigned into one of four groups, (1) control group (placebo intervention), (2) brochure group, who received brochures relevant to healthy lifestyle promotion, (3) Instagram group, who received similar information but through Instagram posts, and (4) online interactive educational workshop group, who also received similar information through an online interactive educational workshop.

Results: In total, 155 participants participated in the online and social media intervention programs. There was a significant improvement in the intervention groups in the total knowledge subscale of the healthy promotion strategies compared with the control group ($p < 0.001$). Overall, the workshop group was the most effective group (effect size = 1.54) followed by the Instagram group (effect size = 0.99) and then the brochure group (effect size = 0.91).

Conclusions: In order to meet the challenges posed by this pandemic, the use of such online and social media interventions is essential and may be the key for health promotion

during this pandemic. Health science students, as future health care professionals, can play a fundamental role during the COVID-19 pandemic in disseminating knowledge relevant to healthy lifestyle to their families and communities thus promoting healthy living and behavioral changes. We propose the development of research initiatives at both national and international levels targeting changes within health science curricula that can meet potential challenges of future pandemics, leading to advancement of health care services globally.

Keywords: pandemic, physical activity, social media, lifestyle modification, cognition, nutrition, environment, health science curricula

INTRODUCTION

The rapid spread of the novel coronavirus (COVID-19) was not anticipated, and it wreaked havoc worldwide causing unprecedented morbidity and mortality that forced the world to shut down. Strategies to effectively control the spread of the virus were implemented worldwide including full and partial lockdowns and curfews (1). Tools for protecting societies through health promotion and wellbeing during this global pandemic became evident to ensure the control of the outbreak and support the safety of people particularly those at risk (2).

Since the spread of COVID-19 has contributed to the change of people's everyday practices (3), it became essential to consider the key role of health promotion and lifestyle modifications in improving the health and wellness of people's lives through healthy eating habits, promotion of exercise and fitness, the development of structured daily routines and adapting to daily stressors (4). This is more important particularly to the individuals with sedentary lifestyle, or the ones with the existence of comorbidities.

To better control the spread of this pandemic, or address issues pertaining to its spread and effect on people, multidisciplinary health care team members and students are expected to collaborate fully. This in turn contributes to the recovery and minimization of the pandemic severe consequences (5–9). Health science students can play a valuable role in health promotion due the nature of the work they do now, as well as their more critical role as future health care providers. Ideally, they are key workers who need to stay healthy to help others such as family, friends and eventually the public as a whole. Health science students can also serve as a proxy of the general population or the public in facing the spread of this disease. Proper education of these students in this regard is therefore essential.

It has been demonstrated that technology and social media-based interventions can play a significant role in promoting healthy lifestyle among individuals with sedentary lifestyle during this pandemic. Such interventions include the use of mobile health, web-based media (i.e., websites, web pages), wearable devices (i.e., accelerometer) and social media (i.e., Facebook platform) (10). The use of such technology and social media-based interventions were demonstrated to facilitate meaningful teaching experience, and to produce desired learning outcomes for students during the spread of COVID-19 pandemic crisis and beyond (11). In one study where the Instagram platform was utilized among health science students, the study found teaching through Instagram to have positive academic effects and to facilitate academic-student interaction and involvement (12). Another study that employed synchronized online classes among medical student found that the students were in favor of digital teaching and learning, in compassion to traditional teaching, particularly during the COVID-19 lockdown. The study concluded that synchronized online classes are potentially promising for future medical education (13). Having said that, this study aimed to assess and measure the change of knowledge among health sciences students regarding healthy lifestyle promotion strategies during the spread of the Covid-19 pandemic, after participation in different types of online and social media educational programs.

METHODS

Participants

The study participants included Health Science University students from the disciplines of medicine, pharmacy, physical therapy, occupational therapy, communication disorders, nutrition, medical laboratory sciences, radiological sciences and health informatics and information management. The inclusion criteria were 1- students from health-related disciplines and 2- students who finished the first yr of study in which all general educational requirements were met. The participants who met the inclusion criteria and agreed to participate in the study were randomly assigned into one of four groups, (1) control group (placebo intervention), (2) brochure group, who received brochures relevant to healthy lifestyle promotion, (3) Instagram group, who received the same information provided to the brochure group, but through written text Instagram posts. The Instagram posts did not contain audiovisual or video contents. The last group, and (4) online interactive educational workshop group, received the same information provided to the second and third groups through a synchronous online interactive educational workshop. The sampling was considered based on the following parameters: α (two-tailed) $= 0.05$, $\beta = 0.2$, leading to an 80% power. A minimum sample of 30 participants per group was required to ensure that a real difference between control and intervention groups could truly exist (14).

The process of randomization was performed through an independent biostatistician. The participants were assigned

randomly into four groups according to the sample size with the intent of having approximately equal numbers in each group. Randomization was completed using a computer-generated random number sequence. Both the principal researcher and participants were blinded to the allocation.

Study Design

The study utilized a four-arm randomized control research design to meet the study objective. A methodological research design was also used to ensure the validation of the developed scale; the COVID-19 Healthy Lifestyle Promotion Scale (COVID-19 HLPS).

Scale Development

An extensive search was conducted using data bases such as Scopus and Medline to identify and generate items relevant to healthy lifestyle promotion specifically pertinent to the COVID-19 pandemic. The COVID-19 Healthy Lifestyle Promotion Scale (HLPS) (**Appendix 1**) was self-developed by an expert panel of health care professionals (faculty members with a wide range of clinical and teaching experiences: three occupational therapists, two physical therapists, two nutritionists and one public health professional) to assess the perception of the health science students regarding their knowledge about healthy lifestyle promotion strategies during the COVID-19 pandemic. Several meetings were held among the expert panel to ensure having desired items that appropriately address the content of the scale. Several revisions were made to the scale until consensus was reached for the approval of its final version.

The approved final version included 27 items covering several subscales outlined below. A pilot testing phase was then conducted with 39 students from various health science disciplines. The intent of this process was to ensure clarity and relevance of all scale items. To support the content validity of the scale, a content validity index (CVI) was developed. This index included two components; (1). clarity of items (comprehensibility), (2). relevance of items (appropriateness). In addition, for each of these two components, there was a 4-point scale response to choose from for each item (1- strongly disagree, 2- disagree, 3- agree and 4- strongly agree). The magnitudes of floor and ceiling effects were analyzed to support the content validity of the scale. A face validity form was also provided to participants which asked the following question: Do you think that this scale reflected the knowledge base regarding healthy lifestyle promotion pertained to Covid-19 pandemic; the response to this question was dichotomous with either yes or no response. After reviewing and analyzing the results of the content validity index, floor and ceiling effects, and face validity, two questions were deleted, and several items were reworded leaving 25-items for the final scale.

The reliability of the developed scale was assessed in two separate stages. The first stage was conducted after the pilot testing phase where the scale was sent to 90 randomly selected participants. The participants were requested to fill the scale and then after one wk, they were requested to fill it out again. Fifty-two out of the 90 participants completed the scale. The purpose of filling it out twice was to assess the test-retest reliability of the scale. The second stage of measuring reliability was through assessing the internal consistency as well as item-total correlations; this was conducted when the actual data collection process was initiated with a larger sample size.

Structure and Scoring of the HLPS

Demographic Data: Consists of participants' age, gender, email, major, whether or not being educated about the value of other interdisciplinary team member contribution to the health care system, whether or not they learned about the specific role of other disciplines as part of the interdisciplinary team, curriculum coverage of health crisis management within its content, curriculum coverage of the guidelines for infection prevention and control, whether or not they were infected with COVID-19 and whether or not they had an intent to get vaccinated against COVID-19.

Knowledge Subscale: Consists of five subscales assessing the knowledge base of the followings:

I. Health and Cognition: 4-items addressing the influence of COVID-19 on cognition (i.e., attention, memory, planning, and problem solving) on cognition, the impact of isolation on the individual's cognition, the impact of COVID-19 on elderly people with cognitive deficits and proper steps to deal with potential cognitive problems due to the COVID-19 pandemic.
II. Daily routine and Environment: 5-items relevant to optimal use of time, proper sleeping patterns, role of spirituality in supporting the individual's mental health, the value of social and virtual environments in promoting health and the importance of public policy in addressing issues relevant to the pandemic.
III. Health and Exercise: 7-items related to types of exercise, recommended minimum guidelines for physical activity as well as factors pertaining to physical fitness contributing to desired health in relation to the spread of COVID-19.
IV. Health and Nutrition: 9-items addressing important information relevant to diet, eating habits and nutritional factors associated with the individual's own illnesses and health to promote a healthy regimen for people that could be at risk of developing COVID-19.
V. Beliefs about Coronavirus Vaccination: 5-items that enquire about the familiarity, effectiveness and duration of immunity relevant to the available vaccines against COVID-19. Of note, this component was added following the pilot testing phase and the test-retest reliability process. However, when assessing the internal consistency and item-to-total correlations with a larger sample size, this component was included. The reason of its addition later on was due to the development and approval of the vaccination afterwards. Hence, the items were developed, reviewed and fully approved by the expert panel prior to its inclusion as part of the scale. Following the addition of this component, the total number of items became 30 items.

The five knowledge subscales consist of a 5-item Likert Scale ranging from 1 (least level of knowledge) to 5 (highest level of knowledge). The total score for each subscale were as

follows: health and cognition: 4 questions with a maximum score of 20; daily routine and environment: 5 questions with a maximum score of 25; health and exercise: 7 questions with a maximum score of 35; health and nutrition: 9 questions with a maximum score of 45; and knowledge/beliefs about vaccinations: 5 questions with a maximum score of 25. A higher score indicates better knowledge in healthy lifestyle promotion strategies during the COVID-19 pandemic.

Procedure

Ethical approval from the local institutional review board was obtained. Students were invited through emails and Microsoft Teams platform to participate in the study. The purpose and procedure of the study was explained to the students and informed consent was obtained. Confidentiality was assured.

Prior to random allocations, the participants were contacted through Microsoft Teams and were asked to fill out the online COVID-19 HLPS. The participants were asked at the end of the scale if they were willing to participate in the intervention programs regarding the acquisition of knowledge relevant to healthy lifestyle promotion during the COVID-19 pandemic. After two wk, all participants who were willing to participate in the intervention programs, and completed one of the four programs, were asked to fill out the COVID-19 HLPS again.

Statistical Analysis

Descriptive statistics of the data including means, ranges, standard deviations, numbers and percentages were utilized. Internal consistency was measured using Cronbach's alpha coefficient and corrected item-to-total correlations. Test–retest reliability was measured using the intra-class correlation coefficient (ICC). The normality of the data was assessed using the Kolmogorov–Smirnov test. The results of the Kolmogorov–Smirnov test indicated that the data were not normally distributed. Therefore, non-parametric tests were used to analyze the data. Kruskal-Wallis test was used to compare medians of the exposure levels. Probability values (PV) for all multiple comparisons were calculated using Bonferroni adjustment procedure. An alpha $P < 0.05$ was considered statistically significant. For all of the study analyses, the Statistical Package for the Social Sciences (SPSS, version 26) was used.

TABLE 1 | Socio-economic and demographic characteristics of the study participants ($N = 385$).

Characteristics	*n* (%)
Gender	
Female	371 (96.4)
Male	14 (3.6)
Age (years)	
Mean (SD)	20.9 (2.1)
Range	18–35
Major	
Medicine	23 (6.0)
Nutrition	14 (3.6)
Pharmacy	14 (3.6)
Allied Health	334 (86.8)
Has your educational curriculum covered the value of interdisciplinary approach to the health care system?	
Yes	313 (81.3)
No	72 (18.7)
Were you educated about the key role of other health care discipline as part of the interdisciplinary team?	
Yes	243 (63.1)
No	142 (36.9)
Has your educational curriculum addressed public health crisis management within its content?	
Yes	184 (47.8)
No	201 (52.2)
Has your educational curriculum addressed the guidelines for infection prevention and control within its content?	
Yes	262 (69.1)
No	123 (31.9)
Have you been infected with COVID-19 before?	
Yes	54 (14.0)
No	331 (86.0)
Do you intend to get vaccinated for COVID-19?	
Yes	250 (64.9)
No	135 (35.1)

RESULTS

The study consisted of 385 participants, with greater participation of women ($n = 371$) than men ($n = 14$). Average age was 20.9 (range = 18 – 35, SD = 2.1). Within their curricula, the majority studied the value of the interdisciplinary approach to the health care system ($n = 313$, 81.3%), while approximately two thirds of the participants specifically studied the key role of these disciplines as part of the interdisciplinary health care team ($n = 243$, 63.1%). Further details of the participant characteristics are outlined in (**Table 1**).

Of the 385 participants, 302 agreed to participate in the online intervention programs and were randomly allocated to the four arms as follows: brochure group ($n = 75$), Instagram group ($n = 75$), online interactive educational workshop ($n = 77$), and control ($n = 75$). During the implementation phase of the online intervention programs relevant to the three intervention groups and control group, 155 participants (51.3%) participated in the online and social media intervention programs: brochure group ($n = 30$), Instagram group ($n = 32$), online interactive educational workshop ($n = 43$), and control group ($n = 50$); specific details of the enrollment, allocation and analysis are illustrated in the study flow diagram (**Figure 1**).

With regards to the reliability of the scale, Cronbach's α-value for the knowledge scale was 0.909 and the Item-to-total correlations ranged from 0.289 to 0.640 ($n = 385$) indicating a satisfactory internal consistency as well as Pearson's correlation coefficients. In addition, the ICC of the scale was 0.896 (95% CI 0.818–0.940) ($n = 52$) suggesting an excellent agreement. Further description of the reliability of the scale is provided in (**Table 2**).

Table 3 describes participant knowledge within groups of the different subscales. Overall, the workshop group was the most effective group (effect size = 1.54) followed by the Instagram

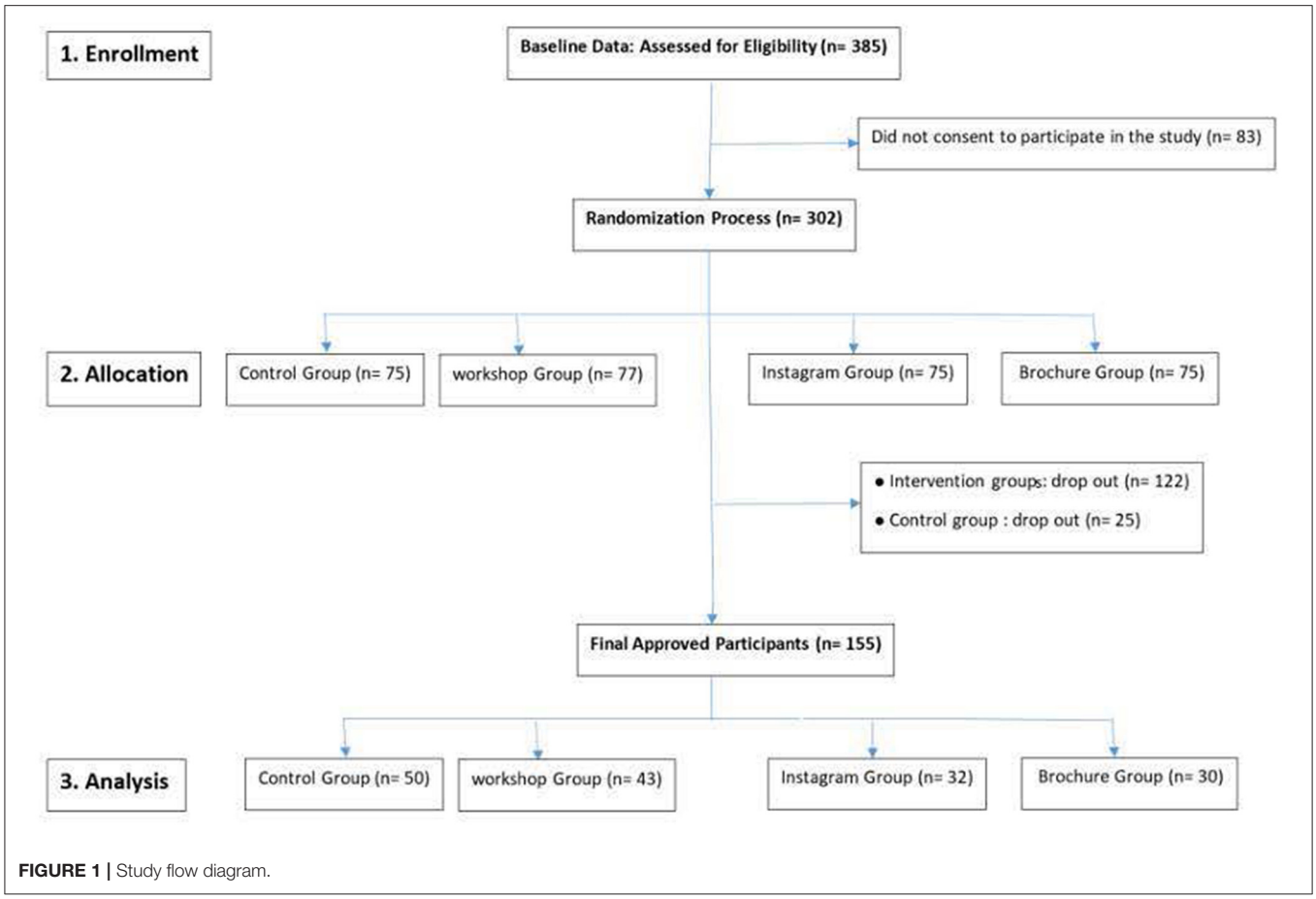

FIGURE 1 | Study flow diagram.

TABLE 2 | Reliability analysis of the HLPS and its subscales ($N = 385$).

Subscale	Cronbach's Alpha[a]	Item-to-total Correlations	ICC[b] (95% CI)
Knowledge (30-items)[c]	0.909	0.289–0.640	0.896 (0.818–0.940)
Health and Cognition (4-items)	0.744	0.489–0.583	0.784 (0.625–0.876)
Lifestyle and Environment (5-items)	0.724	0.427–0.539	0.722 (0.515–0.841)
Health and Exercise (7-items)	0.856	0.422–0.730	0.867 (0.769–0.924)
Health and Nutrition (9-items)	0.855	0.475–0.697	0.801 (0.652–0.886)
Vaccination Knowledge & Beliefs (5-items)	0.787	0.483–0.616	-

[a]*Cronbach's alpha was based on N = 385.* [b]*ICC was based on N = 52.* [c]*Knowledge subscale ICC is calculated based on four subscales (Fifth component was added later).*

group (effect size = 0.99) and then the brochure group (effect size = 0.91). As shown in (**Table 4**), there was a significant improvement in the intervention groups in the total knowledge subscale of the healthy promotion strategies compared with the control group ($p < 0.001$). Total knowledge subscale score for the control group and intervention groups are illustrated in the boxplot (**Figure 2**).

DISCUSSION

This study investigated the knowledge of health sciences students regarding healthy lifestyle promotion strategies during the spread of the COVID-19 pandemic after their participation in different educational programs. The results found significant improvements in all of the intervention groups compared to the control group with the online interactive educational workshop group followed by the Instagram group consistently outperforming the other groups. In addition, the findings support the use of an online platform and social media-based interventions, particularly during a pandemic in promoting healthy lifestyle knowledge among various health care students. Our finding complement previous studies which demonstrated the value and effectiveness of virtual education, such as online and social media intervention programs, for students in their academic environment (11–13).

TABLE 3 | Participant's knowledge subscale Pre-post (within group).

Subscale component	Control ($n = 50$)		Brochure ($n = 30$)		Instagram ($n = 32$)		Workshop ($n = 43$)	
	Post	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**
Health and cognition								
Mean (SD)	13.0 (3.5)	10.72 (3.94)	16.0 (3.0)	11.9 (4.5)	15.5 (3.4)	11.1 (4.0)	16.9 (2.9)	10.9 (4.0)
Range	4–20	4–20	11–20	4–20	8–20	4–20	8–20	4–20
P Value*	0.002		0.001		0.001		0.0001	
Effect size	0.58		0.91		1.1		1.5	
Lifestyle and environment								
Mean (SD)	18.2 (4.1)	18.5 (3.7)	20.5 (3.7)	18.8 (4.3)	22.1 (3.0)	19.2 (4.4)	22.2 (3.6)	18.6 (4.2)
Range	9–25	12–25	13–25	5–25	14–25	6–25	12–25	9–25
P Value*	0.715		0.087		0.008		0.001	
Effect size	0.08		0.40		0.66		0.86	
Health and exercise								
Mean (SD)	25.1 (6.7)	23.3 (6.8)	28.4 (5.0)	23.4 (6.8)	28.8 (7.0)	23.2 (7.2)	31.2 (4.2)	22.6 (6.7)
Range	7–35	8 – 35	14–35	7–35	9–35	7–35	17–35	9–35
P Value*	0.209		0.005		0.008		0.0001	
Effect size	0.26		0.74		0.78		1.28	
Health and nutrition								
Mean (SD)	35.6 (8.2)	33.4 (8.3)	37.3 (7.2)	33.4 (7.3)	38.6 (7.4)	35.9 (7.8)	40.7 (5.4)	33.7 (7.4)
Range	10–45	9 – 45	18–45	10–45	17–45	18–45	25–45	18–45
P Value*	0.759		0.046		0.135		0.0001	
Effect size	0.27		0.53		0.35		0.95	
Vaccination knowledge & beliefs								
Mean (SD)	17.2 (4.3)	14.0 (5.3)	20.5 (4.1)	14.6 (5.2)	21.1 (4.1)	14.7 (5.2)	22.5 (3.8)	14.1 (5.7)
Range	8–24	5–25	9–25	5–25	10–25	6–25	8–25	5–25
P Value*	0.004		0.001		0.001		0.0001	
Effect size	0.60		1.13		1.23		1.47	
Knowledge subscale total score								
Mean (SD)	107.1 (22.8)	99.9 (20.5)	122.7 (20.5)	102.1 (22.6)	126.1 (22.4)	104.1 (22.3)	133.4 (16.8)	99.9 (21.7)
Range	53–144	45–135	66–150	31–150	58–150	46–149	78–150	56–146
p-value*	0.156		0.002		0.001		0.0001	
Effect size	0.35		0.91		0.99		1.54	

**P Value was calculated using Wilcoxon signed rank test on the differences due to pairing.*

Such interventions are also supported by the literature with other populations than students, thereby contributing to the learning and intellectual exchange as well as provisions of health care services, such as maintaining the expected social distancing among people (10, 15). For example, it was reported that social media-based interventions appear to be promising methods for promoting health and wellbeing, especially during the pandemic. Therefore, the need for alternative means of population-based interventions that alter the ways in which society changes their lifestyle and habits may be addressed with such virtual strategies. As a result, health professionals who engage in healthy lifestyle behaviors are more likely to promote healthy living in their communities and educational programs that emphasize healthy diet, exercise, and stress management (16). Therefore, online and social media interventions including online interactive educational workshops, Instagram posts and brochures, can be vital for health promotion during this pandemic. Thus, starting with health care professionals or future health care professionals is a step in the right direction. The risks associated with sedentary lifestyle during lockdowns or partial curfews may be overcome through the social support that these platforms and social medias provide in promoting healthy living and behavioral changes.

The virtual environment can serve as a key factor to provide knowledge as an important source of support to people,

TABLE 4 | Participant's knowledge subscale (between group).

Subscale component	Control	Brochure	Instagram	Workshop	*P* value
Health and cognition					
Mean (SD)	13.0 (3.5)	16.0 (3.0)	15.5 (3.5)	16.9 (2.9)	<0.001
Lifestyle and environment					
Mean (SD)	18.2 (4.1)	20.5 (3.7)	22.1 (3.0)	22.2 (3.6)	<0.001
Health and exercise					
Mean (SD)	25.1 (6.7)	28.4 (5.0)	31.2 (4.3)	29.8 (4.2)	<0.001
Health and nutrition					
Mean (SD)	33.6 (8.2)	37.3 (7.2)	38.6 (7.4)	40.7 (5.4)	<0.001
Vaccination knowledge & beliefs					
Mean (SD)	17.2 (4.3)	20.5 (4.1)	21.1 (4.1)	22.5 (3.8)	<0.001
Knowledge subscale total score					
Mean (SD)	107.1 (22.8)	122.7 (20.5)	126.1 (22.4)	133.4 (16.7)	<0.001

** P Values were calculated using Kruskal-Wallis test comparing equality of medians since the scores in at least one group were not normally distributed.*

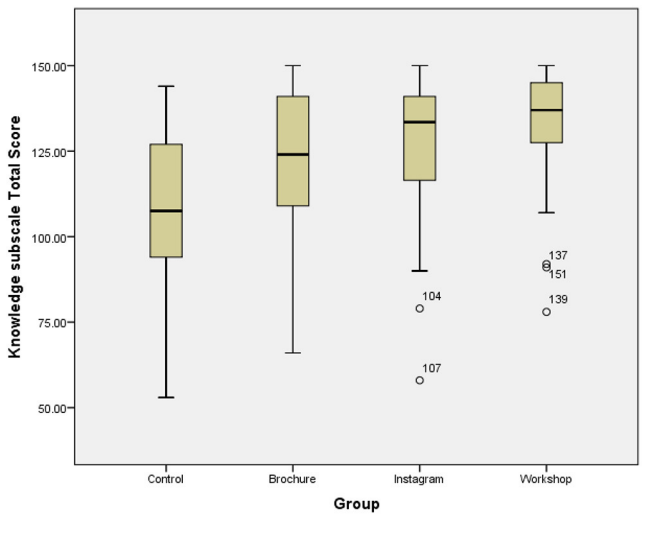

FIGURE 2 | Comparison boxplot of the total knowledge subscale score for the control group and the intervention groups.

particularly due to lockdown and possibly limited socialization. For example, the use of virtual environment, such as electronic and social media as well as web-based communication tools, can be a substitute to facilitate communication, connectedness and learning opportunities thus mitigating the challenges imposed by this pandemic (17–20). Furthermore, it is of importance to note that the use of virtual learning and technology can also be applied cross-culturally to promote accessible learning and guide an international collaborative health education around the world (12). Doing so can contribute to international research opportunities among various University academicians as well as health care professionals to support optimum health care services.

About two thirds of the participants were educated about the specific role of other health care disciplines as part of the interdisciplinary team, which raises a concern that might influence the provision of desired service delivery. Hence, curricular changes of integrating more focus on advancing students' knowledge base about other disciplines domains and practice can assist and prepare students, as future health care professionals, for challenges imposed by the pandemic or potential future pandemics (21). Understanding of how these disciplines are interlinked can also lead to better preparation and adaptation to meet such unprecedented crises in the future. In addition, less than half of the study participants (47.8%) reported that their educational curriculum addressed public health crisis management which further requires changes to be made. It is recommended therefore for health care departments to consider modifications of their curricula to meet the new demand of such global change resulting from newly developed pandemics leading to proper epidemic control in the future (22, 23).

Moreover, addressing the guideline for infection prevention and control within the education curriculum, as reported by the study participants, was about 70% which needs to be even more embedded within its content. The inclusion of the comprehensive coverage of guidelines for infection prevention and control within the health science educational curricula is highly encouraged. This is a vital step that can aid in the management of viral pandemic outbreaks possibly encountered in the future (24). For example, preparing health care students, such as medical students, to tackle problems or issues relevant to the pandemic can serve as a fundamental component required to be part of their educational curricula (25). Having said that, we propose the development of research initiatives both at the national and international levels targeting changes within health science curricula that can meet all potential challenges of future pandemics. In turn, this will guarantee adequate level of preparedness towardz any viral or infection threat encountered leading to improvement and advancement of health care services globally. Nonetheless, policy making, and governmental legislations are crucial elements to ensure prevention as well as control of the COVID-19 Pandemic in their own countries. Thus, investments in health resources and

funding, taking desired precautionary measures and choosing appropriate response strategies are all essential solutions to control and minimize the spread and effect of this pandemic globally (26, 27).

The strengths of the study are of significant value and should be indicated. First, to our knowledge, this study is the first of its kind to examine the use of online platforms and social media interventions, to acquire knowledge relevant to healthy lifestyle promotion strategies during the COVID-19 pandemic, with health science students of different disciplines using a rigorous research design. Second, this study supports the holistic view of interdisciplinary teamwork and collaboration, while addressing individuals' healthy lifestyle promotion strategies reflecting various domains including cognition, daily routine and environment, exercise, nutrition and knowledge and beliefs about vaccinations. Such collaboration is highly encouraged whether in the areas of assessment or intervention to facilitate fruitful research-related opportunities. Third, the study findings encourage health care educators to support the use of online interactive workshops, Instagram posts and brochures as teaching strategies within their curricula to promote students' learning and educational outcomes. Fourth, the psychometric properties established in this study for the COVID-19 Healthy Lifestyle Promotion Scale (COVID-19 HLPS) allow future studies to use this outcome measure to document, monitor and track wellness programs targeting healthy lifestyle promotion of different populations.

Limitations

The first limitation is that the percentages of students from the different majors were not equally represented. Second, the findings relevant to the curriculum contents may not have been comprehensive as the years of study were not reported. Third, the observed gap in educational curriculum regarding public health crisis management was made from a small sample, and from a single university. Future studies should therefore utilize large-scale comparisons to verify whether this gap is frequent. Another limitation of this study is that we did not measure the students' generalizability of the knowledge gained in their environment during the pandemic. We encourage future studies to pay more attention to external validity and enhance generalizability to facilitate more appropriate use of research findings. We further recommend indicating the specific year of study for the students to allow in-depth understanding of the curriculum content throughout the years of study.

CONCLUSION

During the spread of the Covid-19 pandemic, the use of online platforms and social media interventions including online interactive educational workshops, Instagram posts and brochures are of great value to students' knowledge relevant to healthy lifestyle promotion strategies. Therefore, to meet the challenges posed by this pandemic, the use of such online and social media interventions is essential and may be key for health promotion during pandemics. Health science students, as future health care professionals, can play a fundamental role during the COVID-19 pandemic in disseminating knowledge relevant to healthy lifestyle to their families and communities thus promoting healthy living and behavioral changes. In addition, the study findings can encourage health care faculty members to support the use of online educational interactive workshops, Instagram posts and brochures as teaching strategies within their curricula to promote students' learning and educational outcomes. Furthermore, future studies can use the COVID-19 Healthy Lifestyle Promotion Scale (COVID-19 HLPS) as a standardized outcome measure to document, monitor and track wellness programs evaluation targeting healthy lifestyle promotion of different populations. Finally, we propose the development of research initiatives at both national and international levels targeting changes within health science curricula that can meet potential challenges of future pandemics, leading to improvement and advancement of health care services globally.

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.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institution Review Board (IRB) at Kuwait University (VDR/EC/36/8). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

NaA, NoA, MN, AS, AA, and MA: conceptualization, methodology, and resources. NaA, NoA, and MN: validation. NaA and NoA: formal analysis, writing—original draft preparation, funding acquisition, and supervision. NaA, NoA, and MN: investigation and writing—review and editing. NaA, NoA, MN, and AS: data curation and project administration. All authors have read and agreed to the published version of the 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.2021.774678/full#supplementary-material

Appendix 1 | COVID-19 healthy lifestyle promotion scale (COVID-19 HLPS).

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The Influencing Factors of Nutrition and Diet Health Knowledge Dissemination Using the WeChat Official Account in Health Promotion

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Background: The promotion of a healthy diet *via* health education is a component of the "Healthy China 2030" plan. However, few studies have reported whether health knowledge about nutrition and diet has gained public attention, and whether it is needed by the public.

Methods: The numbers of views, shares, and reads of articles published by the official WeChat account of a hospital in China were accessed. The influence index was obtained *via* the entropy analysis of these three indices. A questionnaire survey was developed based on the purpose of the study and the conclusion of the content analysis, which conducted to analyze users' requirements for health knowledge and their influencing factors. Moreover, risk factors were explored by logistic regression models.

Results: Of the 103 articles considered in this study, four articles in the Top 10 were related to nutrition and diet. The influence index of nutrition and diet knowledge was found to be the highest in the content analysis ($p < 0.05$). The higher degrees of humor ($\beta = 0.224$, $p = 0.027$), nutrition and diet articles ($\beta = 0.776$, $p = 0.034$), and cover articles ($\beta = 0.312$, $p = 0.021$) have significant influences on the influence index. In total, 581 questionnaires were obtained, and 78.1% of the respondents reported believing that the health knowledge of greatest concern was that related to nutrition and diet. Multivariate logistic regression analyses were conducted to explore the associations between the features of the articles and users reading nutrition and diet knowledge; it was found that gender (female, OR: 4.651, 95%CI: 2.598, 8.325, and $p < 0.001$), age (young adult, OR: 0.358, 95%CI: 0.266, 0.481, and $p < 0.001$), cancer precaution knowledge (OR: 4.333, 95%CI: 2.262, 8.299, and $p < 0.001$), traditional Chinese medicine (OR: 2.121, 95%CI: 1.064, 4.230, and $p = 0.033$), the knowledge acquisition approach [circle of friends (OR: 2.586, 95%CI: 1.373, 4.868, and $p = 0.003$), social media (OR: 2.183, 95%CI: 1.204, 3.960, and $p = 0.010$)), hospitals (OR: 3.194, 95%CI: 1.793, 5.692, and $p < 0.001$), television media (OR: 4.348, 95%CI: 2.341, 8.077, and $p < 0.001$)], and social media strategies [professionalism and authority (OR: 2.354, 95%CI: 1.231, 4.505,

and $p = 0.006$)] have statistically significant relationships with users reading nutrition and diet knowledge.

Conclusion: Nutrition and diet knowledge could contribute to WeChat user engagement of health information dissemination. Nutrition professionals should improve the scientific popularization ability and effectively use social media for health promotion.

Keywords: WeChat, nutrition and diet, health promotion, Healthy China, social media

INTRODUCTION

Due to the growing prevalence of diet-related noncommunicable diseases, especially those exacerbated by rising rates of obesity and improvements in survival, the total number of obese adults in China reached 85 million in 2018 (1). In 2016, the number of deaths of Chinese people related to diet-related chronic diseases reached 2.493 million, accounting for 29.1% of all deaths from chronic diseases in the country, with a mortality of 182.4/100,000 (2). Studies have shown that an unhealthy diet, is the main behavioral risk factor for the development and progression of chronic diseases (3). Evidence based on macro-data from 1961 to 2017 revealed that the structural imbalances in dietary consumption in China have seriously threatened national health (4). In the past 30 years, the diet of Chinese people has changed from the traditional plant-based diet to a Western-style diet, which is mainly reflected in the increased intake of animal products and the consumption of fine processed grains, sugary drinks, and highly processed foods (5). Another key factor is that increasingly more young and middle-aged people use take-out services, which increases their consumption of foods high in sugar, salt, fat, and calories (6). Because these unhealthy diet behaviors affect health, it is necessary to strengthen health education and guide healthy dietary behavior. "Healthy China" is an important strategic policy with obvious Chinese characteristics implemented by the Chinese government, and it has been deemed important to change the living and dietary habits of Chinese people *via* health education (7).

The acquisition and dissemination of health information play a significant role in promoting positive behavioral changes related to health (8), and social media is currently becoming a new channel for information acquisition and exchange (9). With the rapid development of new media, mobile phone-centered intelligent devices are gradually covering more areas of social life and are a popular means of information acquisition and exchange by the public (10). Network platforms are the major distribution centers of information flow. Furthermore, the demand for health information is also surging, and the use of social media to obtain health information has gradually become the norm (11, 12). Recent evidence suggests that social media platforms, such as Facebook and Twitter, are being used to promote health management and education, increase doctor-patient communication, and provide direct services (13, 14).

Many internationally popular social media apps, such as Twitter, Facebook, and Instagram. WeChat is a mobile social app launched by Tencent in 2011, and supports the functions of sending text, voice, and video messages, multi-person voice intercom, and reading and sharing information. As of January 2021, the app, which is China's most active social media platform with 1.225 billion monthly active users, has had an undoubtedly substantial impact on the communication and lifestyle of users (15). The widespread public engagement *via* WeChat creates a ready platform for successful online information distribution and diffusion by health promotion agencies (16). During the outbreak of the COVID-19 pandemic, WeChat official accounts (WOAs) provided necessary medical support for the public, reduced social panic, promoted social isolation, enhanced the self-protection ability of the public, and promoted epidemiological screening, thereby playing an important role in preventing and controlling the spread of COVID-19 (17).

Communication and education are inextricably linked to the effective dissemination and uptake of health information. Previous studies on online health communication largely focused on the influencing factors of user engagement with disseminated health information, including highlighting celebrity involvement, the use of humorous appeals, etc. (18, 19). Zhang et al. (20) reported that article content, article type, communication skills and article length were associated with user engagement. Gabarron et al. (21) revealed that health education on social media, such as Facebook and Instagram should consider videos and emoji in their posts to increase user engagement. Jenkins et al. (22) found that nutrition professionals should convey positive emotions and success to enhance the trustworthiness of their posts. However, there remains a lack of quantitative analysis and empirical research on how to accurately parse out the health needs of users from massive amounts of health information.

According to use and gratification theory, users actively select the type and content of information to satisfy their needs, and media that provide the most satisfying content will be used more often than others. Thus, it is necessary to evaluate and understand users' cognition of and attitudes toward the contents of media. WOAs edit and publish articles, and then push them to their followers, who spread the articles by reading and sharing them with their circle of friends. Thus, the numbers of views, reads, and shares have become important criteria by which to judge the attention paid to articles. Professional medical institutions are the main bodies of health information dissemination in China.

Public hospitals, especially top tertiary hospitals, have the most adequate medical personnel, resources, and technology, and are the main providers of health information. Shanghai Ruijin Hospital is one of top tertiary hospitals in China. As the affiliated hospital of Shanghai Jiao Tong University, Ruijin hospital is a leading general hospital incorporating research, education and care. Based on the heritage of Western medicine and enriched

by Chinese medicine and culture, the hospital has established a strong global reputation for medical innovation. Besides, the WOA of Shanghai Ruijin Hospital is also a benchmark in the field of health promotion. The influence of Shanghai Ruijin Hospital's WOA ranks among the top 20 hospitals in China.

The promotion of a healthy diet *via* health promotion and education is an important component of the "Healthy China 2030" plan. However, few studies have reported whether health information about nutrition and diet has gained public attention, and whether it is needed by the public. The research questions in this paper are as follows:

1. Whether health information about nutrition and diet has gained public attention, and whether it is needed by the public?
2. What were the influencing factors and the key elements of nutrition and diet health knowledge dissemination?
3. What techniques are associated with greater user engagement with nutrition and diet health knowledge?

In the present study, the WOA of Shanghai Ruijin Hospital was surveyed. By describing the numbers of views, shares, and reads of WeChat articles, the types of health knowledge most needed by users were determined, and factors that promote the wide dissemination of health communication were acquired. Then, a questionnaire was designed based on the content analysis to provide evidence to evaluate the effectiveness and practicality of using WOAs in public health education.

MATERIALS AND METHODS

Content Analysis

The WOA of Shanghai Ruijin Hospital (https://mp.weixin.qq.com/mp/profile_ext?action=home&__biz=MzIwNzEwOTM2MA==&scene=124) was chosen as the study subject. Beginning on April 17, 2020, it officially published two to four health knowledge articles every week. As of June 11, 2021, a total of 101 health knowledge articles had been published. These articles were used as samples for quantitative analysis in the present study to better understand users' preferences and make early preparations for the questionnaire surveys conducted in the later stage of research.

Data Collection

The data used in this study were the backstage data of the WOA, including the numbers of articles published, viewed, shared, and read. At the bottom of each article, the options "like" and "reading" can be selected. The selection of "like" indicates the recognition of the article, which is then seen by a user's followers. The selection of "reading" allows the users' friends to see the article, interact with each other, and carry out secondary dissemination (23, 24). Moreover, a six-category feature framework by which to consider each article was developed, referring to the research of Kite et al. (18) and Zhang et al. (20), with modification made during iterative testing to ensure consistency across features and make feature framework more relevant to effectiveness of the WOA. Specifically, we added three degrees of humor was adapted from the research of Kuangand Wu (25), which is feature that may affect the health communication in WOA. Such as, "*I am a mosquito and I prefer to bite fat boys, ahahaha…*" and the whole article was cheerful, we defined this article as high degree of humor. "*Elevated tumor markers = tumor? You must promptly seek medical advice if you have these eight big signs*" and nearly half of the article is humor written, we defined this article as normal degree of humor. "*Muscle soreness is a side effect of the COVID-19 vaccine*" and the description of the whole article is very rigorous, we defined this article as low degree of humor. Coding of all feature framework was completed independently by all authors, with any discrepancies resolved through discussion. The final feature framework and related definitions are reported in **Table 1**.

TABLE 1 | The final feature framework used in this study.

Item	Definition
Article content	
Nutrition and diet	The topic is related to nutrition or diet, e.g., the topic introduces the effects of food and nutritional therapy
Covid-19	The topic is related to COVID-19, e.g., the topic describes vaccines and precautions.
Healthy lifestyle	The topic is related to popular knowledge of life, e.g., ways to protect your eyes, the dangers of sedentariness, etc.
Chronic diseases	The topic is related to chronic diseases, e.g., the prevention and therapy of non-alcoholic fatty liver disease, etc.
Clinical trials	The topic is related to clinical trials, such as those for Parkinson's disease.
Digital healthcare	The topic is related to digital health, such as how to see a doctor online.
Cancer precaution	The topic is related to cancer, such as tumor markers.
Degree of humor	
Low	No humorous technique is used to convey health messages.
Normal	A slightly humorous technique (such as slight sarcasm, jokes, etc.) is used to convey health messages.
High	A very humorous technique (such as overt sarcastic, jokes, etc.) is used to convey health messages.
Presence of caricatures	
Text only	The article contains only text.
Text and caricatures	The article contains text and caricatures.
Article length	
0–1,500 words	The number of words in the article text.
1,500 or more words	The number of words in the article text.
Title type	
Declarative sentence	The sentence aims to state a fact with a period.
Exclamatory sentence	The sentence aims to state a fact with an exclamation point.
Interrogative sentence	The sentence has a question mark.
Imperative sentence	The sentence has an exclamation point without a subject.
Cover article	Whether the article is a cover article.

Questionnaire Survey and Quality Control

A questionnaire was developed based on the purpose of the study and the conclusion of the content analysis, and primarily included questions on each respondent's age, gender, educational background, occupation, accessibility and frequency of access to health information channels, types of health knowledge needs, and social media strategies. Respondents' attitudes toward each statement were measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). When the preliminary design of the questionnaire was completed, it was reviewed by experts familiar with the Research Topic, who ensured that the survey questions successfully captured the topic and did not contain common errors such as leading, confusing, or double-barreled questions. Prior to the survey, a pilot study was conducted among 20 subjects to ensure that there were no problems in reading the frame information, understanding and answering the questions in the questionnaire. All participants said the frames were easy to understand and the length of the questionnaire was appropriate.

Quality control measures: the questionnaire was accompanied by detailed instructions and informed consent. All survey respondents must follow and read more than five health articles in the WOA of Shanghai Ruijin Hospital. Besides, we set all the questions must be completed before submitted the questionnaire. Additionally, we set the same IP or WeChat account can only be filled once to prevent repeated filling. We also set a limit on the time required to fill the questionnaire. All questionnaires that taken <1 min to answer were excluded. Moreover, the same answers for consecutive questions also were excluded. Finally, a total of 21 questionnaires were excluded, resulting in 581 valid questionnaires.

The questionnaire survey was conducted on June 25, 2021 *via* the function of "reading" the original article at the bottom of the WOA. The data used in this study were sourced from the backstage management function of the WOA and stored in the cloud network. The questionnaire survey was also conducted online, which ensured reliable data sources and accurate content.

Principal component analysis (PCA) was then performed, and the questionnaire was checked for internal consistency. According to the results of PCA and internal consistency, several disturbance terms were deleted. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.783, the *p*-value of the Bartlett test of sphericity was <0.001, and Cronbach's alpha was 0.763.

Calculation Formula of Influence Index and Statistical Analysis

Hirsch (26) proposed an index *h*, defined as the number of papers with citation number ≥h, as a useful index to characterize the scientific output of a researcher. A high *h* is a reliable indicator of high quality of the researcher's research paper and high accomplishment. WOA is equivalent to a researcher, the articles published by WOA were similar to the research paper published by researchers. The number of views and reading of articles published by WOA also had similar characteristics to those cited by researchers. The WeChat communication index (25) was established the dissemination and coverage of messages published by WOA as well as the maturity and impact of WOA. In our research, the influence index of articles was derived from rigorous calculation formulas adapted from WeChat communication index (27), Kaur (23), and Hirsch (26), which consist of three dimensions, that is, *viewing*, *reading*, and *sharing*.

Given that the number of people each article was sent to was different, and because the sending situation has a great impact on reading, the number of views was transformed by the number of serviced people; the viewing index = 100 × number of views/number of sends. Moreover, because sharing and collection occur on the premise of reading, and represent the readers' recognition of the article, the number of views was used to standardize the number of shares and reads; the sharing index = 100 × number of shares/number of views, and the reading index = 100 × number of reads/number of views. The *z*-scores for the viewing index, sharing index, and reading index were computed to create a standardized score for each.

After standardization, descriptive analysis was performed on the *z*-scores of the viewing, sharing, and reading indexes. For each domain, we incorporated the values of the *z*-scores of the viewing, sharing, and reading indexes into the scoring by using entropy weight, in which weights are systematically calculated based on the level of the difference between the original values (28).

Entropy weight method:

Matrix after logical transformation:

$$M = \begin{pmatrix} x11 & \cdots & x1m \\ \vdots & \ddots & \vdots \\ xn1 & \cdots & xnm \end{pmatrix} \quad (1)$$

Where n: number of health articles; *m*, number of variables.

$$P_{ij} \;\; P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \quad (2)$$

$$E_j \;\; E_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \quad (3)$$

$$d_j \;\; d_j = 1 - E_j \quad (4)$$

$$W_{j(\text{weight for each } z-\text{indexes})} \;\; W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (5)$$

Collinearity diagnostics were determined *via* the tolerance statistic and variance inflation factor (VIF), which revealed that collinearity was not a problem between covariates (29). The differences in the z-scores of the viewing, sharing, and reading indexes and the influences of nutrition and diet-related articles and other types of articles were studied by a univariate analysis of variance. Next, stepwise regression analyses were conducted to assess the associations between the features of the articles and the influence index (described in section Analysis of Article Influence).

Microsoft Excel software was used to create a database for data entry and verification, and data were cleaned after entry to form the database. SPSS 22.0 software was employed for data analysis.

TABLE 2 | Health knowledge articles with 100,000+ views.

Title (English)	Views
Sugar? Fat? Here are the real low-sugar fruits! (A list of the sugar contents of fruits)	326,274
What should your daily diet be if your thyroid gland has a problem?	219,859
Elevated tumor markers = tumor? You must promptly seek medical advice if you have these eight big signs	143,046
How to take a good nap!	127,830
Look here! "Fast track" of Shanghai Ruijin Hospital COVID-19 nucleic acid detection	126,752
Skin disease, hypertension, thyroid disease? If you have several types of chronic diseases, can you get the COVID-19 vaccine?	123,668
Diego Maradona died of a heart attack. Five things you need to know to save your life	123,619
What is the "antibody cocktail" that Donald Trump is receiving?	119,394
Why are your eyelids twitching all the time?	118,607
Did the use of a humidifier like this cause 14,000 deaths? A doctor says that these four points should be considered!	115,682
Eating like this every day can improve the body's immunity	107,598
Where is the "held fart"? Will it affect your health?	102,294
What is the effect of red bean Semen Coicis water on the human body?	101,575

FIGURE 1 | A screenshot of a counter-rumor article. Source: Shanghai Ruijin Hospital WOA; online: https://mp.weixin.qq.com/s/Ltizmq1x6plwvSacAjjbYw (accessed August 21, 2020).

The odds ratio (OR) and its 95% confidence interval (CI) were calculated to determine the association of risk factors with nutrition and diet knowledge. Variables with $p < 0.5$ in the univariate analyses were then included in a multivariate regression model to identify the independent risk factors *via* backward elimination analysis. The variables included in the multivariable logistic regression analysis were included as categorized variables. A test level of $\alpha = 0.05$ and $p < 0.05$ was considered statistically significant.

RESULTS

Basic Information

On April 27, 2020, the number of followers of the Shanghai Ruijin Hospital WOA was 661,223. By June 11, 2021, the number was 1,120,533, of which female followers accounted for 59.73% (669,350) and male followers accounted for 40.21% (450,624). Moreover, 69.19% (767,061), 10.74% (119,033), and 7.51% (83,256) of the followers were from Shanghai, Jiangsu Province, and Zhejiang Province, respectively.

Basic Information of Articles

The total number of views of health knowledge articles was 4,832,682, the maximum number of views of one article was 326,274, the average number of views was 48,814, and the minimum number of reads was 1,809. Due to the settings of the Tencent system, a number of views of more than 100,000 is expressed as "100,000+," which is considered the most popular. Thirteen of the 103 articles considered in this study had more than 100,000 views, four of which were on nutrition and diet (**Table 2**, **Figure 1**).

Analysis of Article Influence

To comprehensively present the numbers of views, shares, and reads of the article, the entropy method was used to determine weights, and the influence index was used to comprehensively describe the influence levels of the articles.

The weights of the viewing index, sharing index, and reading index were, respectively, 0.493, 0.277, and 0.229. According to the results of the entropy method analysis, the influence index = z-score of the viewing index × 0.493 + z-score of the sharing index × 0.277 + z-score of the reading index × 0.229 (**Table 3**, **Figure 2**).

A rank-sum test was performed, and the results revealed significant differences between the viewing index and influence index of articles with different topic categories ($p < 0.001$).

Multiple Regression Analysis of the Influence Index of Health Knowledge

Table 4 reports the multiple linear regression results based on the least-squares method and stepwise regression. The results reveal that higher degrees of humor ($\beta = 0.224$, $p = 0.027$), nutrition and diet health articles ($\beta = 0.776$, $p = 0.034$), and cover articles ($\beta = 0.312$, $p = 0.021$) have significant influences on the influence index.

Demand for Nutrition and Diet Health Knowledge by Questionnaires

Feedback was collected from a total of 581 users, 196 of whom were male respondents. Of the users, 91.9% took the initiative

TABLE 3 | The analysis of the influences of different article contents (median).

Category of health knowledge	Accumulated articles	Viewing index	Sharing index	Reading index	Influence index
Nutrition and diet	22	0.166	0.405	0.204	0.367
Healthy lifestyle	26	−0.241	−0.131	−0.412	−0.308
COVID-19	12	−0.321	−0.101	−0.049	0.186
Chronic disease	21	−0.598	0.220	−0.045	−0.378
Digital healthcare	14	−0.334	−0.592	−0.430	−0.209
Clinical trials	3	−0.769	−0.355	−0.131	−0.6215
Cancer precaution	5	−0.020	−0.168	−0.626	−0.070
K		14.316	11.045	6.784	14.102
P		0.026	0.087	0.341	0.029

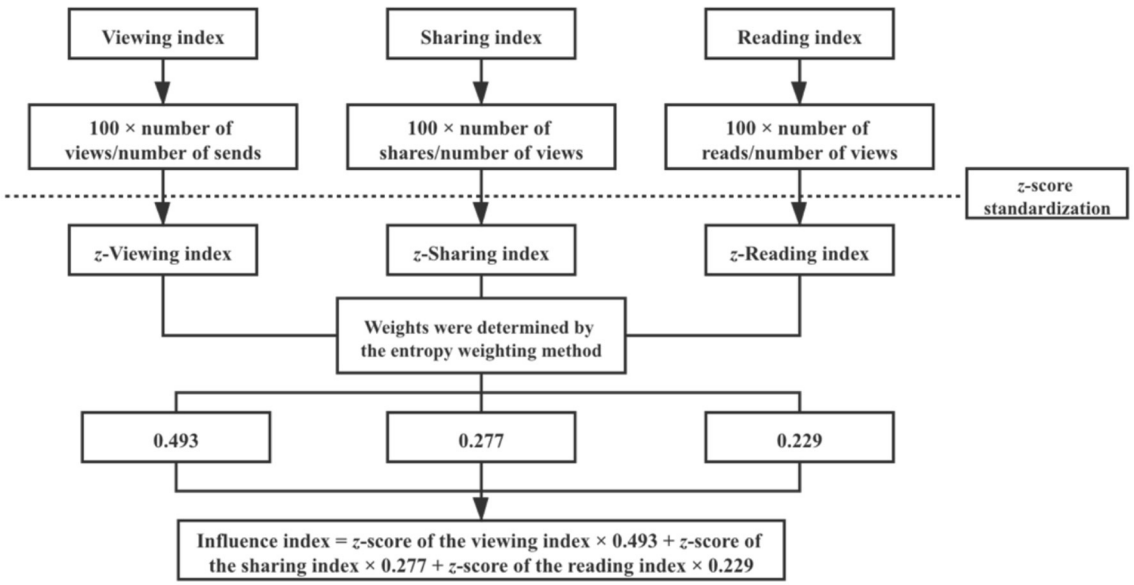

FIGURE 2 | Steps of influence index calculation.

TABLE 4 | The stepwise regression analysis of the influence index of health knowledge.

	β	*t*	*p*
Degree of humor	0.224	2.246	0.027
Nutrition and diet health articles	0.776	2.148	0.034
Cover article	0.312	2.352	0.021

to acquire health knowledge, 75.9% reported that WOAs and other social media were major sources of health information, and 78.1% reported that nutrition and diet information is the health knowledge of greatest concern. In addition, 69.38% (403), 10.00% (58), and 3.10% (18) of the followers were from Shanghai, Jiangsu Province, and Zhejiang Province, respectively. The population distribution of respondents was basically consistent with the distribution of WOA of Shanghai Ruijin Hospital followers (**Table 5**, **Figure 3**).

The Influencing Factors of Users Reading Health Articles About Nutrition and Diet Knowledge

The univariate analysis results showed that gender, age, the knowledge acquisition approach (circle of friends, WOAs and other social media, hospitals, off-line classes, television media and internet search), the contents of health knowledge (cancer precaution, traditional Chinese medicine, debunking health rumors, first-aid knowledge, and digital healthcare), and social media strategies (providing new health knowledge, being an important source of health knowledge, professionalism and authority, close-to-life articles, the use of caricatures, engagement with the public) are closely related to users reading articles of nutrition and diet knowledge ($p < 0.5$) (**Table 6**).

The multivariate analysis results showed that female respondents were 4.651 times more concerned with nutrition and diet than male respondents ($p < 0.001$). Moreover, younger respondents were more likely to read nutrition and diet articles

TABLE 5 | Respondents' demand for health knowledge.

Basic information	Number of cases	Percentage (%)
Gender		
Male	196	33.7
Female	385	66.3
Age distribution		
≤35 years	213	36.7
35–45 years	112	19.3
45–60 years	96	16.5
≥60 years	160	27.5
Whether you actively acquire health knowledge		
Yes	534	91.9
No	47	8.1
Where you get your health knowledge		
Newspapers and books	249	42.9
Television media	283	48.7
Internet search	293	50.4
WOAs and other social media	441	75.9
Circle of friends	239	40.8
Hospitals	309	53.2
Off-line classes	185	31.8
What type of health knowledge are you most concerned about?		
Cancer precaution	237	40.8
Nutrition and diet	454	78.1
Chronic diseases	324	55.8
Traditional Chinese medicine	209	36.0
First-aid knowledge	197	33.9
Mental health	237	40.8
Debunking health rumors	229	39.4
Digital healthcare	136	23.4

($p < 0.001$). Regarding the knowledge acquisition approach, articles shared by a user's circle of friends, a WOA and other social media, hospitals, and television media were found to increase users' engagement with nutrition and diet articles by 2.586, 2.183, 3.194, and 4.348 times, respectively ($p < 0.05$). It was also found that users were 4.333 and 2.121 times more likely to be concerned about cancer precaution and traditional Chinese medicine articles than nutrition and diet articles ($p < 0.001$). In terms of social media strategies, professionalism and authority, were found to increase users' preference for nutrition and diet knowledge by 135.4%, respectively ($p < 0.0001$), but no effects of the use of a humorous strategy or caricatures, close-to-life articles, and engagement with the public were observed.

DISCUSSION

Food is an indispensable part of life, and there is an old Chinese saying that "food is the most important thing for the people." Chronic diseases and even tumors are closely related to poor eating behaviors. Throughout the past three decades, the dietary intake of Chinese people has changed substantially (3, 30), and the current dietary structure is unreasonable. Combined with the unhealthy lifestyle factors of insufficient physical activity, smoking, and excessive drinking, the problems of overweightness, obesity, and diet-related chronic diseases are becoming increasingly more serious in China (31, 32). Obesity increases the risk of many chronic diseases, such as hypertension, cardiovascular disease, and diabetes. China spends approximately CNY 24.35 billion (USD 3.24 billion) each year to treat obesity-related diseases, accounting for 2.46% of its annual healthcare expenditures (33). Primary prevention is the most effective and affordable means by which to prevent chronic diseases, and emphasizing the quality and quantity of food may be the best measure to achieve long-term personal and social goals at each stage of the life cycle. In 2016, the Chinese government proposed the "Healthy China" strategy (9), and has issued a series of nutrition and health policies, such as the "China Nutrition Improvement Action Plan," the "Food and Nutrition Development Strategy for China (2014–2020)," the "National nutrition plan (2017–2030)," and "Healthy China action (2019–2030)," to realize the popularization of health knowledge, an appropriate diet and national fitness, and other major actions.

Yang et al. (34) reported that Chinese adults have poor dietary knowledge, attitudes, and behaviors, while healthy dietary knowledge, attitudes, and behaviors are associated with higher self-rated health. The theory of knowledge, attitudes/beliefs, and behaviors/practices (KAB) was originally proposed to emphasize the vital role of knowledge, attitudes, and behaviors in health management (35). Sun et al. (36) found that, in China, to improve one's health, the most important measure is to increase one's own dietary knowledge. Specifically, the assessment of diet-related knowledge attitudes is of vital importance in dietary health promotion at the population level (37, 38), and whether the nutrition policies and implementation of nutrition education are of interest to the public must be determined. The results of the regression analysis conducted in the present study revealed that nutrition and diet-related health knowledge is associated with a higher influence index.

WOAs can effectively combine limited health education resources with modern science and technology and can promote people to learn about the health concepts of various diseases to effectively prevent and treat chronic diseases (39, 40). Zhang et al. (41) found that online nutrition education improved participants' knowledge of, as well as their intentions regarding, healthy dietary and lifestyle choices. A systematic review evaluated improvements in chronic disease management based on social media use, and revealed that social media, especially Facebook and blogs, provides social, spiritual, and empirical support for chronic diseases; the use of these social media platforms are thus highly likely to improve patient health (42). The present study analyzed data released by the Shanghai Ruijin Hospital WOA, and found that the nutrition and diet articles published by the WOA had the highest influence index values. This result is similar to the findings of previous research; for instance, Zhang et al. (41) found that the public likes to read and praise articles about food safety and nutrition, infectious diseases, vaccination, and healthy lifestyles.

The factors that affect people's interest in nutrition and diet knowledge were investigated in this work. A questionnaire survey

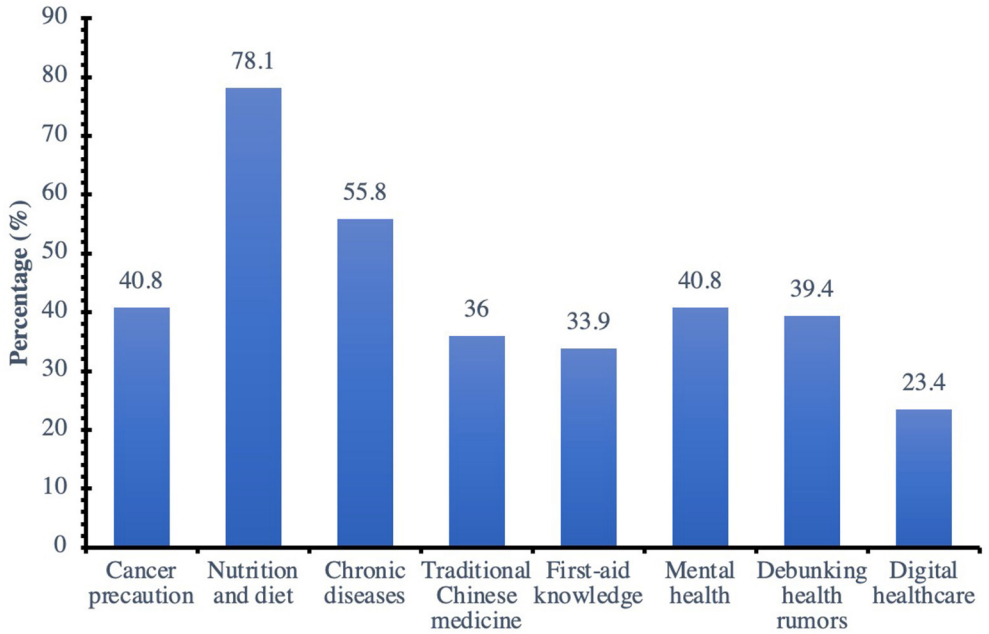

FIGURE 3 | What type of health knowledge are you most concerned?

was conducted, and it was found that women are more interested in nutrition and diet knowledge than men. This result is similar to the findings of previous research. For example, Lacaille et al. (43) reported that women expressed a more specific desire to eat healthily and indicated that this was of greater value to them than did men; moreover, women seemed more motivated to eat healthily. Nelson et al. (44) found that women regarded all five food motives (including health and weight concerns) to be more important than their male counterparts. Surprisingly, the multivariate logistic analysis conducted in this study showed that younger people are more concerned with nutrition and diet knowledge. Many young people have access to the internet anywhere at any time on several portable digital devices, and this has enabled more opportunities to look up information rapidly and conveniently. By managing weight and appearance *via* diet, young adults feel that they could enhance their social image, popularity, and attractiveness, and ultimately their success in finding a partner (45, 46). Despite the predominance of overweightness and obesity, the "thin and fit" ideal remains the default societal standard. Young adults note that healthy eating is ultimately within their power, and that autonomous or self-driven motivation exists.

In the present study, it was also found that social media, circles of friends, and television media affect users' concerns about nutrition and diet knowledge. Social cognitive theory considers that adults adopt the behavior of others through observation and vicariousness, and that such behavior becomes ingrained through positive outcomes. Regarding dietary behavior, this observation is multifaceted, e.g., what family and friends eat day-to-day (47). This influence is becoming increasingly notable *via* numerous social media platforms (48). A scoping review suggested the necessary use of social media platforms due to their viral nature, their reach and influence *via* peer pressure, and their popularity for health promotion (49). It was also found that the knowledge source of hospitals and the strategy of professionalism and authority affect users' concerns about nutrition and diet knowledge. Of course, healthcare professionals are trained to be literate in health matters and have information about the human body and causes of diseases. Regarding nutritionists and doctors in China's top public hospitals, their nutrition and diet knowledge represents professionalism and authority, and is favored by followers. It would be therefore worthwhile for healthcare professionals to package health information in an easily accessible manner using online resources to reach young adults and sensitize young individuals (50).

After multivariate analysis, the results showed that interest in cancer precaution and traditional Chinese medicine is connected to users' preferences for nutrition and diet knowledge, as this type of health information is inextricably linked to nutrition and diet, indicating that cancer precaution and traditional Chinese medicine knowledge related to nutrition and diet is of greater interest to the public. For example, among the 101 articles considered in this study, the influence index of the following nutrition-related cancer precaution article was ranked 11th:

Does eating red meat cause cancer? Does eating red meat cause diabetes? Nutrition experts tell you how to eat meat.

The high consumption of red meat (e.g., beef, pork, lamb, and goat) and processed meat (e.g., luncheon meats, frankfurters, bacon, and sausage) has been associated with the increased risk of colon, stomach, and pancreatic cancers, and with higher cancer mortality overall (51). Therefore, consuming a healthy diet aid

TABLE 6 | The influencing factors of users' reading of nutrition and diet knowledge articles.

	Univariate logistic analysis		Multivariate logistic analysis	
	OR (95% CI)	***p***	**OR (95%CI)**	***p***
Basic information				
Gender	2.813 (1.879, 4.212)	0.000*	4.651 (2.598, 8.325)	0.000*
Age	0.538 (0.451, 0.641)	0.000*	0.358 (0.266, 0.481)	0.000*
Knowledge acquisition approach				
Circle of friends	2.572 (1.648, 4.014)	0.000*	2.586 (1.373, 4.868)	0.003*
WOAs and other social media	3.640 (2.384, 5.556)	0.000*	2.183 (1.204, 3.960)	0.010*
Hospitals	3.311 (2.173, 5.044)	0.000*	3.194 (1.793, 5.692)	0.000*
Off-line classes	1.676 (1.065, 2.637)	0.025*	0.916 (0.473, 1.772)	0.795
Television media	1.766 (1.180, 2.643)	0.006*	4.348 (2.341, 8.077)	0.000*
Internet search	1.385 (0.932, 2.057)	0.107*	0.718 (0.386, 1.337)	0.296
Contents of health knowledge				
Cancer precaution	3.793 (2.345, 6.136)	0.000*	4.333 (2.262, 8.299)	0.000*
Chronic diseases	1.120 (0.794, 1.579)	0.519		
Traditional Chinese medicine	2.952 (1.823, 4.780)	0.000*	2.121 (1.064, 4.230)	0.033*
First-aid knowledge	1.262 (0.825, 1.933)	0.284*	0.675(0.371, 1.226)	0.196
Mental health	1.034 (0.693, 1.545)	0.869		
Debunking health rumors	1.783 (1.165, 2.728)	0.008*	0.985 (0.510, 1.901)	0.964
Digital healthcare	1.405 (0.859, 2.301)	0.176*	0.598 (0.292, 1.227)	0.161
COVID-19	1.059 (0.667, 1.680)	0.808		
Subjective social media strategies of the Shanghai Ruijin Hospital WOA				
Providing new health knowledge	1.411 (1.150, 1.732)	0.001*	0.746 (0.401, 1.388)	0.355
Being an important source of health knowledge	1.341 (1.106, 1.626)	0.003*	1.422 (0.793, 2.549)	0.238
Professionalism and authority	1.580 (1.285, 1.944)	0.000*	2.354 (1.231, 4.505)	0.010*
Close-to-life articles	1.504 (1.224, 1.848)	0.000*	0.886 (0.434, 1.812)	0.741
Use of caricatures	1.533 (1.256, 1.876)	0.000*	1.547 (0.998, 2.398)	0.051
Use of humor	1.300 (1.064, 1.588)	0.010*	0.814 (0.542, 1.225)	0.324
Engagement with the public	1.032 (0.834, 1.277)	0.771		

*$p < 0.05$.

in achieving and maintaining a healthy weight, and provides nutrients that may aid in preventing cancer. Furthermore, Miyashita et al. (52) reported that there is a need for more knowledge about healthy nutrition, which is often not satisfied, as was demonstrated in the context of a survey of Japanese breast cancer patients.

The present study also found that the type of communication used in articles is also related to user engagement. Compared with the use of a declarative sentence to convey health knowledge, articles that use humor and caricatures were found to be more likely to have a high influence index value and a higher number of "likes." These results are in concordance with previous publications that have reported the use of humor and caricature strategies as the key features for attracting the greatest amount of user engagement, and that posts with images have higher rates of liking and sharing (53, 54).

However, nutrition science now is facing a credibility problem with the public (55–57). Although numerous discoveries and advances in the field have made great contributions to human health, nutrition science is more complex than other scientific disciplines in many aspects. According to the "2017 Tencent Rumor Governance Report," articles related to health, health preservation, and food safety are the most numerous (58). Thus, real and scientific health information, especially that related to nutrition and diet, is particularly important for health promotion and education.

Meyrowitz proposed the theory of the "media scene," and posited that the emergence of and changes in media will inevitably lead to changes in the social environment and human behavior (59). The mode of "new media → new scenario → new behavior" reflects the combination of media studies with social studies, the inclusion of the audience in media situations, and the change of the social structure and society *via* new media scenes. Research on health communication in China is in its infancy, and nutrition education-related research is rare. *Via* an objective analysis of real data, the present study found that nutrition and diet information is the most influential health knowledge, and then analyzed the health knowledge concerned by users and its influencing factors from the perspective of user needs. Finally, the health knowledge needed by the public was found to be consistent with the "Healthy China" health education strategy advocated by the Chinese government. *Via* social media, such as WOAs

and, recently, TikTok, health education has changed, which has caused people to change their lifestyles and behaviors. Indeed, for the release of health and diet knowledge, it is suggested that an elite professional team be set up to produce reliable, authentic, rigorous, and humorous health knowledge to gain public recognition.

The results presented in this research provide hospitals or public health agencies some guidance on how they may improve health promotion and engagement with social media users. Some practical suggestions are also provided on the basis of the findings of this study. First, social media account operators can help increase information dissemination. The careful study of users' information consumption and dissemination behavior may allow operators to decide the type of information that is of interest to the public. The article content has been identified as an essential factor in determining whether WeChat users forward or share articles with friends (25). Therefore, medical institutions should fully utilize nutrition and diet knowledge to enhance diffusion. Second, the conclusions of this study could be explored in greater depth by investigating Twitter, Facebook, and/or YouTube trends in other countries, which would reflect the worldwide campaign in the domains of nutrition informatics and health dissemination. This strategy might help authorities determine what kind of information the public needs. If dissemination is efficient, the public will receive accurate information and useful prevention suggestions in a timely manner.

However, this study was characterized by some limitations. First, the methods of only a single hospital were reported and analyzed, and data from other hospitals were not collected or analyzed for comparison. However, the WOA of Shanghai Ruijin Hospital has 1,120,533 followers until June 11, 2021 and the influence of Shanghai Ruijin Hospital's WOA ranks among the top 20 hospitals in China. Thus, we consider the WOA of Shanghai Ruijin Hospital is a benchmark in the field of health promotion in China. Second, the types of social media and channels are changing rapidly, such as *via* the emergence of TikTok; due to its increasing popularity over WeChat, the construction of a TikTok group for Shanghai Ruijin Hospital has already been expedited. Third, the Shanghai Ruijin Hospital WeChat account was established in 2016, whereas the reference data considered in this study was only from 2020, when the hospital started its WOA drive. Fourth, because WeChat and mobile phones began to gain in popularity in China in recent years, these social media strategies have only been implemented for the past several years; details on longitudinal trends remain to be studied.

CONCLUSIONS

WeChat official accounts are widely accepted media that provide health articles to users. Nutrition and health information is the most important type of health knowledge concerned by users. In this study, the factors that influence users' attention to nutrition and diet knowledge were found to be gender (female), age (young adult), contents of health knowledge (cancer precaution), and various social media strategies. Medical institutions should make full use of social media to popularize nutrition knowledge. Nutritionists or personnel engaged in nutrition education should also pay more attention to the importance of social media, not only off-line classes or outpatient consultation, to popularize the concept of nutrition and health.

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 Ethics and Research Committee of Ruijin Hospital. The patients/participants provided their written informed consent to participate in this study. Informed consent was obtained from all subjects involved in the study.

AUTHOR CONTRIBUTIONS

FZ and DB: conceptualization. DB and GL: methodology. FZ, YS, and CS: validation. DB: formal analysis and writing—original draft preparation. DL, KH, and WT: investigation. CS: data curation. GL and FZ: writing—review and editing. YS and WT: supervision. All authors have read and agreed to the published version of the 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.2021.775729/full#supplementary-material

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Assessment of Knowledge, Attitudes, and Factors Influencing the Selection Student of Generic Medicine

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Background: Generic replacements for branded medicines have become a typical practice among registered pharmacists all over the world. Therefore, this study was aimed to determine the influence of the knowledge and attitudes of PharmD students and other factors on the selection of unbranded medicines.

Methods: A descriptive, cross-sectional study was conducted through Google Forms to collect data using self-reported questionnaires. The data was collected over a period of 3 months, from January to March 2021, among junior level pharmacy students who are currently undertaking a PharmD course at the King Saud University, College of Pharmacy, Riyadh, Saudi Arabia.

Results: The mean age of the students was 21.05± (SD = 1.03), majority of students 70.2% ($n = 134$) were able to define the term generic medicine, and about 65% ($n = 123$) were able to correctly define bioequivalence. More than half of the students, 56.5% ($n = 108$) lacked knowledge about the pharmacokinetic parameters of generic products. Meanwhile, the majority, 85% ($n = 122$), supported generics over branded medicines, and about 66% ($n = 99$) agreed that wider use of generic medicines would lead to less money required for the research and development of new pharmaceuticals.

Conclusion: Findings revealed that most pharmacy students possess sufficient knowledge of generic medicines, although knowledge in some aspects remains lacking.

Keywords: generic drugs, knowledge, attitudes, factors, pharmacokinetic, bioequivalence

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BACKGROUND

With advanced healthcare, costs are on the rise, including the cost of pharmaceuticals (1, 2). Consumption of drugs has been identified to be a large factor in the increasing costs of medical services, although evidence suggested that generic replacements for branded medicines have become a typical practice among registered pharmacists all over the world (3–5). Generic drugs are pharmaceutical products that are bioequivalent to branded drugs in both physical and chemical qualities (6–8). The estimated global spending on drugs is expected to exceed USD 1.5 trillion by 2023 (9). However, reports revealed that the estimated Saudi pharmaceutical expenditures are closer to USD 8 billion (9–11). Despite the supply and demand of drugs in the market, the prevalence of

communicable and non-communicable diseases have become increasingly worldwide, and Saudi Arabia is not an exemption, which in turn increases the medicine expenditure cost to the patient and health care system (9–11). According to recent estimates, ∼18.5% of the population over the age of 20 is disabled, 35% is obese, and over 23% has hypertension. The Saudi Arabian healthcare burden has been noted to rise at a rapid rate in recent years, and it is expected to grow even further (9–11). However, more initiatives and investments have begun in recent years to stimulate pharmaceutical products as part of a strategic plan to produce at least 40% of all medicines locally in the long term (12, 13).

Multiple reports revealed that the use of generic drugs in comparison to branded medicines has allowed patients to save money without compromising healthcare quality (8, 13–15). The knowledge and attitudes of pharmacists were found to be influencing factors in promoting this generic substitution. Several previous studies also evaluated the knowledge and attitudes of pharmacists about prescribing generic drugs at both the national and international levels (3–6). Several previous studies measured the attitudes and perceptions of community pharmacists (3–5, 16) and other health care professionals toward generic drugs including in Saudi Arabia and other international countries (8, 13, 16). Besides this, earlier studies among practicing health care workers, including pharmacists, concluded that generic drugs are therapeutically equivalent to their brands and effectiveness was similar to branded medicine (4, 13, 17, 18). Although data among student pharmacists found negative attitudes (14). In Yemen, a previous study by Othman and Abdulghani among pharmacy students reported negative attitudes and beliefs that generic medicines are less effective than branded medicines (14). Similarly, another study by Othman and Abdulghani reported negative perceptions of generic medicines as inferior, less effective, and produced more side effects compared with branded medicines (14). Likewise, another study among health care students from Pakistan reported positive perceptions and knowledge about prescribing generic drugs (15). In Saudi Arabia, there have been many published reports examining the attitudes of practicing pharmacists. Although studies among pharmacy students remain to be lacking. As pharmacy students represent our future pharmacists, determining their views about generic prescriptions is crucial in promoting generic drug substitution. In this study, we evaluated the knowledge and attitudes of pharmacy students, as well as other factors that may affect the selection of generic drugs.

METHODS

This study used a descriptive, cross-sectional design and was conducted at the King Saud University, college of pharmacy, among PharmD students over 3 months, from January to March 2021. The data collection was carried using self-administered questionnaires through Google Forms. The inclusion criteria included were participants who were currently enrolled in the King Saud University College of Pharmacy and students of entry levels (second and third year), who were enrolled in the study. Senior students and students from other courses and other universities in Saudi Arabia were excluded from the study.

The questionnaires for this study were prepared after an extensive review of similar studies published in other countries (13, 14). The First draft of the questionnaires was reviewed by the research team comprised of a professor and the researcher. The first section had 10 questions examining the knowledge of pharmacy students on generic drugs I binary answers (Yes/No). The second section of the survey contained questions concerning attitudes, which were measured using a 5-point Likert scale ranging from "strongly agree" to "strongly disagree," with a total of 14 items. The third section contained questions regarding possible barriers or factors that might influence the prescription of generic drugs in Saudi Arabia, adopted from a previous study (13, 14).

The questionnaires were translated into the national language using the assistance of an Arabic-speaking senior professor in the Clinical Pharmacy department and a certified Saudi Arabian translator. Before the survey questionnaires were distributed to the intended participants, a pilot study was conducted among a randomly selected group of 10 pharmacy students. The pilot study was done to test the reliability of the questionnaires. The reliability was determined using the Cronbach alpha value, which was found to be 0.71. The results of the pilot study were not included in the main study. The validated Arabic questionnaires were then used for data collection. Social media platforms were chosen as the potential medium for data collection.

The Raosoft online calculator was used to calculate the sample size for this study (http://www.raosoft.com/samplesize.html). The sample size was calculated by assuming 300 students as the population and currently registered in the university pursuing their second and third-year courses with a confidence level of 95% and a predetermined margin of error of 5%, which resulted in a sample of 169 individuals (16). We assumed that the response distribution for each question would be 50% because we are not sure what to expect the results for each question. We used 50% as the response distribution, which gave a larger sample size for this research (16).

The data were collected through online questionnaires after personally contacting the leader of the course. We created the google forms and the electronic survey link was distributed to the students. In the survey link, before answering the questionnaire, there was an introductory paragraph that talked about the objectives and importance of the study. The students were informed that their contribution was voluntary and anonymous and the students who read and agreed to the next page were redirected to research questions, considered as the consent from the student. However, this study was conducted following the guidelines of the Checklist for Reporting the Results of Internet E-Surveys (CHERRIES) (19). The ethical committees from the College of Medicine King Saud University have reviewed the questionnaires and granted permission to carry out the study. The study got institutional ethical approval from the College of Medicine, King Saud University Riyadh Saudi Arabia.

TABLE 1 | Knowledge of Saudi PharmD students on generic medicines ($n = 193$).

Knowledge items	Correct (%)	Incorrect (%)
1. A generic medicine is a drug that is sold under a different brand name or the drug's non-proprietary name.	134 (70.2)	57 (29.8)
2. Before they can be licensed for marketing, generic products must be bioequivalent to the innovator brand.	123 (64.4)	68 (35.6)
3. In nations that require bioequivalent data, product quality data are NOT necessary before a generic product can be registered.	170 (89)	21 (11)
4. It is thought that a generic product's efficacy, quality, and safety are comparable to the original branded product if it meets bioequivalence and product quality requirements.	123 (64.4)	68 (35.6)
5. Two pharmacological drugs are bioequivalent if they are pharmaceutically equivalent and their bioavailability is close enough that their effects can be expected to be substantially the same in terms of efficacy and safety.	112 (58.6)	79 (41.4)
6. The 90% confidence intervals for the ratio of each pharmacokinetics parameter must be within the range of 90–110% for a generic medicine to be bioequivalent to its innovator brand or other generics.	83 (43.5)	108 (56.5)
7. A generic drug is typically created without a license from the innovator business, but marketed after the patent or other exclusive rights on the original medicine have expired.	133 (69.6)	58 (30.4)
8. When two medicinal products are bioequivalent, the calculated Cmax and AUC ratios for each formulation can differ by 20–25%.	138 (72.3)	53 (27.7)
9. Where a "generic substitution" policy exists, community pharmacists are permitted to distribute a different brand of the drug, but may or may not refer the patient back to the doctor, depending on the jurisdiction/law.	94 (49.2)	97 (50.8)
10. If a generic drug is bioequivalent to a branded drug, it is also therapeutically equivalent.	126 (66)	65 (34)

TABLE 2 | Possible factors influencing generic drug selection.

Variables	Least important factor *n* (%)	Important factor *n* (%)	Neutral *n* (%)
Lack of faith in generic drugs	23 (12)	85 (44.5)	83 (44.5)
Policies, laws, and regulations are readily available.	16 (8.4)	133 (69.6)	42 (22)
Consequences for law	17 (8.9)	126 (66)	48 (25.1)
Customer costs are lower.	15 (7.9)	153 (80.1)	23 (12)
No other option is available.	29 (15.2)	108 (56.5)	54 (28.3)
The appearance or nationality of the customer	115 (60.2)	29 (15.2)	47 (24.6)
Generic drugs are cost-effective.	15 (7.9)	137 (71.7)	39 (20.4)
Confidence in the product	46 (24.1)	89 (46.6)	56 (29.3)

Statistical Analysis

The data were analyzed using SPSS Version 26 (IBM, Armonk, New York, United States) for Windows. Descriptive statistics, including percentages and frequency distribution, were calculated for each variable. For the age variable, the mean values were presented.

RESULTS

In total, 193 PharmD students self-administered the online questionnaire. The mean age of the students was 21.05± (SD = 1.03). The knowledge of generic medications among the PharmD students is shown in **Table 1**. More than 70% of the students (134/193, 70.2%) were able to define the term generic medicine, and more than half (123/193, 64.4%) were able to correctly define bioequivalence. Between 89 and 65% of the surveyed students identified the requirement for the bioequivalence data, quality efficacy, and safety requirements for generic drugs, similar to the original branded products. More than half of the students (108/193, 56.5%) lacked knowledge about the pharmacokinetic parameters of generic products; however, more than 70% of the students (138/193, 72.3%) agreed that when two drug products are bioequivalent, it means that the Cmax and area under the curve (AUC) ratios estimated for each formulation can vary by 20–25%. Finally, most of the students (126/193, 66%) correctly identified that if the generic is bioequivalent to a branded medicine, it implies that it is restoratively similar.

Students reported that cheaper costs to patients (153/193, 80.1%); cost-effectiveness of generic medicines (137/193, 72%); availability of policies, laws, and regulations (133/193, 69.6%), and legal implications (126/193, 66%) were the most important factors influencing generic drug selection (**Table 2**).

As per our findings, the majority of students (122/193, 85%) reported (agreed/strongly agreed) that they would support generic over brand name drugs in all cases where a generic is

TABLE 3 | Attitudes on generic medicines utilization ($n = 193$).

Variables	Strongly agree *n* (%)	Agree *n* (%)	Disagree *n* (%)	Strongly disagree *n* (%)	Neutral *n* (%)
In all circumstances where a generic is available, I favor generic substitutes for brand-name medications.	45 (23.6)	77 (40.3)	9 (4.7)	5 (2.6)	55 (28.8)
Less money will be spent on research and development of novel drugs as generic medicines become more widely used.	32 (16.6)	67 (34.7)	33 (17.3)	15 (7.8)	44 (23)
The government of Saudi Arabia will save money on healthcare if generic drugs are used more widely.	23 (11.9)	52 (26.9)	49 (25.7)	12 (6.2)	55 (28.5)
Switching a patient from a branded to a generic treatment can have an impact on the drug's outcome.	16 (8.4)	36 (18.8)	64 (33.5)	21 (11)	54 (28.3)
Most generic products have a high rate of therapeutic failure.	19 (9.9)	43 (22.5)	47 (24.6)	20 (10.5)	62 (32.5)
All medications approved as generic drugs by Saudi Arabia's health authorities can be regarded therapeutically similar to their brand-name counterparts.	47 (24.6)	69 (36.1)	14 (7.3)	4 (2.1)	57 (29.8)
Because the price difference between generic and branded drug is frequently so large, I feel compelled to administer prescriptions with generic replacement, especially for those who do not have prescription drug coverage in Saudi Arabia.	34 (17.8)	67 (35.1)	26 (13.6)	7 (3.7)	57 (29.8)
Patients should be given a thorough explanation of why generic drugs were chosen for their therapy.	45 (23.6)	59 (30.9)	14 (7.3)	34 (17.8)	39 (20.4)
When it comes to dispensing generics, the intensity of promotional actions by medical representatives is crucial.	19 (9.9)	70 (36.6)	9 (4.7)	19 (9.9)	74 (38.7)
Bioequivalence evidence should be required before a generic product is marketed in Saudi Arabia, according to health officials.	58 (30.4)	55 (28.8)	5 (2.6)	22 (11.5)	51 (26.7)
Without consulting the prescribing physician, pharmacists should be able to make generic substitutions.	32 (16.8)	55 (28.8)	37 (19.4)	20 (10.5)	47 (24.6)
Pharmacists must consult with the prescribing physician before beginning generic substitution.	19 (9.9)	56 (29.3)	32 (16.8)	24 (12.6)	60 (31.4)
Only when substituting specific types of medications, such as those with a limited therapeutic index, should pharmacists speak with the prescribing physician.	29 (15.2)	63 (33)	23 (12)	20 (10.5)	56 (29.3)
In general, I would not provide my patients generic medications (in the future, if I became a pharmacist in KSA).	4 (2.1)	23 (12)	60 (31.4)	28 (14.7)	76 (39.8)

available. More than half of the students (99/193, 66.7%) agreed that the wider use of generic medicines would mean that less money would be required for the research and development of new pharmaceuticals. Further, most students (75/193, 64%) have also agreed that the use of generic medicines would result in decreased healthcare expenditure by the government. When asked about therapeutic equivalence, most of the students (116/193, 82.7%) accepted that all products approved as generic drugs by the health authorities in the state of Saudi Arabia can be considered therapeutically equivalent to their branded counterparts; ∼69% (101/193) of the students agreed that the price difference between generic and branded drugs is often so great that they feel they should dispense prescriptions of generic substitutions, especially for people who do not have prescription drug benefits in Saudi Arabia.

When asked about the requirements of generic drugs, 113/193 (86.4%) of the students agreed that health authorities should implement policies that bioequivalence data are mandatory before a generic product is marketed. More than half of the students (87/193, 60.4%) thought that pharmacists should be allowed to perform generic substitutions without consulting the prescribing physician. Slightly less than half (75/193, 48%) agreed that they should consult physicians before prescribing generics to patients; however, about 62% (92/193) of the students accepted that pharmacists should be required to consult the prescribing physician when substituting certain categories of drugs with narrow therapeutic indices. The details of the attitudes of Saudi PharmD students toward generic substitutions are described in **Table 3**.

The most common source of information for the generic medicine among the students was social media and the internet 117 (60%), followed by academic teacher 109 (55.9%), printed materials and textbook 79 (40.5%), ministry of health 72 (36.9%), and radio or television 4 (2.7%) (refer to **Figure 1**).

DISCUSSION

In this study, the responses of male pharmacy students were collected, but the female students were excluded. This is likely because of the Islamic prevalence of Saudi Arabia, where men are prohibited to interact with females and where coeducation is strictly prohibited. In this study, ∼65% of the students agreed

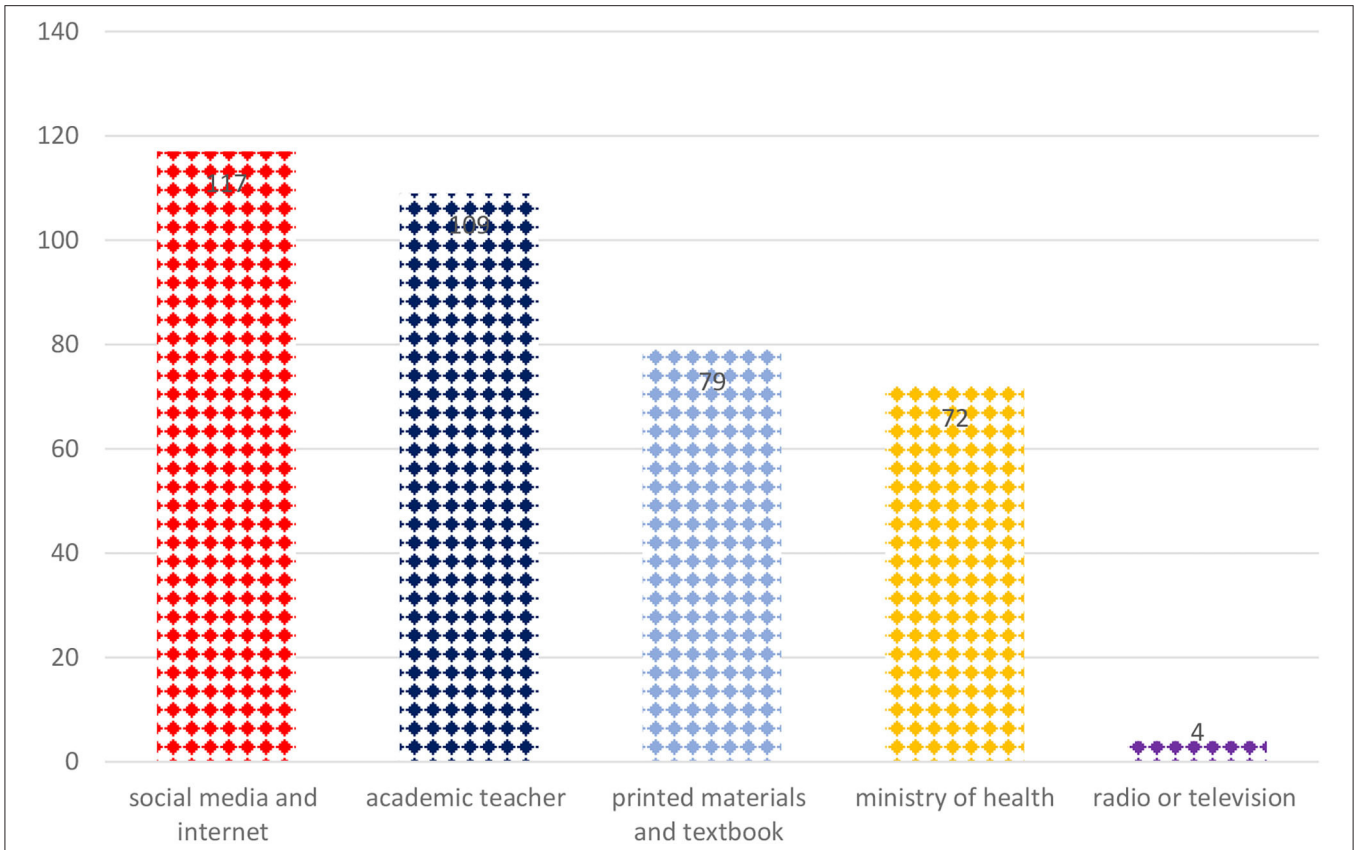

FIGURE 1 | Resources about generic medicine.

that generic products are similar in efficacy, quality, and safety compared to the original branded products. These findings were in line with earlier studies from Ethiopia (67%) (20), but higher than the findings of James et al. (55%) (21), Belay et al. (52.9%) (22), Toklu et al. (46.1%) (23), and Al Hussain et al. (42.2%) (24). However, our results were still lower than earlier studies by Grover et al. (70%) and Wajid et al. (72.2%) among community pharmacists (3, 25). One study among Yemeni pharmacy students from private universities revealed that students perceived generic medicines to be inferior and less effective and, thus, could lead to more side effects compared with branded medicines (14). The difference in knowledge about generic medicines might be due to the fact that the majority of respondents in the current study are currently undergraduates and entry-level students with a lack of working experience or training in pharmacy settings.

Only about 44% of the students correctly answered that pharmacokinetic parameters of generic drugs must lie within 90–110% of their branded counterparts, with a 90% CI, which is lower than the previous study among Yemeni students (55.2%) (14). These current findings suggested that Saudi students might have less understood the concept of bioequivalence and its limits for generic medicine. In this study, the majority of the students used social media as the source for generic medicine followed by academic teachers and printed materials. As evidenced from the current findings how prevalent internet use is among students as it is providing medical and pharmaceutical-related information very quickly at any time period, which might be the fact that students had good knowledge about generic drugs and substitution.

This study found that 85% of the students support generic substitution, while about 67% believe that generic medicines are cheaper, consistent with earlier studies published among pharmacists and pharmacy students. The majority (80%) of students knew the definition of generic drugs, which is similar to earlier studies published among Pakistani and Yemeni students (14, 15). This finding suggested that most students and working pharmacists were well-informed about the prescription of generic drugs, perhaps due to various hospitals and community outlet training and rotations required before their graduation. These current study results were also consistent with those of a previous study published among pharmacy and medical students from Pakistan, which reported that both pharmacy and medical students agreed that the use of generics had the capacity to reduce pharmaceutical expenses as compared to high-priced name brand medicines (15). In our study, slightly less than half of the students agreed that prescribing generics saved costs to the government as well as to the patients. According to this study, most of the students disagreed that therapeutic failure is a serious problem with most generic products, and the majority

of students agreed that all pharmaceuticals approved as generic drugs by the health authorities in Saudi Arabia can be considered therapeutically equivalent to their branded counterparts. These findings also revealed that students had a positive attitude toward generic drugs, which is similar to earlier studies from different countries (15).

Earlier studies suggested that the availability of generic drugs in the pharmacy was mainly due to bonuses being offered by pharmaceutical companies, which was a potential influencing factor for prescribing generics and maximizing pharmacy profits (14, 15, 17). This earlier finding shows that pharmacists and healthcare professionals are also prone to drug promotions and, therefore, need to be trained on how to objectively evaluate drug information from the manufacturers (14, 15, 17).

In this study, students identified that having the cheapest cost to patients; cost-effectiveness of generic medicines; availability of policies, regulations, legal implications; and having no other choices were potential influencing factors in generic drug selection. However, earlier studies found that to improve the awareness and promote the prescription of generic drugs in the public healthcare system, there is a need to publicize the quality control tests of generic drugs, which were similar to the quality of branded medicines (26). Furthermore, educational interventions were most beneficial in improving the knowledge of generic drugs among students and practicing pharmacists, as reported by Almangour et al. (27). In addition to this, allocation of financial sources and good patient–healthcare professional communication can create a positive impact of generic medicines in the minds of patients and the healthcare system. Although the current had some limitations, first this study is limited to only male pharmacy students, from a single institution, therefore the results cannot be generalizable to the whole of Saudi Arabia. Second, the study included junior-level students who are currently in their second and third year of the PharmD course. The cross-sectional nature of the study, could not be able to find out the factors affecting the generic medicine knowledge. We recommend that further studies among pharmacy students with a larger sample size are needed to create awareness and to improve the knowledge toward generic medicine in Saudi Arabia and other countries are needed.

CONCLUSION

This present study identifies that junior Pharm D students from a single university in Saudi Arabia had acceptable knowledge with respect to generic medicines. The matter of generic medicine cost and quality need to be made a focus for students lacking adequate knowledge in some aspects of the pharmacokinetics of generic medicines. Educational intervention and development of policies by healthcare government officials can improve the practice of generic medicine substitution in Saudi Arabia.

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 Committees from College of Medicine, King Saud University was reviewed the questionnaires and granted permission to carry out the study, study got institutional ethical approval from College of Medicine, King Saud University, Riyadh, Saudi Arabia. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Assessment of Beliefs, Behaviors, and Opinions About Blood Donation in Telangana, India—A Cross Sectional Community-Based Study

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Background and Objectives: Blood is an essential body fluid primarily required for regulating the body's systems and maintaining homeostasis. In developed and developing countries, concern about the demand and supply for blood is increasing. The current study aims to assess the beliefs, behaviors, and opinions of the public toward blood donation.

Methods: This was a cross-sectional study in which a self-created questionnaire with 17-items was used for data collection. The self-administered questionnaire was disseminated between November 2019 and January 2020 through social media (WhatsApp© and Facebook©). Data was analyzed using SPSS program version 26.

Results: A total of 356 questionnaires were completed with a response rate of 89%. The majority of participants were male 253 (71.1%), 336 (94.4%) considered blood donation important, 350 (98.3%) believed that blood donation saves lives, and 254 (71.3%) agreed to receive blood from voluntary donors. One-hundred sixty-seven (49.4%) were willing to donate blood voluntarily. The barriers to blood donation were fear of needles 86 (24.2%), fear of contracting a chronic disease 84 (23.6%), and lack of time 40 (11.2%). One day off (91.9%) and receiving a token 73.6% were common motivational factors for blood donation. Overall, 57% of the participants had favorable attitudes toward blood donation and 41.9% were knowledgeable. Favorable attitudes were significantly associated with being married ($P = 0.018$) and having university level of education ($P = 0.005$). Younger participants (18–29 years) had a statistically significant better knowledge than older participants (≥30 years).

Conclusion: The respondents displayed positive beliefs, opinions, and motivation toward blood donation. Additionally, most of them considered blood donation an important act and a national duty of every individual and are willing to donate in the future.

Keywords: attitudes, motivation, blood donation, Indian adults, fear for needle

BACKGROUND

Blood is an essential body fluid primarily required for regulating the body's systems and maintaining homeostasis (1). However, the demand for a safe supply of blood is increasing on a daily basis internationally, and India is no exemption (2, 3). Although previous studies reported that blood transfusions save millions of lives each year, the quality and safety of blood remain a serious concern, particularly in developing countries (2–4). Indeed, concern about the demand and supply for blood is increasing in developed and developing countries (5, 6). However, out of 195 nations, the blood supply of 119 (61%) nations were found inadequate for healthcare needs (5, 7). Interestingly, early findings indicated that India has the world's largest shortage of blood supply. Conversely, the prevalence of blood borne diseases in India is on the rise as blood is essential for the treatment of various diseases (e.g., sickle cell anemia), bleeding disorders (e.g., hemophilia), and cancer. Evidence indicates that India is home to major surgical procedures, such as ∼230,000,000 operations, 331,000,000 cancer procedures, and 10,000,000 pregnancy-related operations, every year. Such procedures require a large amount of blood (7, 8).

Blood donation is a pillar of modern medicine and saves millions of lives every year (7, 8). Nevertheless, many hospitalized patients in low- and middle-income countries lack access to safe and free supply of blood in a timely manner. Previous studies estimated that out of the demand for 303 million units of blood worldwide in 2017, only ∼272 million units were supplied. In the 119 countries with insufficient blood supply, the shortfall reached 100 million units (7, 8).

Moreover, previous studies conducted in India evaluated the attitudes and motivational factors of the public toward blood donation and reported false beliefs among individuals regarding the effects of blood donation, such as infertility, loss of strength, early aging, and anemia (2, 6). Similarly, studies from developed countries like America and Japan also reported similar barriers toward blood donation (9, 10). However, another study by Shah et al. at a blood bank in a tertiary hospital in Mumbai reported laziness and fear of infection as the major factors for blood donation hesitation (11). In developed countries, published reports demonstrated that lack of access to blood donation centers was the main factor for blood donation hesitation (12–16). Additionally, barriers are different between genders. Failing to meet the eligibility requirements has been reported commonly by females while most males reported that they were never asked to donate blood (17, 18).

According to estimates from the Central Drugs Standard Control Organization (CDSCO), the National Regulatory Authority (NRA) of India, Telangana has 151 blood banks comprised of both private and governmental blood banks, with Hyderabad having the most. Healthy adults between the ages of 18 and 75 who fulfill the donor eligibility requirements can donate blood (19–21). All blood banks are easily accessible to the general public, whether by walk-ins or by appointment (20, 21). Additionally, the city has mobile blood banks making blood donation convenient for all citizens and aims to save lives by connecting donors to blood banks (22).

A dearth of literature exists in this regard, particularly in Telangana, a state in India. Furthermore, international studies on blood donation and its acceptance among the public are limited and evaluating public attitudes and motivations toward blood donation using different methods is required. In addition, the availability of a safe blood supply in healthcare centers is another challenge. Research focused on the attitudes, opinions, and motivations toward blood donation can provide an overall picture of the state of blood supply to healthcare centers not only in India but also across the world. Therefore, the aim of this study was to assess the beliefs, behaviors, and opinions of the general public toward blood donation in Hyderabad, the capital city of Telangana, India.

MATERIALS AND METHODS

Participants and Design

A cross-sectional web-based community study was conducted among adults from November 2019 and January 2020 using a structured, self-administered questionnaire. The study included individuals from Hyderabad city, Telangana state, India who aged more than 18 years, who can read and understand the English language.

Sample Size Determination

The sample size (N) was based on the previous number of blood donors in India (89.5%) (2) and calculated as follows:

$$\mathrm{N} = \mathrm{z}^2 \times \mathrm{p} \times \mathrm{q}/\mathrm{d}^2,$$

where N is the minimum sample size; z denotes the level of confidence according to the normal standard distribution that corresponds to the 95% confidence interval ($z = 1.96$); p stands for the prevalence rate of blood donors (0.895); $\mathrm{q} = (1 - p)$; and d pertains to the desired degree of accuracy or tolerated margin of error (5%; 0.05). Substituting these values into the equation, the following equation is derived:

$$\mathrm{N} = (1.96)^2 \times 0.90 \times (1 - 0.90)/(0.05)^2 = 356.$$

Therefore, $N = 356$.

Questionnaire Design

A structured, self-administered questionnaire in the English language was prepared through an extensive literature review (12–15). The questionnaire was composed of the following demographics: age, gender, level of education, and employment status. The second part was intended to collect data on the attitudes, opinions, and motivations toward blood donation using 17 items with binary answers and multiple-choice questions. The questionnaire was assessed for the level of comprehensiveness, clarity, avoidance of ambiguity, and content validity by two senior researchers and one clinical pharmacy professor who were experts in the field. A pilot study was conducted on 10 randomly selected individuals who did not mention any suggestions or corrections related to the wording, length, and format of the questionnaire. The pilot results

were excluded from the main findings. The reliability of the final questionnaire was assessed using internal consistency. The Cronbach's alpha value was 0.71, indicating an acceptable reliability of each item.

Data Collection

The final questionnaire Google Forms® link was sent to the participants through WhatsApp© and Facebook© prefaced by the eligibility requirements of participation such as consent and age restrictions. The snowball technique was used to collect data, that is, one participant was requested to refer other individuals to participate. An invitation link containing the questionnaire was sent randomly to the participants without previous measures. First, the research team targeted friends and family members, explained the objective of the study through phone calls and messages, and invited them to fill and forward the questionnaires to family, friends, acquaintances, and any other eligible individual currently living in Telangana. Complete responses to the survey were considered written informed consent as the survey included a statement on consent. To facilitate completion, the respondents were sent frequent reminders about the importance of their participation and requested to submit the completed questionnaire.

Data Extraction

The submitted questionnaires were checked for accuracy and completeness. Missing or incomplete responses were excluded (**Figure 1**).

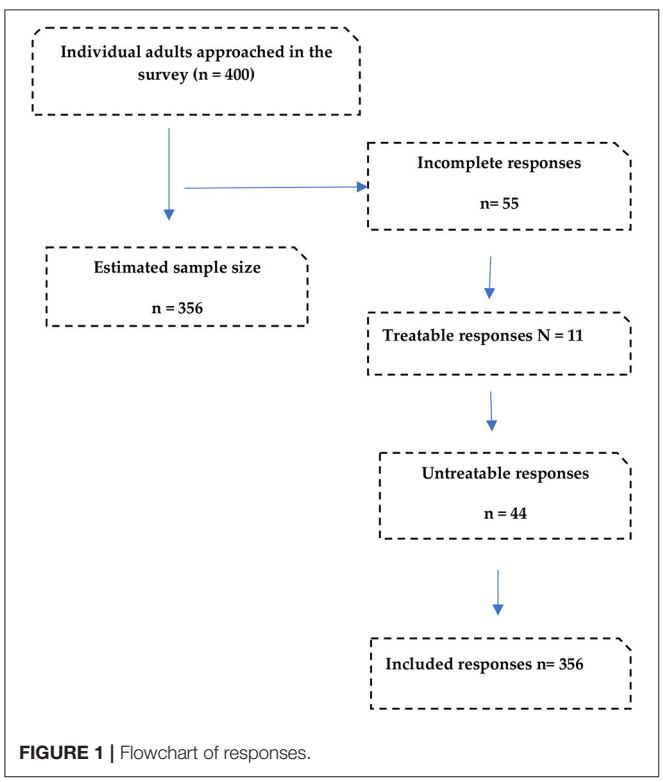

FIGURE 1 | Flowchart of responses.

Data Analysis

Data were further extracted to exclude bias in sample selection, which was limited to only the central region, and analyzed using Microsoft Excel followed by a descriptive analysis. Categorical data were calculated as frequencies and percentages. The Statistical Package for the Social Sciences version 22.0

TABLE 1 | Demographics of the participants ($n = 356$).

Characteristics	Description	Frequency	Percentages (%)
Age in years	18–29 years	291	81.7
	>30 years	65	18.3
Gender	Male	253	71.1
	Female	103	28.9
Marital status	Married	123	34.6
	Single	233	65.4
Level of education	High school	71	20.1
	University	282	79.9
Employment status	Employed	158	44.6
	Students	10	2.8
	Unemployed	186	52.2

TABLE 2 | Attitudes and opinions toward blood donation ($n = 356$).

Statements	Frequency	Percentage (%)	Favorable attitude (%)
Do you think that blood donation is an important act?			
Yes	336	94.4	94.4
No	20	5.6	
Do you think donating blood can save lives?			
Yes	350	98.3	98.3
No	6	1.7	
Do you accept blood donation from others (volunteers)?			
Yes	254	71.3	71.3
No	102	28.7	
Will you donate the blood in the future?			
Yes	341	95.8	95.8
No	15	4.2	
Do you think blood donation is a national duty?			
Yes	203	57	57
No	153	43	
What will be your reason for donating?			
As a volunteer	167	49.4	
For my family and friends	171	50.6	
Attitude score			
Unfavorable attitude (score of 4 or less out of 6)	153	43	
Favorable attitude (scored of 5–6 out of 6)	203	57	

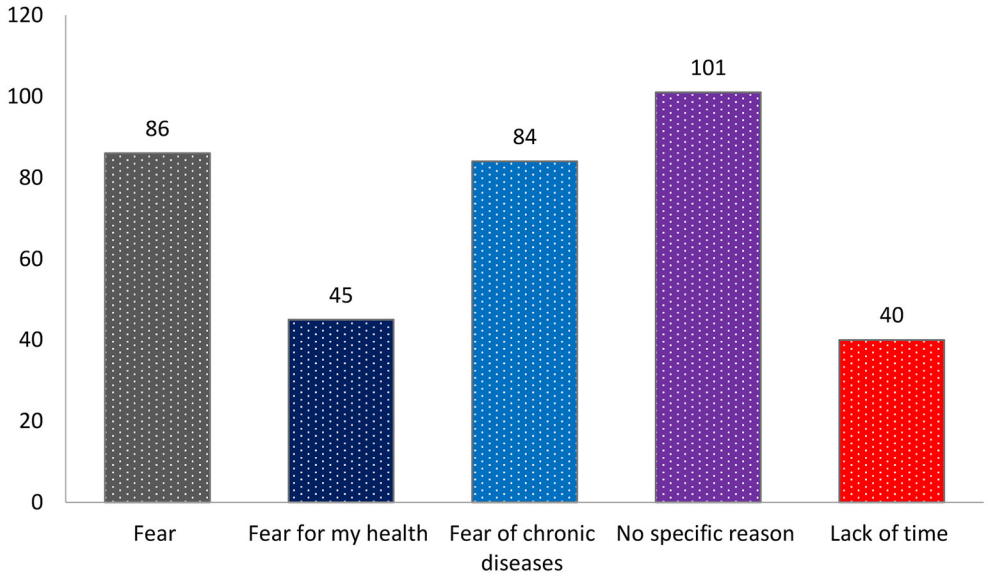

FIGURE 2 | Fears and misconceptions preventing donors from donating blood.

(SPSS Inc., Chicago, IL, USA) was used for statistical analysis. A chi-square test was used to identify associations between variables. A difference with a *P*-value of >0.5 was considered statistically significant.

RESULTS

Participant Demographics

A total of 400 questionnaires were returned, out of which 44 (9%) were incomplete and thus excluded. Therefore, the final number of respondents was 356 for a response rate of 89%. The gender-wise greater proportion of the respondents were male 253 (71.1%), and the majority 291 (81.7%) were aged between 18 and 29 years. Of the 356 respondents, 233 (65.4%) were single, and slightly more than half 186 (52.2%) were unemployed. Most of the study participants, 282 (79.9%), were University graduates. **Table 1** provides the demographics of the respondents.

Attitudes Toward Blood Donation

The majority of respondents 336 (94.4%) recognized the importance of blood donation. Nearly all the participants 350 (98.3%) stated that blood donation can help save lives, whereas 254 (71.3%) agreed to receive blood from voluntary donors. In terms of blood donation being a national duty, 203 (57%) agreed to the statement. However, slightly less than half of the respondents 167 (46.9%) would voluntarily donate blood if needed, whereas 171 (48%) may donate blood to friends and families in the future. **Table 2** provides detailed information of the respondents' attitudes.

Barriers Toward Blood Donation

Figure 2 describes the fears and misconceptions that prevent individuals from donating blood. Approximately one-fourth of the respondents 86 (24.2%) avoid donation for fear of needles, 101 (29%) reported no specific reasons, whereas 84 (23.6%) reported a fear of contracting chronic diseases. However, only 40 (11.2%) reported lack of time as the main barrier to blood donation (**Figure 2**).

Knowledge and Motivational Factors

Approximately 49.7% of the respondents reported that a healthy person may donate once a year, whereas 14 and 11.3% answered twice and thrice a year, respectively. The majority (73.8%) preferred to donate in blood banks, whereas 83.1% of the subjects were not rejected for blood donation in the past year. Regarding motivational factors, the majority (91.9%) agreed that a 1-day leave should be provided as compensation, whereas 73.6 and 25% preferred that a token and money should be given as rewards, respectively. Furthermore, the majority (93%) agreed that blood donation is an important valuable act and reported satisfaction in donating blood as a means of helping friends and family members. **Tables 3**, **4** provide detailed descriptions of the responses.

Married individuals had a statistically significant favorable attitude compared to single participants ($P = 0.018$). Participants with a university level of education had statistically significant favorable attitudes compared to those with high school education ($P = 0.005$) (**Table 5**).

Younger participants (18–29 years) had a statistically significant better knowledge than older participants (≥30 years). A statistically significant differences in knowledge categories were also reported among marital status ($P = 0.003$), educational status ($P = 0.001$) and employment status ($P < 0.001$) (**Table 6**).

DISCUSSION

The respondents indicated positive beliefs, behaviors, and opinions toward blood donation. Furthermore, the majority agreed that blood donation is an important act and helps save

TABLE 3 | Knowledge and motivations about blood donation ($n = 356$).

Variables	Frequency	Percentage (%)	Correct answer %
How many times can a person donate blood per year?			7.4
One time a year	167	49.7	
Two times a year	47	14	
Three times a year	38	11.3	
Four times in a year	42	12.5	
Five times in a year	17	5.1	
Six times a in a year	25	7.4	
If you agree to donate the blood, where do you prefer to donate?			73.8
Blood bank	256	73.8	
Residence	48	13.8	
Workplace	43	12.4	
According to your knowledge, can people with any blood type donate blood?			78.7
Yes	280	78.7	
No	10	2.8	
I don't know	66	18.5	
Do you agree that donors should be paid to promote blood donation?			75
Yes	89	25	
No	267	75	
Knowledge categories			
Knowledgeable (scores of <3 out of 4)	149	41.9	
Not knowledgeable (scores of 3 or 4 out of 4)	207	58.1	

TABLE 4 | Factors motivating blood donation.

Variables	Frequency	Percentage (%)
Do family and friends consider blood donation as an important and valuable act and encourage you to donate?		
Yes	322	90.4
No	34	9.6
Would you donate blood if given a leave from work?		
Yes	327	91.9
No	29	8.1
Does donating blood make you feel like you have helped your family members or friends?		
Yes	331	93
No	25	7.0
Do you agree that a token should be given to donors as a motivational factor?		
Yes	262	73.6
No	94	26.4

lives. Additionally, nearly all respondents indicated willingness to donate if asked, and ∼47% would donate blood as volunteers. The current results are better than those of previous studies conducted in the capital of India, where the authors reported that 69% of the respondents displayed positive attitudes toward blood donation and considered blood donation as the duty of every individual to the community (23). Joshi and Meakin conducted a study among Indian non-donors living in England and reported a variety of attitudes, but generally positive ones (4). Olaiya surveyed citizens in Nigeria, a developing country, and reported that 92.9% of the participants donated blood and demonstrated positive attitudes toward blood donation (24). However, Majdabadi et al. reported moderate attitudes among medical students in Tehran (6). Additionally, other previous studies proposed that increased awareness and motivational factors were associated with good knowledge and attitudes toward blood donation (6, 12, 24–26).

Previously published studies indicated an association between good knowledge, attitudes, and opinions toward blood donation and the availability and safe supply of blood in transfusion centers (12–15). This objective can be achieved further through increased awareness about blood donation and its importance and in-depth research on the motivational factors that encourage donors to donate. The present study found that one's fear of needles, fear of contracting chronic diseases, and lack of time were potential barriers that limit blood donation among the respondents. However, Shah et al. argued that fear of infection (21%), fear of needles (15%), and laziness were the major factors (46%) for the blood donation hesitancy (11). Similarly, a recent population-based study by Alfouzan et al. pointed to lack of time (45%) and access to blood donation centers (41.3%) (12). Karim et al. reported fear among Bangladeshi population (26). Interestingly, Dubey et al. reported that respondents were not requested to donate blood, which was considered the main potential barrier among respondents (2). Moreover, Abdurrahman and Saleh identified the side effects of receiving blood or blood components, health problems, fear of blood, medical errors, time restraints, lack of required conditions for donation, and fear of acquiring infections (e.g., HIV) as barriers among donors (13). The different types of fear among subjects, as reported by the present and previous studies, should be addressed by highlighting the importance of blood donation through programs that promote awareness, whereas misconceptions regarding infections due to blood donation should be elucidated through various educational programs about donation.

The current study demonstrated that the respondents held positive attitudes, opinions, and motivations toward blood donation in India. The findings were consistent with those of previous studies conducted in developed and developing countries and found overall positive and attitudes and perceptions toward blood donation (2, 11–13). In the current study, however, the majority of participants were willing to donate blood if asked and nearly half would donate as volunteers. These findings supported Dubey et al., who stated that most potential donors (57.25%) would donate only if required for family or friends with self-sacrifice as a lesser priority (16%)

TABLE 5 | Cross-tabulation between demographic characteristics and attitudes categories.

	Number of respondents	Unfavorable attitude (*N* = 153)	Favorable attitude (*N* = 203)	*P*-value
Age				0.489
18–29 years	Respondents	128	163	
	% within age	44.0%	56.0%	
	% within attitudes categories	83.7%	80.3%	
≥30 years	Respondents	25	40	
	% within age	38.5%	61.5%	
	% within attitudes categories	16.3%	19.7%	
Gender				0.906
Male	Respondents	108	145	
	% within gender	42.7%	57.3%	
	% within attitude categories	70.6%	71.4%	
Female	Respondents	45	58	
	% within gender	43.7%	56.3%	
	% within attitude categories	29.4%	28.6%	
Marital status				0.018
Married	Respondents	42	81	
	% within marital status	34.1%	65.9%	
	% within attitude categories	27.5%	39.9%	
Single	Respondents	111	122	
	% within marital status	47.6%	52.4%	
	% within attitude categories	72.5%	60.1%	
Educational status				0.005
University	Respondents	133	149	
	% within educational level	47.2%	52.8%	
	% within attitude categories	86.9%	74.5%	
High school	Respondents	20	51	
	% within educational level	28.2%	71.8%	
	% within attitude categories	13.1%	25.5%	
Employment status				0.239
Employed	Respondents	61	97	
	% within employment status	38.6%	61.4%	
	% within attitudes categories	40.4%	47.8%	
Unemployed	Respondents	87	99	
	% within employment status	46.8%	53.2%	
	% within attitude categories	57.6%	48.8%	
Student	Respondents	3	7	
	% within employment status	30.0%	70.0%	
	% within attitude categories	2.0%	3.4%	

Fishers exact test and chi-square test.

Younger participants (18–29 years) had a statistically significant better knowledge than older participants (≥30 years). A statistically significant differences in knowledge categories were also reported among marital status (P = 0.003), educational status (P = 0.001) and employment status (P < 0.001).

(2). However, Abdurrahman and Saleh reported that 61.2% of participants revealed that their main goal for donation is helping others and saving lives, even individuals they do not know (13). Additionally, Dubey et al. found that 13.5% of the respondents were non-donors, where 7.75% agreed to donate to gain awareness about their HIV status (2). Lastly, non-monetary incentives, if carefully targeted, can attract and retain donors (2, 15).

In the current study, the majority of respondents suggested a token, leave from work, and cash money as motivational incentives for donating blood. The results were comparable to those of Alfouzan et al. who reported 1 day off (81.4%), tokens (31.5%), and money (18.9%) as motivating factors (12). Similarly, Baseer et al. surveyed university students and identified that saving lives (98.4%), serving humanity (96.9%), and helping family and friends (95.3%) were the main motivations for donation (14). Karim et al. reported that family background, physical status, urgency for family, awareness/knowledge, and maturity level were the factors that increased participant willingness to donate (26). Irrespective of gender and age,

TABLE 6 | Cross-tabulation between demographic characteristics and knowledge categories.

	Number of respondents	Not knowledgeable (*N* = 207)	Knowledgeable (*N* = 147)	*P*-value
Age				<0.001
18–29 years	Respondents	153	138	
	% within age	52.6%	47.4%	
	% within knowledge categories	73.9%	92.6%	
≥30 years	Respondents	54	11	
	% within age	83.1%	16.9%	
	% within knowledge categories	26.1%	7.4%	
Gender				0.479
Male	Respondents	144	109	
	% within gender	56.9%	43.1%	
	% within knowledge categories	69.6%	73.2%	
Female	Respondents	63	40	
	% within gender	61.2%	38.8%	
	% within knowledge categories	30.4%	26.8%	
Marital status				0.003
Married	Respondents	85	38	
	% within marital status	69.1%	30.9%	
	% within knowledge categories	41.1%	25.5%	
Single	Respondents	122	111	
	% within marital status	52.4%	47.6%	
	% within knowledge categories	58.9%	74.5%	
Educational status				0.001
University	Respondents	177	105	
	% within educational level	62.8%	37.2%	
	% within knowledge categories	85.5%	71.9%	
High school	Respondents	30	41	
	% within educational level	42.3%	57.7%	
	% within knowledge categories	14.5%	28.1%	
Employment status				<0.001
Employed	Respondents	111	47	
	% within employment status	70.3%	29.7%	
	% within knowledge categories	53.6%	32.0%	
Unemployed	Respondents	86	100	
	% within employment status	46.2%	53.8%	
	% within knowledge categories	41.5%	68.0%	
Student	Respondents	10	0	
	% within employment status	100.0%	0.0%	
	% within knowledge categories	4.8%	0.0%	

Fishers exact test and chi-square test.

individuals hold personal beliefs and misconceptions about donating and accepting blood anonymously (2, 13). However, the respondents of the present study agreed with importing blood from abroad. Additionally, previous studies proposed that socio-demographic, organizational, physiological, and psychological factors may influence the decision of individuals to donate and accept blood (13–16). Many studies reported that blood donation is a religious duty, whereas the current results revealed that blood donation is a national duty (13–16). An encouraging fact observed in the study is that individuals are motivated to donate blood.

In this study being younger, educated, married, and employed were shown to have superior knowledge, whereas married individuals and those with higher education had more favorable attitudes scores. Melku et al. revealed similar findings in Ethiopia, with younger people being found to have more knowledge (27). Similarly, according to Javaeed et al., being a female gender was found to have a high level of understanding about blood donation (28). In Bangladesh, Karim et al. found that a parent's education was substantially related to the study participants' blood donation behaviors (26). This data revealed that the participants'

education and age were important determinants in their blood donation decisions.

As such, creating awareness in the community and shedding light on the misconceptions about blood donation can aid healthcare facilities and the public in ensuring the availability of blood when needed. Such outcomes demand the need for additional educational and awareness programs specific to blood donation in Asian communities. In addition, this study proposes that increased knowledge about blood donation through education and awareness campaigns may encourage and motivate the general community and subsequently establish a sufficient supply of viable blood based on voluntarism, which is essential to the healthcare setting.

This study has strengths that should be mentioned. It is one of the first studies to be conducted in Telangana's capital, Hyderabad, which has the most blood donation centers. Secondly, it explored the motivations, perceptions, barriers, and possible strategies to mitigate blood donation hesitancy in one of the world's largest developing countries.

This study has some limitations. First, the study is limited to Hyderabad and included a small sample size; therefore, the findings are not generalizable to the entire state of Telangana. Second, the findings are reliant on the completion of the questionnaire, which may generate false answers and introduce the possibility of bias. Additionally, the study did not assess a full scope of motivational factors for blood donation (such as religion, socioeconomic status), also, the study did not collect past experiences with blood donation or transfusion, as participants who previously donated or received blood may have different attitude and knowledge compared to naïve donors. Lastly, most of the participants are young, and college educated, hence extrapolation to older generation and people with less than university education is limited. Given these limitations, the study suggests that future research should employ a larger sample size from various regions throughout India and reaching wider socioeconomic classes with a greater focus on the opinions, attitudes, and motivations as well as barriers toward blood donation. Future questionnaires should include additional motivational factors for donation and perceptions from historical donors.

CONCLUSION

The findings provide insight into the beliefs, behaviors, opinions, and motivations that are likely to encourage blood donation in Hyderabad. Importantly, the findings represent positive attitudes and motivation toward blood donation, which can provide reference for healthcare systems and blood banks in improving their supply and for supporting the development of programs that aim to ensure a sufficient supply of viable blood in a timely manner. Therefore, education programs that promote motivation and ensure a safe and healthy supply of blood should be advocated at both the national and global levels.

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 the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SW: conceptualization, data curation, formal analysis, and visualization. SS: writing—original draft preparation and review and editing. IS: funding acquisition and writing—review and editing. MM: formal analysis and writing—review and editing. GB and MA: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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REVIEW
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Online Medical Teaching in China During the COVID-19 Pandemic: Tools, Modalities, and Challenges

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Background: The novel coronavirus disease 2019 (COVID-19) pandemic has tested the ability of universities to provide a high-quality, safe educational experience for students due to campuses shutting down. As a result, online learning could shift from a traditional classroom teaching mode and make education accessible to students. Previous studies have used individual online teaching cases to exploit a variety of online learning tools to ensure the continuation of medical education during this difficult time in China. However, for the first time, we have conducted a systematic review of local online teaching approaches, existing challenges, and potential solutions.

Purpose: We present the issues and experience of conducting online medical teaching practices in China with the aim of communicating them to our peers in other countries or regions when examining the transition to e-learning during the COVID-19 pandemic and beyond.

Methods: We searched the keywords below from public databases and reviewed relevant publications reporting on medical online teaching in China during the COVID-19 pandemic to analyze and summarize the online tools, modalities, and challenges.

Results: We listed common online teaching tools and described a variety of online teaching modalities, as well as possible challenges. We also discussed potential solutions for those challenges, as well as the impact of the transition to online teaching on traditional education.

Conclusion: By investigating local online medical teaching in China, we present useful tools and modalities that have been successfully exploited in education during the difficult time of COVID-19, although some challenges remain. The exploration of the transition to online teaching or learning will likely continue to have a profound impact on traditional classroom teaching.

Keywords: online teaching, education modality, virtual classroom, medical education, COVID-19

INTRODUCTION

The outbreak of novel coronavirus disease 2019 (COVID-19) pneumonia evolved into a pandemic and has transformed a large part of daily life worldwide (1). The rapid spread of the disease has had a serious impact on school education, where face-to-face education has been damaged in many countries. According to a report by the United Nations, more than 191 countries and regions have closed their schools, and nearly 1.6 billion students have been affected by the pandemic (2). Many countries have taken steps to prevent infection through social distancing and distance education (3, 4). As one of the earliest responding countries, China also urged for campus closures in February 2020. To mitigate the impact of the pandemic on routine teaching activities, all levels of schools have proactively taken action to promote online education programs under the Chinese Ministry of Education initiative "Disrupted classes, undisrupted learning" (4–6).

Modern medical education encompasses a well-thought-out training system that covers highly structured curricula in a variety of preclinical and clinical environments (7). When considering the current state of medical education, traditional person-to-person educational didactics have now been challenged, like no other time before, given the current recommendations for public health measures to cancel on-site classroom teaching and limit regular clinical training activities. To heed the call for these recommendations, medical schools have switched to an online mode (8). By searching local public databases, namely the China National Knowledge Infrastructure (CNKI, https://www.cnki.net) and VIP Chinese Journal Platform (http://qikan.cqvip.com), we identified a few hundred publications about online teaching practices during the time of COVID-19. However, these publications are mostly based on individual cases exploring appropriate online teaching approaches with a variety of online tools. To systematically review and communicate the local online teaching situation in China, more specifically, we analyzed and summarized the implementation, challenges, and perspectives of online virtual classrooms for medical education programs during COVID-19 and beyond.

LOCAL ONLINE TEACHING PLATFORMS AND APPLICATIONS

Since the beginning of the twenty-first century, information technology (IT) has been explored regarding its integration into the innovation of teaching approaches. For the past decade, online course resource platforms, such as Rain Classroom, have been established successively. Online teaching methods, such as micro-courses and flipped classrooms, have become useful supplements for offline teaching in schools (9–11). The speed of IT integration is accelerating, the range of disciplines involved is expanding, and the degree is deepening.

During the COVID-19 pandemic, online course platforms and applications have been further developed and implemented in distance teaching, including massive open online courses (MOOCs), Rain Classroom, WeChat, Moodle, QQ, and DingTalk (11). These virtual tools in China have been steadily developed and used as assistant teaching tools over the past decade. Asynchronously recorded broadcasting platforms, such as Rain Classroom, focus on home teaching, including videos, presentations, and exercises, which allow students to learn online and download educational materials (12). Instant messaging applications such as WeChat have been used for both sharing medical knowledge and collaboration (13, 14). Although these applications provide useful outlets for medical education, it is difficult to implement educational curricula due to a lack of organization. During COVID-19, a few innovative solutions have been developed to address these demands, such as Tencent Meeting and DingTalk, similar to the international video conferencing platform Zoom (15). In the face of the COVID-19 pandemic, millions of students and teachers have resorted to these applications or platforms to hold online classes (**Table 1**) (6). As revealed by a survey conducted at Tsinghua University on online learning platforms, Tencent Meeting has been the most commonly used (97%), followed by Rain Classroom (91%), and Zoom (86%) (17). However, this is not the same case for all other campuses, since there are no uniform standards for using online tools. Nevertheless, these platforms share common advantages in that they have been designed to be accessed either through PCs or smartphones. Students have therefore been able to learn with more convenience, without limitations of time or space (**Table 2**). Usually, these platforms have been selected to use together in online teaching, as they have different features or functions. For example, MOOCs and Superstar have been used to prepare prerecorded courses, and DingTalk and WeChat can be utilized to manage teaching disciplines and organize online discussions. In contrast, others such as Tencent Meeting and Rain Classroom can deliver online teaching through shared screens in real time or PowerPoint lectures. Their use in combination cannot only deliver learning content, but also keep teaching in good order.

MODALITIES OF VIRTUAL TEACHING FOR MEDICAL EDUCATION AND CHALLENGES

Within our community, academic programs have been stepping up to develop novel pedagogies for online learning. Dr. Song reported an online teaching modality for infectious disease education using MOOCs. The MOOCs provided a range of recorded courses for teaching about new and recurring infectious diseases. Along with problem-based learning (PBL), they highlighted the features of MOOCs in terms of feasibility, openness, and advancement to ensure that learners can master traditional theories and improve their clinical thinking ability (23). Li et al. described another online teaching method using prerecorded courses and a Superstar learning platform for infectious disease education. Meanwhile, they assigned a teaching secretary to communicate the class times and operations by asking and answering questions *via* WeChat and QQ applications. The trial, which lasted for one semester, showed that online learning can result in comparable achievements compared to traditional classroom teaching (24). Liu et al. explored the six-step BOPPPS teaching model when designing an online

TABLE 1 | Major online learning platforms and applications.

Online platform	Developer	Main uses	Accessibility	URL
DingTalk (16)	Alibaba	Check-in/Online discussions/conferences	PCs/smartphones	https://www.dingtalk.com
Tencent Meeting (17)	Tencent	Conferences/Lectures	PCs/smartphones	https://meeting.tencent.com
WeChat (18)	Tencent	Online discussions	PCs/smartphones	https://weixin.qq.com
QQ (19)	Tencent	Online discussions	PCs/smartphones	https://im.qq.com/index
Superstar (20)	Century Superstar	Prerecorded courses	Smartphones	http://about.chaoxing.com
MOOC (21)	Open Source	Prerecorded courses	PCs/smartphones	http://www.umooc.com.cn
Rain classroom (9)	Tsinghua University	Online PowerPoint teaching	PCs/smartphones	https://pro.yuketang.cn
Moodle (22)	Open Source	Assignments/Discussions	PCs	https:/www.modlechina.org

TABLE 2 | Advantages and disadvantages of online teaching.

Advantages	Disadvantages
• No time or geographic constraints • Cost-effective, available to distant learners • Student-centering teaching, able to promote student's autonomy • Less stress and beneficial for online discussions and asking questions • Students' learning progress can be automatically recorded	• Lack of face-to-face communication between teachers and students • Teachers and students are required to master computer skills • Need for PCs and internet access • Need for information technology (IT) support and necessary hosting resources • Online learning materials are usually updated quickly and have a higher rate of abandonment.

MOOC for infectious diseases. By bridging infectious disease cases, preset objectives, and the pre-assessment of students' ability, as well as participatory group discussions and post-class feedback, the model not only improved students' ability to analyze and solve problems related to the epidemic, but also deepened their sense of mission and active exploratory spirit (25). At Peking Union Medical College, teachers in each college chose Rain Classroom, Tencent Conference, and Zoom for online teaching, or used methods such as PowerPoint slides and voice messages to distribute course materials and kept in close contact with students through WeChat, Moodle, and other platforms, including pre-class preparation, assigning after-class homework, and hosting Q&A sessions to ensure the success of online teaching (26).

From these and other examples, online learning exhibits multiple benefits and advantages (**Table 2**). It breaks the limitations of time and space and can deliver large-scale teaching. Instructors and students can obtain plenty of online resources to assist in teaching and self-learning. Moreover, virtual teaching stresses problem-focused learning and eases group discussion, which is beneficial for students to develop self-learning and analytical ability (27, 28). However, the shift to online platforms poses a few challenges for medical education. The primary challenge is that most medical schools do not have sufficient time to prepare for online teaching on a large scale in a short period. Second, during transitions, network congestion, or crashes frequently occur due to a lack of adequate resources to handle sudden network loads. In addition, remote or rural areas do not tend to have stable network connections, and students in these areas may need hardware and IT support to participate in online classes. Third, as mentioned above, although E-learning platforms such as MOOCs provide a large amount of educational resources that come from schools themselves, peer institutions, or others published, it is difficult to probe and locate high-quality educational resources. For medical education resources, there are approximately 22 channels and websites providing more than 2,700 medical courses according to the list recommended by the National Center for Health Professions Education Development (NCHPED) (29). Some of them are presented in English, which creates learning barriers for instructors and students whose English language skills are not adequate. Fourth, a large proportion of instructors lack the confidence to execute online teaching, as they do not have such work experience (30). Other challenges include acquiring adequate clinical medical skills. On the basis of "best practices" reports from 40 medical schools in China, Jiang et al. presented 12 tips to help on-site medical classes move online under the pandemic, including teaching modes, infrastructure construction, platform integrations, and even educational policy decisions (30).

STUDENT FEEDBACK ON ONLINE TEACHING

To explore students' attitudes toward and perceptions of online teaching, a questionnaire survey was administered at Chongqing Medical University about the online teaching of infectious diseases through WeChat, QQ, and the SuperStar platform. The majority of students indicated their satisfaction with online teaching. Of 150 participants, over 90% expressed that online teaching can cultivate multiple abilities, such as self-learning, independent thinking, case analysis, and literature searching. Additionally, they could understand the knowledge of theory and clinical skills well (24). Similar results were obtained from other online teaching studies of different disciplines as well, such as medical imaging (20), obstetrics and gynecology (31),

laboratory medicine (32), to name a few, indicating students could benefit from the student-centered online teaching and improve their multiple abilities mentioned above and even the spirit of teamwork. It's worthy to note that introduction of real-time chat tools extends students' questions beyond the classroom, no longer constrained by limited classroom time. Students can ask questions at any time when they find problems in their studies, and get detailed answers in a short time, and they can also view the questions asked by others. They can also help others solve problems, make up for the deficiencies in their own learning, and enhance self-learning depth (22).

THOUGHTS ON MEDICAL EDUCATION IN THE TIME OF COVID-19 AND THE POST-PANDEMIC ERA

Before the COVID-19 pandemic, distance online learning was not considered the major modality for education on campuses. Most online learning courses involve recorded lectures, which allow flexible attendance with the purpose of helping students understand the content taught in class. However, the occurrence of COVID-19 shifted pedagogy from traditional face-to-face classroom learning to online platforms, using synchronous or asynchronous live streaming techniques to deliver educational materials. Despite various challenges, such as internet streaming quality and coverage, online distance learning has been an efficient approach to learning about different educational topics. Some issues can be addressed with the widespread use of new technologies such as 5G telecommunication and virtual reality. Moreover, they can deliver high-quality, high-capacity transmission for live broadcasting, and interactions. Observations from online teaching in China show that students have revealed a more active attitude in learning when using vivid electronic materials such as images and videos in the teaching process (20). The COVID-19 pandemic aroused an interest in learning about virology. It has made virology more visible and provided content in real time to help students understand and contextualize aspects of emerging coronaviruses (33). In addition, by virtue of instant chat tools such as WeChat, students are more open to participating in group discussions due to the less intimidating environment (34, 35). Incorporating online Q&A sessions could also improve student engagement (36).

Regarding medical education, the main drawback is the impossibility of practicing and acquiring clinical skills. Telemedicine could provide another useful way for medical education to prepare students to participate in and develop competencies, including facilitating basic knowledge acquisition, improving decision-making, enhancing perceptual variation in anatomy lessons or three-dimensional simulations, improving skill coordination, practicing for rare or critical events, receiving team training, and strengthening psychomotor skills. Moreover, telemedicine can help medical students understand complex ethical, regulatory, and legal issues (37, 38). However, warranties should be provided based on learner feedback to address the potential lack of educator training in teaching telemedicine, such as communities of collaboration, professional credentialing standards, and automated guidance systems (37).

Mainstream views acknowledge the trend whereby online learning can replace traditional classroom learning, such as delivering theoretical knowledge except for clinical skills. It has multiple advantages, such as time saving, the flexibility of the classroom, and improved interactions with instructors and students (27, 39). However, counting on online learning for every aspect of medical education is impossible because on-site teaching is more dynamic and can avoid internet connectivity problems that probably occur in live broadcast teaching (40). In particular, online learning is no substitute for laboratory work training, which is usually accomplished person to person (41). Therefore, the blended approach of mixing traditional and e-learning classes would be the preferred way to deliver medical education in the future, and adopting future distance learning is significantly related to the degree of overall satisfaction (3, 42, 43). To maximize the benefits of both face-to-face and online teaching and to improve the efficacy of medical education, proven teaching modalities such as PBL and flipped classes are suggested (10, 44, 45). When setting up online learning courses, instructors can explore the topic to make students pursue self-paced enquiry under their own initiative. In addition, virtual teachers should conduct frequent assessments and check in by phone or other telecommunication formats with each student to enable them to catch up in courses (40).

Although there are differences in terms of cultural background and educational systems between different countries, higher education in all countries in the post-epidemic era is facing similar challenges and opportunities, such as the development of online or integrated teaching, teachers' professional development and information literacy improvements, the establishment of courses and training plans, and emergency management mechanisms. Like other disciplines, maintaining and strengthening medical education in the midst of and after COVID-19 will require thoughtful, concerted efforts on the part of governments, universities, and academic communities to collaboratively develop, implement, and fund long-term plans that elevate the voices of students and researchers in national policy decisions. In China, virtual teaching has significantly reshaped and innovated the teaching model and engagement with our medical trainees. In the future, with the advancement of technologies and the innovation of teaching modalities, we believe that medical training programs will benefit greatly from incorporating virtual learning platforms even beyond the time of COVID-19.

CONCLUSIONS

By virtue of online learning platforms, students can access education anytime, anywhere. Online teaching has definitely played an important role in coping with course learning during the COVID-19 pandemic. Although isolation is a major disadvantage for online learning, we found through observation and analysis that this challenge can be overcome, and that online distance learning can be beneficial for both students and

academic staff with the appropriate techniques and tools to support interactions and communication. To ensure the quality of online distance learning, China's 5G telecommunications network infrastructure can guarantee quick access to internet resources, as well as real-time communication. In addition, to minimize the requirement for computer skills and to ease online teaching management, efforts have also been made to preserve interactions in online distance learning courses. For example, in China, many schools have adopted popular local tools and platforms, such as using WeChat and MOOCs to perform online teaching management and deliver learning materials. Online teaching can be made more engaging and effective for both teachers and students through interactive teaching tools such as chat functions and videos. Of course, different regions and countries may utilize their own popular tools and platforms according to user habits or resource configurations, such as Zoom and Slack, to name a few widely used in Western countries for online teaching (46). In addition to hardware and software configuration, integration with appropriate teaching approaches is of great importance to online teaching. For example, flipped classroom teaching could be of great utility for encouraging independent learning and building student-centered teaching modalities. Just like exploring for more effective approaches through learning and absorbing advanced teaching modes and educational systems all over the world (47, 48), Chinese medical schools effectively integrated local resources with foreign teaching modes for dealing with the challenge of the COVID-19 pandemic imposed to medical education. In the future, further surveys are required to be conducted to monitor the development of online learning as this pandemic carries on, including the improvements in shortcomings of the current online distance learning for medical students. We also hope to continuously share these valuable educational experience with peers in the medical community.

AUTHOR CONTRIBUTIONS

BS conceptualized the study. BS, LY, CH, and XC searched the literature, selected studies, and extracted the data. BS, TZ, CC, and DC contributed to the analysis and interpretation of the data and provided important scientific input. BS analyzed the findings and wrote the manuscript. BS, CC, and DC supervised the whole study. All authors collaboratively discussed key decisions throughout the course of the review, provided critical feedback on preliminary manuscript, and approved the final version.

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HIV/AIDS-Related Knowledge and Attitudes Among Chinese College Students and Associated Factors: A Cross-Sectional Study

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In recent years, adolescent has become one of the high-risk groups for HIV. Meanwhile, good HIV awareness and positive attitude are essential for HIV prevention. This study aims to evaluate the extent to which college students understand HIV and their attitudes toward HIV-infected patients, as well as the correlative factors. The data used in this study came from a cross-sectional survey. An anonymous online questionnaire was used to investigate the demographic characteristics, HIV/AIDS-related knowledge, and attitudes toward HIV-infected patients of 17,678 students from a university in Henan. Descriptive statistics, Chi-square test and logistic regression were used to analyze differences and connections between variables in SPSS version 25.0. Participants' HIV/AIDS-related knowledge awareness rate was 80.8%. Levels of students' HIV/AIDS-related knowledge correlated with their gender, nationality, marital status, and their grade ($p < 0.01$). Female students [OR = 0.757, 95% CI (0.699–0.820)] and minority students (OR = 0.717, 95% CI (0.619–0.832)] had insufficient HIV health education knowledge. Meanwhile, male students (OR = 0.845, 95% CI (0.773–0.924)], and students with good HIV knowledge (OR unaware-ness/awareness = 2.385, 95% CI (2.111–2.694)] were more likely to hold a positive attitude toward HIV-infected patients. The relevant education departments should strengthen and promote the education of AIDS transmission and prevention. Many college students still hold negative attitude toward HIV-infected patients. The government should further make efforts to eliminate social discrimination in HIV-infected patients and lead people to approach HIV-infected patients fairly.

Keywords: HIV/AIDS, HIV knowledge, student, attitudes, adolescent

INTRODUCTION

AIDS (Acquired Immunodeficiency Syndrome) is an infectious disease caused by HIV (Human Immunodeficiency Virus). The emergence of HIV has brought new challenges to the public health of countries around the world, especially developing countries (1, 2). According to a report by the World Health Organization, in 2020 alone, 410,000 young people aged from 10 to 24 years were newly infected with HIV, of whom 150,000 were adolescents between the ages of 10 and 19 (3).

AIDS was first discovered and reported in China in 1985. In order to better respond to HIV/AIDS, Chinese government has successively promulgated a number of related policies, such as the "Four Frees and One Care," which have played a very positive role in the prevention and control of HIV in China (4). Although China attaches great importance to HIV health education for young students, related policies have declined after 2006 (5). The awareness rate of HIV health education knowledge among young students (69.22–81.24%) is generally lower than the national standard (90%) [14], especially the misunderstanding of the transmission mode of HIV (6, 7).

China is the most populous country in the world, there are approximately 230 million young people in the 10–24 years age group (8). Due to the gradual liberalization of sexual concepts, the incidence of premarital sex among college students has continued to increase (9), yet sex education has not yet been fully popularized in Chinese families and schools (10). Unprotected sex is one of the high-risk factors for AIDS, especially in low-income countries (11, 12). The lack of sexual knowledge among college students has led to an increase in the rate of HIV infection among college students, which is why college students have gradually become the key monitoring population for AIDS prevention and control in recent years. According to the Chinese Center for Disease Control and Prevention (CDC), the recent increase in the number of HIV infections among college students has increased by 30–50% per year (13). In recent years, more than 95% of newly diagnosed HIV-infected persons in China have been infected through sexual behavior, among which about 70% are heterosexual transmission (14), but the main mode of transmission among young students is male homosexual behavior. The incidence characteristics of AIDS in Henan Province are the same as those of the whole country, with a higher proportion of same-sex transmission among young students aged 15–24 years (15).

Insufficient knowledge about HIV makes people's misunderstanding of AIDS groups continue to deepen, and even affects a person's basic beliefs and leads to discriminatory attitude. Negative attitude makes people less willing to know more about HIV/AIDS. This discrimination has become one of the obstacles to the elimination of HIV discrimination (16). In addition, some news about HIV-infected patients maliciously spreading HIV in society also makes people more resistant to HIV groups. Studies have proved that good education can effectively enhance people's awareness of HIV health education knowledge (17), and good HIV awareness can effectively reduce people's high-risk behaviors and improve people's discrimination against HIV-infected patients (6, 18).

Significance and Objectives of the Study

This article takes a university in Henan Province as an example to study the awareness of HIV health education knowledge of Chinese college students and their attitudes to live with HIV-positive roommates. In order to discuss the current status and problems of sex education among college students, and explore the influencing factors that affect the level of cognition and attitudes to live with HIV-positive roommates. The final research results can provide references for China's future HIV health education, and at the same time make the popularization of sex education in China more targeted.

Abbreviations: HIV, Human Immunodeficiency Virus; AIDS, Acquired Immunodeficiency Syndrome; OR, Odds Ratio; CI, Confidence of Interval; CDC, Chinese Center for Disease Control and Prevention; CNY, Chinese yuan; PBL:Problem-Based Learning; AMP, Arts-based, Multiple component, Peer-education; GBL, Game-Based Learning; SPSS, Statistical Product and Service Solutions.

METHODS

Data Sources

This cross-sectional study was carried out in a university in Henan Province in November 2020. After seeking the informed consent of the interviewed students, we collected data in the form of an anonymous online questionnaire. A total of 18,238 questionnaires were distributed to undergraduates in the school, 18,179 were recovered, with a response rate of 99.7%. After excluding the questionnaires with missing values, a total of 17,678 valid questionnaires were included in our analysis. The questionnaire effective response rate was 97.2%. The ethics committee of Wuhan University approved this study (Approval ID:2021YF0047). All informed consents were obtained.

Survey Design

The HIV health education knowledge questionnaire used in the data collection of this study was adapted from the "adolescent awareness rate" in "Chinese AIDS Sentinel Testing Implementation Plan" and consisted of three sections. The overall reliability and validity test passed, but the load of the entry one factor is too small, so we deleted the first question.

The first section collected the sociological demographic characteristics of the participants including grade, gender, nationality, marital status, monthly living fee level.

The second section used a nine-question questionnaire to assess participants' level of HIV health education knowledge. The score calculation method was: each correct answer in each block of HIV health education knowledge counted for one point. The overall score was the total number of correct responses (ranged from 0 to 8 points). According to the "adolescent awareness rate," a score of 6 or more was considered to be up to the standard for HIV health education knowledge.

The third section assessed the attitudes of participants toward HIV-infected patients.

Data Analysis

Data analysis was carried out using SPSS version 25.0. The mean and standard deviation were used to describe the continuous variables, whereas the proportion was used to describe categorical variables. Chi-square test was used for comparison between two or more groups. To analyze the relationship between dependent and independent variables, binary logistic regression and multinomial logistic regression were used. Significance was set at $p < 0.05$.

RESULTS

Socio-Demographic Characteristics of Participants

In this survey, there were 12,352 males (69.9%) and 5,326 females (30.1%). Freshman to Senior year students accounted for 36.2, 32.4, 21.8, and 9.6%, respectively. Participants were mostly Han (16,634; 94.1%) and unmarried students (17,509; 99.0%). Students with monthly living expenses of 1,000–2,000 CNY accounted for the largest proportion accounted for 59.4% (**Table 1**).

TABLE 1 | Demographic characteristics of participants.

Variables	*N* (%)	Male (*N* = 12,352)	Female (*N* = 5,326)
Grade			
Freshman	6,392 (36.2)	4,618	1,774
Sophomore	5,740 (32.4)	4,014	1,726
Junior	3,853 (21.8)	2,529	1,324
Senior	1,693 (9.6)	1,191	502
Nationality			
Han	16,634 (94.1)	11,617	5,017
Minority	1,044 (5.9)	735	309
Marital status			
Unmarried	17,509 (99.0)	12,246	5,263
Married	169 (1.0)	106	63
Monthly living expenses			
≤1,000 CNY	6,157 (34.8)	4,577	1,580
1,000–2,000 CNY	10,496 (59.4)	7,123	3,373
2,000-3,000 CNY	782 (4.4)	490	292
≥3,000 CNY	243 (1.4)	162	81

TABLE 2 | The reliability of the questionnaire.

Questions	Cronbach's α	Deleted entry Cronbach's α
The incidence of AIDS among young Chinese students is increasing, and the main mode of transmission is male homosexual behavior, right?	0.729	0.733
Can it be judged by appearance that a person is infected with AIDS?		0.708
May AIDS be contracted through daily life and studying?		0.712
Can proper use of condoms reduce the risk of contracting and spreading AIDS?		0.684
Will drug abuse increase the risk of contracting AIDS?		0.696
After a high-risk behavior occurs, should we seek HIV testing and counseling?		0.689
Are the rights of HIV-infected people such as marriage/employment/schooling protected?		0.703
Is it necessary to use condoms when sex with acquaintances?		0.692

The Reliability and the Validity Examination

The reliability and validity tests of the HIV Health Education Knowledge Survey Module were conducted by internal consistency reliability, convergent validity and construct validity. The internal consistency reliability of the questionnaire was tested by calculating the Cronbach's α coefficient through SPSS 26.0. Confirmatory factor analysis (CFA) was conducted to examine the construct validity through Mplus 8.4. First, KMO and Bartlett test were performed. The KMO value of our scale was 0.845, which was higher than the threshold value of 0.6, and the Bartlett's test of sphericity reached statistical significance ($p < 0.001$), indicating that it was suitable for exploratory factor analysis (EFA). Principal-component factor models with maximum variance orthogonal rotation were used for EFA. The factor loadings are >0.4 except for the first item (0.328). We removed item 1 and conducted reliability and validity tests of the remaining 8 items. Results of CFA showed that the comparative fit index (CFI) was 0.957, Tucker-Lewis fit index (TLI) was 0.940, standardized root mean square residual (SRMR) was 0.044, root mean square error approximation (RMSEA)

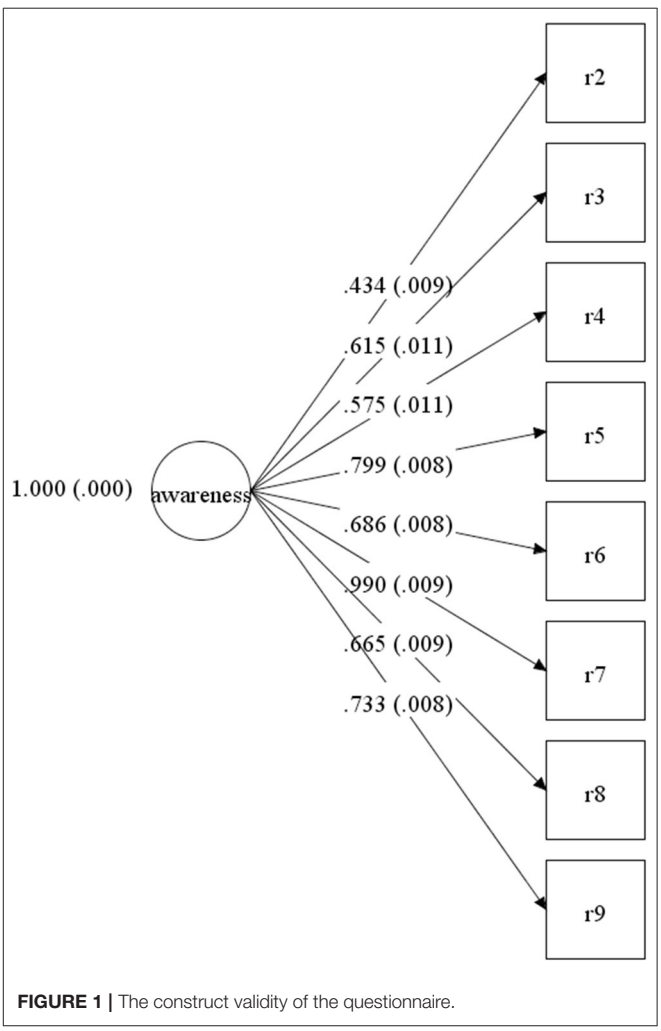

FIGURE 1 | The construct validity of the questionnaire.

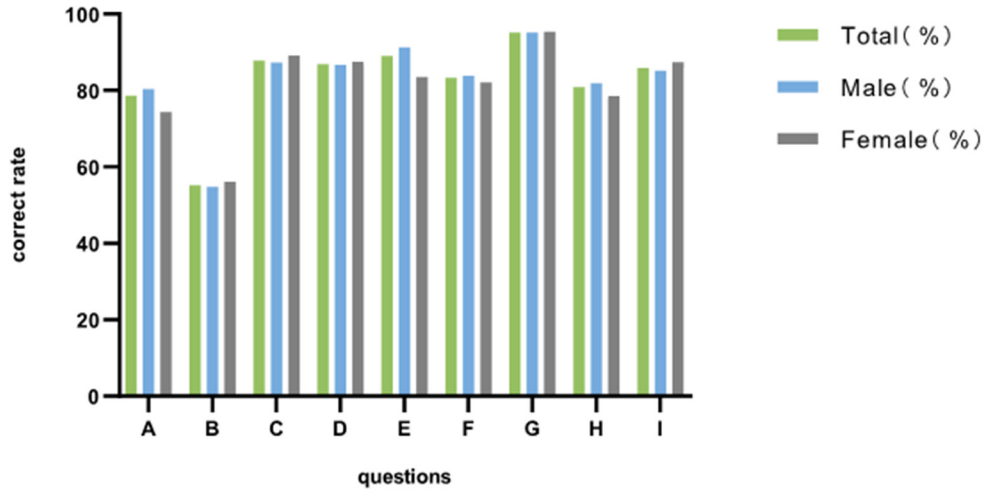

FIGURE 2 | The correct rate of participants' HIV health education knowledge by gender. (A) AIDS is an incurable disease. (B) The incidence of AIDS among young Chinese students is increasing, and the main mode of.transmission is male homosexual behavior. (C) It can be judged by appearance that a person is infected with AIDS. (D) AIDS may be contracted through daily life and studying. (E) Proper use of condoms can reduce the risk of contracting and spreading AIDS. (F) Drug abuse will increase the risk of contracting AIDS. (G) After a high-risk behavior occurs, we should seek HIV testing and counseling. (H) The rights of HIV-infected people such as marriage/employment/schooling are protected. (I) Sex with acquaintances also need to use condoms.

was 0.055 and all factor loadings were >0.40. The value of average variance extracted (AVE) was 0.882. The Cronbach's α coefficient of our scale was 0.726. Results indicated that the scale displayed good reliability and validity. Details were shown in **Table 2** and **Figure 1**.

Correct Rate of HIV Health Education Knowledge

Among the 9 questions, the one with the lowest correct rate was the mode of transmission of AIDS among Chinese adolescents, with a correct rate of 55.2%. The question with the highest correct rate is seeking HIV testing and counseling after high-risk behaviors, with a correct rate of 95.2%. There were 15,370 people (86.9%) who know that they would not be infected by exposure to AIDS in daily life. Generally speaking, the correct rate of each question was about the same between boys and girls (**Figure 2**).

HIV Awareness and Knowledge

The overall HIV health education knowledge awareness rate of the survey respondents was 80.8%, and the average score of the HIV health education knowledge part was 7.93 (±1.64). Among them, 4,679 people answered all 9 questions correctly, accounting for 26.5% of the total survey respondents.

Calculated the proportions of awareness of different demographic characteristics, and compared them with the Chi-square statistical test. It can be known that the third-year students in the grade have the best awareness, boys have better awareness than girls, Han students have better awareness than minority students, unmarried students have better cognition than unmarried students, and participants whose living expenses are in the range of 2,000–3,000 CNY have the best awareness. There were differences in the knowledge of AIDS health education among college students of different grades, genders, ethnicities, marital status, and living expenses, and the differences were statistically significant ($p < 0.05$) (**Figures 3**, **4**).

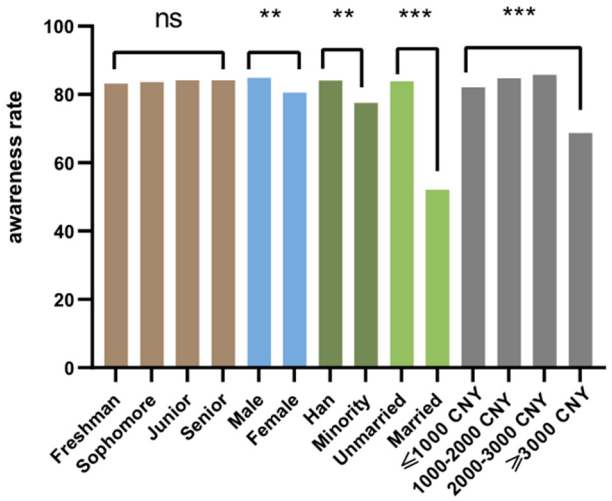

FIGURE 3 | Awareness rate of AIDS-related knowledge among college students. ns $p > 0.05$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Influencing Factors of Knowledge About AIDS Health Education

The results of multivariate logistic regression showed that the participants' awareness were associated with their gender, ethnicity, and marital status ($p < 0.05$). Specifically, boys were 1.268 times more likely to be aware of reaching the standard than

TABLE 3 | Multivariate unconditional logistic regression on awareness of HIV health education knowledge.

Variables	*B*	*P*	OR	95% CI
Gender				
Male	0.237	<0.001	1.268	1.162–1.384
Female (Ref.)				
Nationality				
Han	0.337	<0.001	1.400	1.194–1.641
Minority (Ref.)				
Marital status				
Unmarried	1.375	<0.001	3.957	2.846–5.502
Married (Ref.)				
Monthly living expenses				
≤1,000 CNY	0.301	0.059	1.352	0.989–1.847
1,000–2,000 CNY	0.594	<0.001	1.812	1.329–2.471
2,000–3,000 CNY	0.639	0.001	1.895	1.315–2.732
≥3,000 CNY (Ref.)				

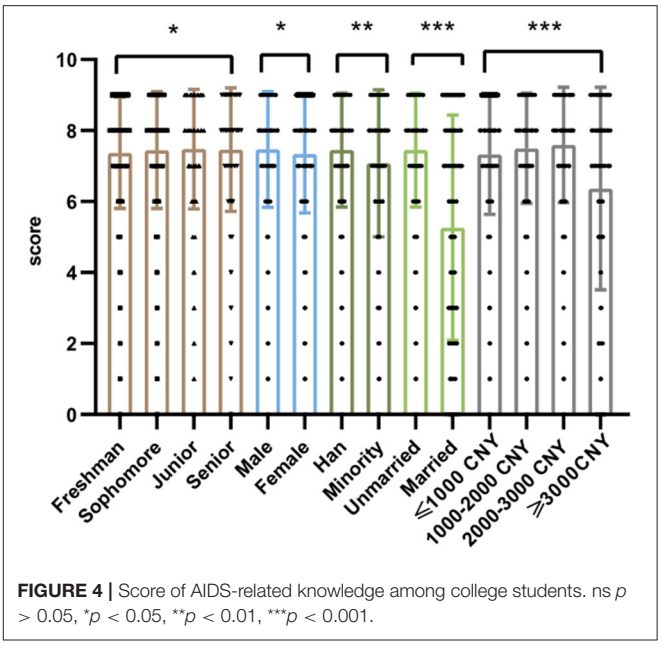

FIGURE 4 | Score of AIDS-related knowledge among college students. ns $p > 0.05$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

boys (OR = 1.268, 95% CI = 1.162–1.384); among participants from different nationalities, Han students were 1.4 times more likely than ethnic minority students to meet the standard (OR = 1.400, 95% CI = 1.194–1.641); unmarried students were more than 3 times more likely to meet the standard than married students (OR = 3.957, 95% CI = 2.846–5.502) (**Table 3**).

Attitudes Toward Live With HIV-Positive Roommates

In this survey, in the question "Are you willing to share a dormitory with a roommate who is infected with HIV/AIDS?" 3,667 people chose "Yes," accounting for 20.7%; 9,201 people chose "unwilling," accounting for 52.0%; 4,810 people chose "uncertain," accounting for 27.2%. Among them, those who choose "Yes" were considered to have a positive attitude toward AIDS patients, while at the same time, those who choose "No" were considered to have a negative attitude.

The results indicated that freshmen students had shown to be more accepting of living with a HIV-positive roommate. More boys than girls among participants who had a positive attitude toward AIDS patients. Moreover, among participants with different monthly living expenses, those with more than 3,000 CNY had the most positive attitudes. Additionally, People who had a better understanding of HIV/AIDS-related knowledge accept AIDS patients better. The above differences are statistically significant ($p < 0.01$) (**Figures 4**, **5**).

Influencing Factors of Attitudes Toward Live With HIV-Positive Roommates

Taking different demographic characteristics and awareness as independent variables, whether they are willing to share a dormitory with students who are infected with HIV/AIDS (1 = yes; 2 = no; 3 = uncertain) as dependent variables, taking the last item in each category as the control group. Multivariate logistic regression were performed. The analysis showed that the gender, marital status and knowledge of college students had varying degrees of influence on their attitudes to live with HIV-positive roommates:

"Positive" compared to "negative." Male students were 0.845 times more likely to have a negative attitude than female students (OR = 0.845, 95% CI = 0.773–0.924); The possibility that those who did not meet the standard were unwilling to live with HIV-infected patients was 2.753 times that of those who met the standard (OR = 2.753, 95% CI = 2.391–3.170).

"Positive" compared to "uncertain." Male students were 0.552 times more likely to choose "uncertain" than female students (OR = 0.552, 95% CI = 0.501–0.609). Compared with those who met the standard of AIDS health education knowledge, those who did not meet the standard are 3.569 times more likely to choose "uncertain" (OR = 3.569, 95% CI = 3.079–4.137) (**Table 4**).

DISCUSSION

This study aims to describe the current situation of HIV health education among Chinese college students and the acceptance of contemporary college students to live in the same room with HIV-positive roommates, then analyze its influencing factors. The results of this study showed that the overall awareness rate of HIV health education knowledge of the university is 80.8%. Compared with previous studies in this province, it is lower than the HIV knowledge awareness rate (84.7%) of college students in Henan Province in the study of Yin et al. (18) in 2017. Compared with other provinces, the overall awareness rate is higher than that of Jining college students in the study by Liu et al. (19) (66.59%), but lower than that of Chen et al. (20) in the study of Central Nantong University (87.87%). The different awareness of various local universities may be related to the way and intensity of HIV prevention publicity and education

TABLE 4 | Multivariate logistic regression of the attitudes to live with HIV positive roommates.

Variables	Negative (%)				Uncertain (%)			
	B	*P*	OR	95% CI	B	*P*	OR	95% CI
Grade								
Freshman	−0.427	<0.001	0.652	0.566–0.752	−0.227	0.006	0.797	0.678–0.937
Sophomore	−0.123	0.095	0.884	0.765–1.022	−0.063	0.455	0.939	0.796–1.108
Junior	0.167	0.036	1.181	1.011–1.381	0.162	0.073	1.176	0.985–1.404
Senior (Ref.)								
Gender								
Male	−0.168	<0.001	0.845	0.773–0.924	−0.594	<0.001	0.552	0.501–0.609
Female (Ref.)								
Nationality								
Han	−0.037	0.669	0.964	0.814–1.142	−0.150	0.117	0.861	0.714–1.038
Minority (Ref.)								
Marital status								
Unmarried	0.922	<0.001	2.514	1.715–3.686	0.737	0.001	2.089	1.342–3.252
Married (Ref.)								
Monthly living expenses								
≤1,000 CNY	−0.008	0.963	0.992	0.718–1.372	0.838	<0.001	2.311	1.505–3.548
1,000–2,000 CNY	0.089	0.588	1.093	0.793–1.507	0.780	<0.001	2.182	1.425–3.341
2,000–3,000 CNY	0.220	0.238	1.246	0.865–1.794	0.381	0.119	1.463	0.907–2.360
≥3,000 CNY (Ref.)								
Awareness of HIV/AIDS								
Unawareness	1.013	<0.001	2.753	2.391–3.170	1.272	<0.001	3.569	3.079–4.137
Awareness (Ref.)								

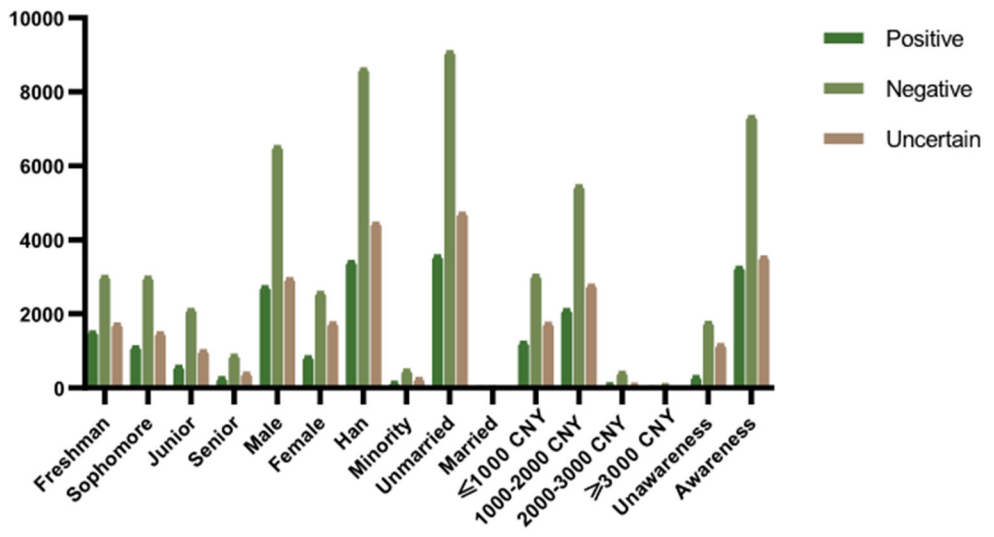

FIGURE 5 | Attitudes towards live with HIV-positive roommates.

work in different regions and schools. Our survey found that only 26.5% of the participants correctly answered all 9 questions about HIV health education knowledge. The lowest correct rate is "At present, the prevalence of HIV among young students in China is increasing rapidly. The main mode of transmission is male homosexual sex, followed by heterosexual sex." Only 55.2% answered correctly. It shows that the students of this school do not fully understand the main transmission mode of HIV among the young population and the risks of unprotected sex. This result is similar to the results of several foreign studies (6, 7, 21); the highest accuracy rate is "After the occurrence of high-risk behaviors (sharing needles, drug use, unsafe sex, etc.), you should

actively seek HIV testing and counseling" accounted for 95.2% of the total answers. This result shows that students have a strong sense of self-protection after high-risk sexual behaviors occur. The difference in the accuracy of these two questions also shows from the side that college students' learning of HIV health education knowledge is not systematic and complete, and the accuracy of general problems is always higher, but the accuracy of some professional problems is obviously lower (22).

In terms of humanity characteristics and HIV health education knowledge, we found that the awareness of boys is better than that of girls. This is the same as the results of some previous studies (22–24). This is understandable, as girls are likely to have a more conservative attitude toward sexual behavior than boys (23, 25). There is not much difference between college students with different living standards, but overall, there is a trend that the higher the living expenses level, the higher the awareness rate. On one hand, for college students in the same university, it may be because they come from regions with different economic levels. Students from regions with high economic levels are more likely to have earlier and more comprehensive exposure to sex education, so they have a better understanding of HIV/AIDS-related knowledge (26). On the other hand, it may also be because their family pays more attention to sex education in the family. This suggests that we should pay attention to differences caused by different factors such as gender and region, and carry out targeted HIV health education. Schools should regularly hold AIDS health education lectures or relevant theoretical courses. Some studies have found that peer education has a greater advantage in sex education because their growth backgrounds are similar and easy to communicate with (20). It is recommended that colleges and universities try to let medical students assist schools to carry out regular health counseling activities after training. At the same time, give full play to the role of clubs and other platforms in schools, encourage students to actively participate in AIDS publicity and education activities, and further strengthen AIDS publicity and education in colleges and universities.

Regarding the relationship between HIV health education knowledge level and attitudes to live with HIV-positive roommate. The analysis of our study found that people with AIDS awareness standards were more likely to accept cohabitation with HIV-positive roommates than people who did not meet the standards. This is consistent with the conclusion in other literature that people with better HIV/AIDS-related knowledge awareness have a more positive attitude toward HIV-infected patients (27). The development of publicity and education on HIV prevention among college students will not only help college students prevent HIV, but also help eliminate discrimination against HIV-infected patients. However, although 86.9% of students know that they will not be infected with HIV in daily life and study contact, 52% of students still do not want to live with HIV-positive roommates. This result shows that even if you have a certain understanding of HIV/AIDS-related knowledge, it is still difficult to accept emotionally. This suggests that psychological prevention and treatment should also be paid attention to during HIV health education.

Due to the influence of traditional culture, Chinese people's attitudes toward "sex" has always been relatively conservative, At the same time, comprehensive sex education has not been widely and comprehensively carried out in China., sexual education is very lacking in both school education and family education (10, 28, 29). Someone compared Chinese and foreign sex education policies in 2019. The initial education time for sex education in China started in junior high school, much later than the internationally stipulated 5–8 years old (30). In addition to the lack of middle school education, many universities in China are not offering sexual education and do not have sound HIV test facilities (31).

Relevant studies around the world have shown that educational intervention can effectively improve people's HIV health education knowledge, effectively increase student population's awareness of HIV/AIDS-related knowledge (5) and willingness to test for HIV (32), and improve people's discrimination against AIDS groups (33). In today's internet age, schools can adopt a variety of new ways to educate students on AIDS prevention and treatment, such as the PBL method that integrates clinical actual cases into teaching materials (34), the theater-based AMP method (35), and the GBL method based on games (36). Compared with traditional book-based teaching, these new educational methods integrate knowledge into real life and present it to people in a more vivid way. It is easier to arouse the interest of young people and thus obtain better educational effects.

Limitations

The limitation of this study is that this survey was conducted only in one university, which is somewhat different from the overall situation of the country. In addition, this study did not involve factors such as the participants' majors, hometown, parents' marital status, which may also affect their level of HIV/AIDS-related knowledge. Despite the limitations referred to above, the results of this study can still provide references for the communication of HIV health education knowledge among college students nationwide.

CONCLUSIONS

The results of this study showed that this college students had a certain understanding of HIV health education knowledge, but they did not know enough about the sexual transmission of HIV. Meanwhile, many students showed a relatively negative attitude toward HIV-infected groups. What needs attention is the cognition of AIDS among female students, they showed a greater lack of awareness of AIDS in this study. Therefore, in the future HIV/AIDS-related work, it is necessary to strengthen the education of women. The results provided by this study showed that raising awareness of AIDS health education knowledge can effectively alleviate people's negative attitudes toward HIV-infected patients. This suggests that China should carry out targeted sex education and psychological education as soon as possible, and pay attention to gender characteristics in the popularization of HIV/AIDS-related knowledge. Furthermore, education methods

can learn from some new foreign education methods to improve students' awareness of HIV/AIDS-related knowledge more efficiently.

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 the Ethics Committee of Wuhan University approved this study (Approval ID: 2021YF0047). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LZ designed the survey, analyzed the data, and reviewed manuscript. HY analyzed the data, wrote the manuscript, and prepared figures and tables. HL designed the survey and collected the data. WR, XM, and XD analyzed the data and wrote the manuscript. XT edited the manuscript. All authors contributed to the article and approved the submitted version.

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OPINION
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Online Education Plight and Countermeasures for MBBS in Chinese Regional Medical Schools Based on the OBE Concept During COVID-19 Pandemic

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INTRODUCTION

When national borders for studying in China will open, it remains unknown as the coronavirus disease 2019 (COVID-19) pandemic persists. The teaching mode changed from offline to mainly online or a hybrid of the two modes, which generated huge challenges in international education in China. In June 2020, the Ministry of Education issued an announcement emphasizing improvements in education quality and imposing high requirements for international education. Although teachers are unable to teach students face-to-face, they must promote the teaching quality to ensure the reputation and competitiveness of Chinese medical education (1). Outcome-based education (OBE) was proposed by Spady in 1994, which advocates the implementation of teaching activities based on the abilities of students and obtained results by learning, emphasizing student centeredness, and focusing on ability acquisition (2–4). Bachelor of Medicine and Bachelor of Surgery (MBBS) is a highly practical applied major. To obtain medical knowledge, students undergo basic training in the diagnosis, treatment, and prevention of diseases and develop abilities to identify the etiology and pathogenesis of diseases. OBE emphasizes ability training and its core is educational "output" under the guidance of the OBE concept; the exploration of MBBS teaching reform is aimed at integrating ability training into professional education and laying the foundation for the cultivation of high-quality applied medical talents. Although international students in China hail from all over the world and have different ways of thinking, values, and living habits, their attitudes, and understanding of medicine are the same. Regional medical schools are increasingly focusing on improving the quality of international undergraduate education and the OBE concept permeates through the entire process. Schools made many pertinent adjustments during the COVID-19 pandemic, but numerous difficulties remain (5, 6).

DEVELOPMENT OF MBBS EDUCATION BASED ON THE OBE CONCEPT

With the implementation of "The Belt and Road Initiative" (the Silk Road Economic Belt and the 21st Century Maritime Silk Road unveiled by Chinese President Xi Jinping during his visits to Central and Southeast Asia in September and October 2013), the number of international students in China increased steadily each year. Presently, China has the largest number of international students in Asia. According to relevant statistics, the proportion of academic students reached 54.6% in 2019, which is an increase of 7% from 2016. Students from the countries along the Belt and Road Initiative account for 54.1% of the total, and the number of students who choose to major in MBBS is the largest (7). However, owing to the insufficient attention paid to MBBS, teaching conditions and the quality of faculty in regional medical schools is uneven. Currently, China is experiencing a strategic transition period emphasizing "standardized management, improved quality, and efficiency." Schools are exploring MBBS reform actively under the OBE concept and taking a series of measures to integrate ability training into professional education and provide support for the cultivation of high-quality applied medical talents (8–12). During the early stages of the COVID-19 pandemic, regional medical schools practiced "classes suspended but learning continues" actively, as the quality of online international education at the time was poor. After the COVID-19 pandemic was effectively controlled in China, classes gradually resumed, moving to "online + offline" teaching. Moreover, students on campus returned to the classroom and those outside China engaged in synchronized online learning.

DIFFICULTIES IN MBBS EDUCATION OWING TO COVID-19 PANDEMIC

Lack of Experience of Teachers in English Online Teaching and Confidence in the Process

Currently, more than 70% of students in China are temporarily stranded outside the country and cannot return to school. Thus, implementing normal teaching methods is difficult, especially in courses such as biochemistry, pathology, pathogen biology, immunology, internal medicine, and so on. Before the COVID-19 pandemic, a variety of teaching methods could be adopted flexibly and teachers could adjust their strategies to improve the attention of students. In addition, teaching effects could be tested regularly. By contrast, lacking the assistance of a blackboard for writing and body language, teachers rely only on verbal expressions in online teaching; thus, understanding the learning status of students is difficult. Moreover, concentrating on online classes is difficult for students, resulting in unsatisfactory learning effects. Owing to the short time period for large-scale enrollment, the establishment and operation of online courses are substantial in regional medical schools. English online courses are being developed slowly, leaving only a few resources for students to select. In addition, students outside China are unable to obtain reference books and materials owing to the COVID-19 pandemic.

Non-integrated Online Teaching Platforms and Various Learning Constraints of Students Outside China

Teachers select online teaching platforms based on their preference including massive open online course (MOOC), Wisdom Tree, Rain Classroom, Superstar Learning Pass, Tencent Classroom, Tencent Meeting, DingTalk, and so on. Although such platforms are convenient for Chinese students, not all are suitable for international students. For example, students outside China are not allowed to register and log into such platforms without a Chinese ID and SIM card and access to certain platforms is restricted in some countries or regions. Therefore, using a unified teaching platform during the COVID-19 pandemic is difficult. Moreover, students outside China face the problem of time differences and are prone to absenteeism and tardiness owing to their inability to adapt to Beijing time. In addition, a reliable network is among the necessary conditions for learning. Some students, especially those in certain African countries, do not have access to reliable networks and, thus, experience network problems such as freezes and disconnections or wired or WiFi networks and use only mobile data. Hence, their willingness to attend classes is reduced significantly owing to high network costs. As a consequence, such students are typically unable to take online classes or log into platforms to watch videos, complete homework, take quizzes, and accomplish other tasks.

Poor Learning Effect of Experimental Courses Taken by Students Outside China and Inability to Participate in Internships

Experimental courses start as scheduled through major online education modes such as "live broadcast +" "recorded broadcast +," and "MOOC +." However, observation and operation are the main class activities. Despite teachers' provision of considerable material and detailed explanations, such contents are not as direct as operational experience. Moreover, audiovisual materials cannot be provided for courses such as regional anatomy, surgery, diagnostics, and medical functional experimentations owing to ethical issues. Thus, students outside China are highly dissatisfied with such courses. Based on the MBBS training program, students begin their internships, combining theoretical, and practical courses, in their fifth academic year. Regional medical schools arrange for students to intern in affiliated hospitals, which is among the long-awaited learning journeys of students. Internships lay the foundation of students for entering hospitals in their final academic year. However, completing internships on the schedule is impossible for students outside China. Some schools uniformly postponed internships for fourth-year students; however, this measure is not a long-term solution.

EFFECTIVE MEASURES THAT REGIONAL MEDICAL SCHOOLS CAN ADOPT IN RESPONSE TO THE CHANGES

Improve Teachers' Online Education Abilities Under the OBE Concept

Considering the characteristics of MBBS international students, who are keen on active questioning and extensive research, regional medical schools are attempting to integrate teaching and independent learning organically by changing formats, improving knowledge transfer efficiency, and cultivating students' autonomy in learning. Common teaching methods include team-based learning, case-based learning, problem-based learning, and presentation, assimilation, and discussion. To ensure teaching quality, theoretical course instructors should have solid professional knowledge and rich clinical experience. In principle, such teachers must have more than 1 year of study experience in a native English-speaking country. Internship instructors must be clinicians with an intermediate-level clinician qualification or higher. A hierarchical training model should be adopted by schools to improve teachers' online teaching competencies, including teaching skills, foreign language proficiency, and ability to use multimedia technology. Teachers can observe the teachings of experts from their or other well-known schools, cooperate and exchange with overseas universities, and share educational resources online, which can enable them to obtain guidance from overseas experts. Meanwhile, teaching departments should adhere to the effective traditions of leading newcomers, prepare lessons collectively, and teach demonstratively. Teaching skills competitions should be organized regularly to continuously improve the teaching abilities of young instructors. In addition, teachers should be fully prepared to address potential problems before the start of classes by establishing a sign-in system, providing preview materials, setting up in-class tests, and group discussions, and so on. Moreover, teachers should increase the frequency of video interactions to understand students' attitudes and reflect on teaching effects based on students' opinions and teaching evaluations results.

Use Online Teaching Platforms Normally and Adopt the "Online + Offline" Blended Teaching Mode

Presently, the blended teaching mode is the most common. A particular platform should be used uniformly and its functions should be adopted as much as possible to reduce the anxiety of students from online platforms. DingTalk stands out among existing platforms, which focus on the co-construction, sharing, application, and integration of high-quality educational resources into teaching, learning, management, and other tasks. Schools should arrange fixed classrooms for online teaching. DingTalk can be downloaded to computers and teachers can hold classes after logging into their accounts. Teachers should prepare PowerPoint courseware to display pictures, animations, videos, and other types of content vividly and intuitively. In class, teachers should pay attention to the status of online students, ask them questions, and get feedback regularly. The preparation of experimental courses is essential in online teaching. For regional anatomy experiments, teachers should provide videos for explaining the entire anatomy process and content and then teach by asking questions. Although online experimental teaching is similar to offline experimental teaching in terms of theoretical knowledge, the interpretation process and visual observation, actual hands-on training, the knowledge acquisition process, and multisensory experiences cannot be obtained and developed solely online. Hence, online experimental teaching should be supplemented once the COVID-19 pandemic is over to compensate for its shortcomings. For internships, roleplaying, which is a new teaching method, should be used to makeup for reduced clinical practice opportunities as well as the comprehensive application of digital resources. The status of students after class should also be determined and questions should be answered in a timely manner. Extracurricular knowledge should be supplemented appropriately, which can serve as an effective measure for face-to-face online teaching. Students outside China should be encouraged to seek hospitals for their internships and the effect can be consolidated through the "online + offline" mode. Furthermore, students must complete their internships and internship tasks in strict accordance with their school's regulations.

Make Online Teaching and Management Work Together

Cultivating a team of teachers with satisfactory English proficiency to conduct online teaching is necessary and an assessment system must be established by teaching departments. Supervision and inspection should be conducted at the beginning and teaching effectiveness should be assessed at the end of the school year. Supervisory experts, leaders, and instructors should create a specialized group to collect feedback from students and reflect online teaching effects and existing problems in a timely manner. One of the biggest challenges in online education is improving low attendance rates. Teaching departments and instructors should develop an effective attendance management system based on actual conditions, including punishments and linking attendance rates with grades. A formative evaluation combining staged and final assessments should be adopted and the proportion of staged assessment results should be maintained at 60% or higher. Staged assessments include in-class examinations, periodic examinations, laboratory reports, and homework, which are converted into a final score. Formative evaluation can enhance the learning autonomy of students. Additionally, psychological counseling and humanistic education are important for international students. Each student should be taken seriously and effective guidance should be given to those struggling with psychological problems. Teachers can discuss Chinese COVID-19 pandemic prevention measures and the latest policies in class, which can help to alleviate the anxiety of students. Teachers must also bear the burden of conveying the importance of medical skills and ethics to the students to enhance their sense of responsibility and competence.

CONCLUSION

Online education accords with the OBE concept and though teaching modes differ, the goals are the same. Ultimately, both methods allow students to acquire knowledge, master skills, and gain expertise. Online teaching is the main method used before restarting the Chinese exchange portal for MBBS. Chinese regional medical schools acquired certain resources and experience since the implementation of online teaching. However, such resources and experience are far from meeting the requirements for efficient and orderly development and increased online education exploration and improvement are necessary. Insufficient online teaching experience, poor classroom conditions, and difficulties in experimental teaching for students outside China are the common online education problems encountered by regional medical schools. Reformation in medical education was stimulated by the COVID-19 pandemic, and online teaching is a powerful accelerator. Schools have become committed to summarizing experiences and lessons from online education by improving management systems to strengthen collaboration and reforming teaching methods to adjust strategies. We should adapt to the changes and seize opportunities during the post-COVID-19 pandemic period, prepare for the establishment of a new online education pattern, and improve MBBS education for international students.

AUTHOR CONTRIBUTIONS

ZL and YL conceived the idea, investigated, analyzed the current situation, and wrote the initial draft of the manuscript. CK, NH, JZ, and AM participated in revision, discussion, and presented opinions in this study. XS conceived the idea, and revised the manuscript. All authors contributed to the final manuscript and agreed on the final version of the manuscript.

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Enhancement of Medical Students' Performance and Motivation in Pathophysiology Courses: Shifting From Traditional Instruction to Blended Learning

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Blended learning is a learning approach that combines face-to-face classroom lectures and e-learning. It has grown rapidly to be commonly used in medical institutions, especially in the local medical universities where there is lack of qualified teachers and instructional materials. Massive open online courses (MOOCs) are the latest revolution in e-learning and provides learners with access to quality educational resources. Nevertheless, there is seldom reports concerning how to effectively integrate MOOCs into blended learning in local universities, as well as the evaluation of knowledge outcomes. In order to achieve this aim, a blended learning approach was carried out in teaching pathophysiology in Guilin Medical University. This blended learning model was based on combination of Chinese University MOOC with case based learning (CBL), as an alternative to conventional learning. The medical students in the 2017 and 2018 classes received the blended learning method, while the medical students in the 2015 class received the traditional classroom instruction. The results showed that students in the 2017 and 2018 performed significantly better than students in the 2015 class at mid-term exam and the final exam. Perception surveys also revealed that both students and teachers had positive attitude toward blended learning, and they shared similar viewpoints of blended learning. A large proportion of students and teachers believed that the blended learning enhanced students' motivation to learn independently, improved their time management skills, and allowed them to experience personalized learning. Also, most students and teachers recognized that Chinese University MOOC provided substantial educational resources suitable for their need. In addition, teachers indicated that the blended learning improved student learning quality, facilitated interaction between teachers and students, and helped them to establish

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a student-centered model in teaching pathophysiology. Overall, the blended learning method that combines Chinese University MOOC with CBL is effective in enhancing students' achievement and motivation in pathophysiology than the traditional learning method, and helps to strengthen the cultivation of talent in local medical universities.

Keywords: education, medical students, local university, blended learning, MOOC, pathophysiology

INTRODUCTION

With the development of internet and information technology, e-learning have become popular in medical education. Generally, e-learning refers to the use of new multimedia and communication technologies to enable the delivery of part or all of a course (1). This online learning setting is able to transcend the boundaries of institutions, time and geographical location. It allows students to learn at their own rate and plan in order to obtain a satisfactory learning outcome, due to their availability and ease of access to a large amount of learning resources (2). Therefore, e-learning is becoming more and more important in medical institutions of higher education. Nevertheless, e-learning also has some disadvantages (3). First, the high cost of technical infrastructure and network equipment is the most important barrier to e-learning development. Secondly, students are encouraged to depend on themselves during the online study, while the lack of strong intrinsic motivation and high time management skills may decrease student's learning effectiveness. In addition, when it comes to communication between students and teachers, face-to-face interaction in traditional methods may be more effective than e-learning.

Actually, many local universities are still being based on traditional learning method and follow the conventional setting of face-to-face lectures in a classroom instead of e-learning. Unlike e-learning, traditional learning requires students to attend classes at fixed time and place, which may facilitate the development of time management skills (4). Also, when students go to class, they have to learn how to interact with teachers and peers from diverse backgrounds and cultures. It is helpful to strengthen student's social skill and broaden their horizons. On the other hand, traditional learning is constrained by classroom size and teacher-student ratio. Undoubtedly, this constraint is more pronounced in local medical universities in the developing countries, where the school size and the number of qualified teachers has not increased in proportion to the rapid increase in school enrollments (5).

Due to the merits and demerits of both traditional learning and e-learning, their careful combination would be better than replacing each other. Blended learning is one of modern learning that combines face-to-face traditional learning and online learning. There is increasing evidence that blended learning is more effective in knowledge acquisition than traditional learning (6, 7). Consequently, a growing number of institutions of higher education are adopting blended learning including Guilin Medical University.

Recently, massive open online courses (MOOC) is developing rapidly and widely used in education. The aim of MOOC is to provide open and high-quality online education resources for self-study, and thus undergoes a shift from teacher-centered to student-centered learning (8). In China, MOOC construction began in 2013 and has made great strides in recent years. Until now, these platforms have been available online including Chinese University MOOC, Tsinghua University's "School Online," Shanghai Jiaotong University's "Good University Online," and the domestic basic education MOOC platform such as Zhihuishu and Fanya (9). Among them, Chinese University MOOC is the largest online open education platform, and provides the public with high-quality courses in science, medicine, engineering, economic and computer from the top universities in China (10). An increasing number of reports have indicated that Chinese University MOOC has made big contributions to the development and reform of higher education in China and the world (11).

In this study, Chinese University MOOC platform combined with classroom teaching was applied to pathophysiology courses for 3rd-year medical students in Guilin Medical University. Moreover, we here implemented case based learning (CBL) as an alternative to traditional formal learning. The use of blended learning based on Chinese University MOOC and CBL was compared with the traditional classroom method. Meanwhile, the reaction of our students and our faculty to these reform initiatives was explored. The goal of this study is to find a approach to improve the quality and outcomes of pathophysiology teaching suitable for the local medical universities.

METHODS

Students

In Guilin Medical University, students take the pathophysiology courses in their 3rd year. The students who participated in this study were undergraduate clinical students in the academic years 2015, 2017, and 2018. Four hundred and thirty-one students from the 2015 class who attended traditional lectures were selected as control group (traditional learning methods). Four hundred and eighteen students from the 2017 class and 586 students from the 2018 class attended the blended learning courses that combined Chinese University MOOC resources with CBL method.

Teaching Plan

Recently, most Chinese universities have introduced online teaching platform, which can make up for the disadvantages of classroom instruction. Therefore, we used a combination of online educational platform (Chinese University MOOC) with CBL. This MOOC platform enables students to find learning resources that suits their needs and learn at their own pace.

In terms of curriculum design, the blended learning plan includes pre-class self-study, pre-class quizzes and face-to-face CBL classes. The pathophysiology course contents include water and electrolyte balance and imbalance, acid-base balance and imbalance, shock, hepatic failure, renal failure, heart failure, respiratory failure. Each lecture consists of two teaching hours (40 min each). (1) In pre-class self-study, students were required to read relevant chapters in the textbook and watch relevant videos on Chinese University MOOC platform. Meanwhile, the relevant PPT prepared previously by teachers and questions selected from the test database of Chinese Medical education were recommended by teachers to be used as Supplementary Materials. (2) During class, students completed a pre-class quiz (10–15 min, total 20 points) within the MOOC. Next, the teachers gave specific explanation for the questions with high incorrect answer ratios. (3) During the course of teaching, the teachers first presented the clinical cases to students. Then, students were asked to discuss a series of questions regarding the cases such as involved pathogenic mechanisms and therapeutic principles. A few student volunteers were asked to share their answers and received timely feedback from the teachers. (4) At the end of the course, the teachers summarized the main points of lessons and evaluated students' performances, as well as answer the questions.

Course Assessment

All 2015, 2017, and 2018 class students were tested twice in the course: in the middle of course and at the end. The middle test included 60 multiple-choice questions with a total score of 60 points and conducted by means of an on-line examination. The final test was established in an offline, closed-book format. The examination papers with total 100 points were carefully prepared by experienced teachers, including multiple-choice questions (MCQ), short answer questions (SAQ) and case analysis questions. The papers had adequate coverage of the course contents.

Questionnaire

To better assess this learning method we, respectively, conducted anonymous questionnaire survey to the students and teachers at the end of a term. The questionnaire was based on previous peer instruction studies in medical education (12, 13). The questionnaire determined students and teachers opinion regarding the blended learning method and Chinese University MOOC on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

Statistics

The quiz scores were presented as means ± standard deviation (SD). Data were analyzed using SPSS 12.0 software for Windows (SPSS Inc., Chicago, Illinois, USA). ANOVA, *T*-test and LSD were used to determine differences among 2015, 2017, and 2018 classes. For the results of the questionnaires, the collected data were analyzed using SPSS with Chi-square test. A *P*-value of <0.05 was considered statistically significant.

RESULTS

Comparison of Student Achievement Under Different Learning Methods

The 2015 class took the pathophysiology course *via* traditional learning approach, whereas the 2017 and 2018 classes was taught using the blended learning method. Assessment of student performance in the middle of course showed that the mean exam score of the 2018 class (54.83 ± 5.76 points) was the highest, followed by the 2017 class (50.56 ± 5.85 points), while the mean score of the 2015 class (47.87 ± 6.11 points) was the lowest (see **Figure 1A**, $P < 0.001$). In the final exam for the

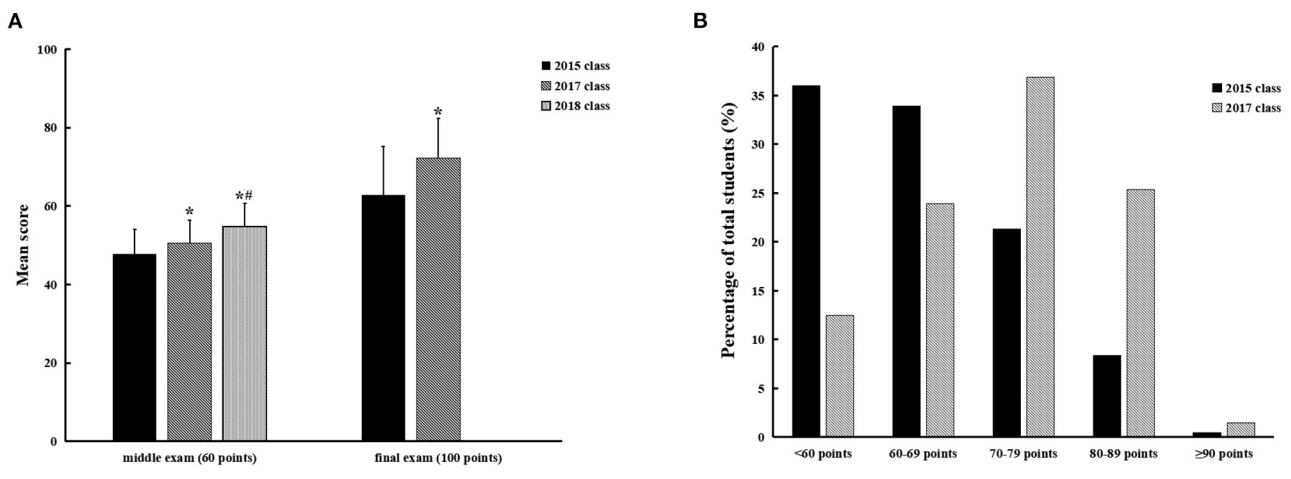

FIGURE 1 | Comparison of student achievement between traditional instruction and blended learning. **(A)** Average scores of the middle exam and final exam in the 2015 class ($n = 431$), 2017 class ($n = 418$) and 2018 class ($n = 586$), analyzed by ANOVA, *T*-test and LSD. Values are means ± SD. $^{*}P < 0.001$ vs. 2015 class without blended learning. $^{\#}P < 0.001$ vs. 2017 class. **(B)** Distribution of the final exam scores in the 2015 class ($n = 431$) and 2017 class ($n = 418$). The results were presented as percentage of total students of the class.

2018 class, the examination paper only include multiple-choice questions that were randomly selected from the Test Database of Chinese Medical Education maintained by People's Medical Publishing House. It was different from the final exam for the 2015 and 2017 classes. Thus, we only compared students' final exam performance of the 2015 and 2017 classes (**Figure 1A**). It was found that the mean score of the 2017 class with blended learning was statistically higher than that of the 2015 class (72.32 $\pm$ 9.98 points vs. 62.83 $\pm$ 12.28 points, $P < 0.001$). Meanwhile, we observed the distribution of the final exam scores (see **Figure 1B**). Student must score at least 60 points to pass the final exam. The proportion of students with a final score <60 points in the 2015 class was much higher than in the 2017 class (36.0 vs. 12.4%, $P < 0.001$). On the other hand, the proportion of students with a final score $\geq$ 80 points in the 2017 class (26.8%) significantly elevated in comparison with that in the 2015 class (8.8%) ($P < 0.001$).

Observation of Students' Self-Study Before Class

In our teaching plan, the MOOC platform played an important role in pre-class self-study. With online videos shared on the platform, the students in 2017 and 2018 classes were required to preview the related content before class. The goal was to extend their learning time and improve the teaching effect.

TABLE 1 | Mean scores of pre-class quizzes in 2017 and 2018 classes (total 20 points).

Class	Water and electrolyte balance and imbalance	Acid-base balance and imbalance	Shock	Hepatic failure	Renal failure	Heart failure	Respiratory failure
2017 class	19.1 ± 1.3	16.6 ± 4.1	19.0 ± 1.9	18.8 ± 1.8	17.4 ± 4.8	17.0 ± 3.4	11.8 ± 3.9
2018 class	18.9 ± 1.8	17.9 ± 4.9	19.1 ± 1.8	19.9 ± 1.4	19.9 ± 1.8	19.8 ± 1.8	19.8 ± 1.2*

$P < 0.05$, Compared with corresponding 2017 class.

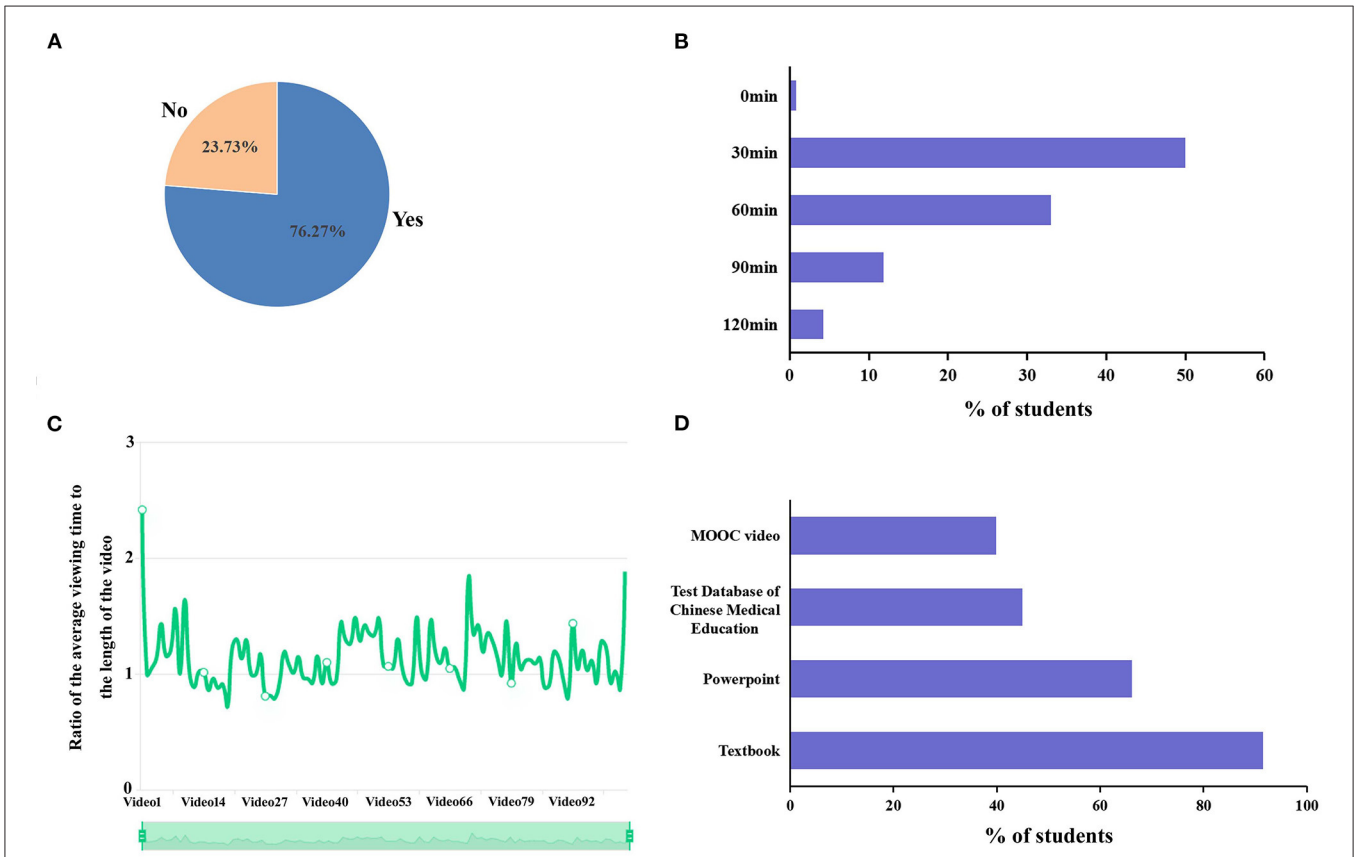

FIGURE 2 | The status of students in 2018 class in completing the pathophysiology self-study before class ($n = 118$). **(A)** Percentages of students divided by whether they can complete the pre-view. **(B)** Time spent by students in pre-view. **(C)** Comparison of video viewing duration and video length (automatically generated by Chinese Universities MOOC platform). **(D)** Percentages of students who preferred different learning materials to complete the pre-learning.

Students' pre-class quiz scores reflected that the majority of students really previewed the contents (**Table 1**). Meanwhile, to analyze students' self-learning activities with the MOOCs platform before class, the survey data were collected from a sample of 118 students in 2018 class using Wenjuanxing, an online survey platform. Totally, 76.27% students pre-viewed before class with the aid of the MOOC platform (**Figure 2A**). In terms of time, 33.05% students spent ∼60 min completing the pre-class activities, while a half of students spent ∼30 min on preview (**Figure 2B**). Hence, we were interested in how students watched the lecture videos in the online learning system. Since 2020, the Chinese University MOOC began to provide statistical data on students' online behaviors. The average viewing duration of each video is calculated, and then compared with the length of the video. For students in 2018 class, the data showed that the viewing time length of learners is generally 1–2 times longer than the length of the video, indicating that some students watch the same video repeatedly (**Figure 2C**). Nevertheless, regarding the learning materials for preview, the majority of students still preferred textbook as first-order preference (91.53%), followed by PPT (66.1%), the test database of Chinese Medical Education (44.92%) and MOOC videos (39.83%) (**Figure 2D**).

Student's Attitudes Toward Blended Learning

Students showed positive attitudes toward blended learning. They tended to express enjoyment and satisfaction from the blended learning experience (see **Table 2**). The majority of the 2017 class (69.9%) and 2018 class (67.8%) considered that blended learning meet the need of personalized learning, and the modified learning method helped 62.5% students of the 2017 class and 67.5% students of the 2018 class to manage their study time effectively. Moreover, 67% of students in the 2017 class and 66.4% of students in the 2018 class acknowledged that they took more initiative for learning in the blended format. When it comes to online resources for medical education, the majority of the students in both the 2017 and 2018 classes held the opinion that Chinese University's MOOC platform could provide appropriate and sufficient e-learning resources for students to conduct autonomous learning. However, it should be noticed that less students in the 2018 class agreed that the online resources of Chinese University's MOOC were suitable for their need in comparison with the 2017 class (55.0 vs. 66.5%, $P < 0.05$). Indeed, more students in the 2018 class chose "neutral" about these resources, indicating that they were not very satisfied with this platform.

Teacher's Attitudes Toward Blended Learning

Analyzing teachers' questionnaire revealed that the majority of them expressed a willing to make use of Chinese University MOOC while designing a blended learning course (see **Table 3**). In addition, they considered that the combination of e-learning and CBL result in a positive effect on students' motivation, experience, performance and interaction with teachers. The teachers also believed that the implementation of blended learning made a transition from teacher-centered to student-centered mode of education, which was adapted to the requirement for cultivation of quality of talents. On the other hand, we observed that half of the teachers indicated a neutral response toward the online learning resources on Chinese University MOOC, which was consistent with students' response to this platform.

TABLE 2 | Responses from medical students regarding the blended learning experience.

Item	Agree (score: 5 and 4)				Neutral (score: 3)				Disagree (score: 2 and 1)			
	2017 class ($n = 176$)		2018 class ($n = 289$)		2017 class ($n = 176$)		2018 class ($n = 289$)		2017 class ($n = 176$)		2018 class ($n = 289$)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Chinese University's MOOC platform provides appropriate e-learning resources	117	66.5	159	55.0*	53	30.1	116	40.1	6	3.4	14	4.8
There are rich resources available for students on Chinese University's MOOC platform	120	68.2	213	73.7	49	27.8	62	21.5	7	4.0	14	4.8
The blended learning method met the need of personalized learning	123	69.9	196	67.8	44	25.0	73	25.3	9	5.1	20	6.9
The blended learning method enabled you to manage your study time effectively	110	62.5	195	67.5	49	27.8	72	24.9	17	9.7	22	7.6
The blended learning method enabled you to take more initiative for learning	118	67.0	192	66.4	50	28.4	76	26.3	8	4.5	21	7.3

Values are n, no. of students, and percentage of students. Responses were scored using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).
**P < 0.05, Compared with corresponding 2017 class.*

TABLE 3 | Responses from the classroom teachers regarding the blended learning approach.

Item	Agree (score: 5 and 4)	Neutral (score: 3)	Disagree (score: 2 and 1)
The Chinese University MOOC-based blended learning helped to promote the research and practice of teaching innovation in pathophysiology	7	3	0
The Chinese University MOOC-based blended learning better met the demand for talent training in student-centered model	7	3	0
The Chinese University MOOC-based blended learning improved the quality of student learning	7	3	0
The Chinese University MOOC had online learning resources at an appropriate level for our students	5	5	0
The blended learning promoted the interaction between students and teachers	6	4	0
The blended learning met the need of personalized learning	9	1	0
The blended learning enabled students to manage their study time effectively	8	2	0
The blended learning enabled students to take more initiative for learning	7	3	0

Values are no. of responses. Responses were scored using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

DISCUSSION

Traditional learning methods mainly consists of face-to-face classroom lectures where knowledge was passed from teacher to student *via* verbal interaction. However, students tend to remain relatively inactive or even passive, and depend on teachers (14). On the contrary, e-learning help student to achieve increased flexibility and give them more control over study pace. MOOC is a potent platform for open online resources, by which the learners can choose courses suitable for their learning needs. According to the data from the 2020 Global MOOC Conference held by Tsinghua University in September 2020, China ranks the first in the number of MOOCs (over 30 platforms and over 3,400 courses) (15). With the increasing number of education institutions that implement the online learning mode, MOOC is having a strong impact on the reform and development of Chinese higher education. In China, some national online platforms have appeared such as XuetangX, CNMOOC, Chinese University MOOC, "Fanya" and Zhihuishu. Liang et al. conducted a comparative analysis of these five platforms (16). The results showed that there are more effective discussion boards for communication in Chinese University MOOC platform, including general discussion board, comprehensive discussion board, teacher question-and-answer board and communication board, enhancing student-student and teacher-student interaction. Besides, the assessment criteria is only available in Chinese University MOOC platform, so that the learner can have proper evaluation about their learning level and plan their own learning. In particular, this platform has relatively complete course guidance resources in order to provide positive guidance for students with low self-learning ability. For these reasons, we used Chinese University MOOC as teaching support in our university where the students need more guidance and supervision from the teachers in comparison with students from well-known universities.

In our teaching plan reform, students preview course content in advance with open online courses from Chinese University MOOC. All online videos were selected by the pathophysiology team and watched by the students at least once, which provides learners with in-depth explanations and valuable repetition. Generally, most students could complete autonomous learning before class, and spent <60 min in pre-viewing. After the preview with online courses, students gained a general understanding of the main course contents. Next, in the face-to-face classes, we adopted CBL as a teaching method other than conventional lecturing. Studies have shown that CBL promotes deep learning and better understanding of the contents. Moreover, CBL helps student to improve critical thinking, analytical and problem solving skills (17). It is worth mentioning that students in local universities exactly lack these skills in some extent because of inadequate cultivation of creative and practical ability. As a result, the undergraduate courses of these universities tend to produce a qualified medical graduate, but not an educated man who will become more and more qualified as time progresses by lifelong learning. Therefore, we believed that with the implementation of CBL in regular curriculum, students could not only enhance their understanding of the course content but promote critical thinking and creativity abilities after the classes ended. Simultaneously, in the process of CBL course, students' attitudes toward the subject shifted from "what I have been taught" to "what I want to learn," where they were prompted by teachers to learn the knowledge that was relevant in order to solve the problem (18). As expected, most of the students enrolled in the blended pathophysiology courses agreed that the learning method cultivated their autonomous learning abilities.

It is well-accepted that successful implementation of CBL is based on proper case selection and question design (level appropriate for students). In the context of relatively low professional ability and comprehensive quality, each of the "cases" and "problems" was carefully designed in close consultation with clinicians and experienced CBL faculty. The "cases" covered all the key and difficult points of the course. Conversely, the easy parts required students to study by themselves, allowing more class time for discussion. What's more, the "problems" mainly focused on general principle instead of specific technical measures, and thus most of students could find out correct answers to the questions after consulting literature and discussing with other students. This learning method

enabled students to cultivate their clinical interests and increase their confidence in themselves.

Students' performance under the blended learning approach was, respectively, evaluated in the middle of course and at the end of course. The middle exam was online and included only multiple-choice questions. We found that performance of the 2018 and 2017 classes was both better than that of the 2015 class. Unlike the middle exam, the final exam was closed book and more complex, including MCQ, SAQ and case analysis questions. Thus, the final test score could further reflect student learning performance. More profound differences were found with respect to average exam scores between the 2015 and 2017 classes. Moreover, the proportion of students scoring in the 80s and 90s in the 2015 class was lower than that in the 2017 class, and more students in the 2015 class failed to pass the final exam (whose score was lower than 60 points). On the basis of these results, it can be concluded that the blended learning, combination of Chinese University MOOC approaches with CBL, promotes the learning of student and improves their academic performance. Meanwhile, given the higher mean score of the 2018 class than 2017 class, it may be speculated that students' performance could further arise as this blended learning method becomes more flexible and controllable.

Since the launch of Chinese University MOOC in 2014, this platform provides learners with high-quality open online courses, the number of which grew rapidly (19). For example, the online courses of pathophysiology were only offered by Central South University in 2019, while in 2020, three more well-known Chinese universities begin to provide the public with MOOC courses including Huazhong University of Science and Technology, NanChang University and Wuhan University. Considering the high quality of course content on Chinese University MOOC platform, we made innovation on teaching mode of pathophysiology based on this MOOC. To understand students' attitude toward Chinese University MOOC-based blended learning course in pathophysiology, a total of 465 questionnaires from students (176 in the 2017 class and 289 in the 2018 class) were collected and analyzed. The blended learning approach had a good acceptance from the students. The majority of the students agreed that the most useful advantage of the blended learning model is time flexibility and location convenience. Because of this, they could effectively control the time and pace of their learning, finally promoting their learning autonomy.

Unexpectedly, we observed that students in the 2018 class had less positive attitude toward Chinese University MOOC in comparison with students in the 2017 class, although more students acknowledged that this platform provided rich medical resources. This was consistent with the survey in which students in 2018 class tend to use textbooks and PPT rather than MOOC videos for pre-class study. Chinese University MOOC is famous for the top-quality courses offered by well-known universities, thus these courses are designed primarily for the students of high ability in these institutions (20). Nevertheless, the students' professional ability and comprehensive quality is relatively low in local/regional institutions such as Guilin Medical University (21). As a result, some courses contain insufficient detail for our students, while others are really hard to understand against the background of students' low level of prior knowledge. In this context, we tried to integrate Chinese University MOOC teaching resources with self-built resources including videos, PPT and chapter tests available on campus network. The resources of self-built courses were carefully designed by pathophysiology teaching team according to the medical licensing examination requirements, and more closely related to our students' level of knowledge and ability. This change was implemented from the start of the 2018 class, which might partly contribute to the increased average score of the middle test in comparison with the 2017 class. Therefore, we will continue to integrate high-quality online resources such as Chinese University MOOC into our blended learning in pathophysiology courses at Guilin Medical University in the future teaching practice. On the other hand, the proportion of our self-built online resources may gradually increase.

We also collected questionnaire data from the involved teachers. Generally, they were satisfied with Chinese University MOOC-based blended learning and welcomed this student-centered learning method model. In agreement with students' opinion, most teachers believed that the blended learning was a good way to motivate students and cultivate their ability of autonomous learning and communication, leading to improved students' performance in pathophysiology. Hereby, they would desire to continue the implementation of blended learning in teaching pathophysiology. Otherwise, a half of teachers were "neutral" on the applicability of Chinese University MOOC as an independent learning platform, triggering the further development of self-built online resources.

Taken together, it is concluded that blended learning method that combined Chinese University MOOC with face-to-face CBL courses could improve students' performance and motivation. This learning method was valued positively by the students and teachers for its flexibility and personalization, and suitable for the talent training in local universities. Meanwhile, as a result of this research, it became clear that teachers in local medical universities urgently need to better identify and use more appropriate online learning resources that match students' ability and academic levels.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Guilin Medical University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JT and HL conceived and designed research and approved final version of manuscript. HL, QW, and XL performed experiments. GS analyzed data. DW, HL, and XL interpreted results of experiments. JT prepared figures. JZ drafted manuscript. JT, DW, and HL edited and revised manuscript. All authors contributed to the article and approved the submitted version.

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Doctor of Public Health-Crisis Management and COVID-19 Prevention and Control: A Case Study in China

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In the fields of public health policy and public health care, advanced educational programs are an important strategy in dealing with public health crises. The COVID-19 pandemic has exposed the global need for skilled public health leaders and managers to address complex public health challenges, which requires the strengthening of public health education at the highest levels. This paper is a qualitative case study of a special educational program for doctors of public health in China. The program's educational objectives are in line with epidemic prevention and control. With the goal of developing the world's leading national public health management system, the Chinese government established an advanced academic program for public health crisis management. The program offers doctoral students a multidisciplinary degree based upon the theoretical knowledge of crisis management, supported by advanced training in the foundational concepts, theories, and practices of public health, and the study of basic medicine which provides the theoretical support for developing essential clinical skills. Program graduates develop the theoretical, practical, and leadership-related capabilities required for the management of national emergencies. The program introduced in this paper meets current epidemic prevention and control needs and should be considered by public health policy makers, leaders, and scholars in the discussion of advanced public health policy and health care education in China, including the development of an internationally recognized Doctor of Public Health program.

Keywords: COVID-19, public health crisis, doctor education, curriculum, scientific research

INTRODUCTION

The recent coronavirus disease (COVID-19) pandemic has exposed the global shortage of workers in the fields of public health and health care (1) and, in particular, the need for skilled leaders and managers to translate public health research into effective policies and programs to manage emerging public health threats, staff response efforts, and improve population health (2–5). To respond to the ongoing exigencies of public health and health care that have been exacerbated

by COVID-19, countries have developed various emergency strategies to strengthen their public healthcare systems. For example, to support its COVID-19 contact tracing operations, Germany developed the Contact Scout Initiative to increase the nation's public health workforce with short-term labor solutions (6), and Italy mobilized its residents to create a non-professional healthcare workforce to support its national COVID-19 prevention and control measures (7). However, national public health policy makers, leaders, and scholars worldwide have recognized that these temporary strategies do not address the fundamental global public healthcare workforce crisis—and specifically, the need for skilled public health and health care leaders and managers to address complex public health challenges—that require the strengthening of public health education at the highest levels (8).

While China's public health system has made remarkable progress in proactively responding to COVID-19, it has also exposed many problems. From severe acute respiratory syndrome epidemic in 2003 to COVID-19 in 2020, the shortcomings of China's public health system have not been fully addressed. The entire public health system lags far behind in terms of personnel, technology and equipment. The growth of government's public health investment lags behind the speed of social and economic growth, and the phenomenon that "the god of wealth follows the god of misery" remains unchanged. Public health policy makers and leaders in the People's Republic of China (China) have recognized the importance of high-level leadership in the fields of public health and health care, and the need for advanced education in public health to address complex problems of public health policy in the COVID-19 era. At the national level, the Chinese government has proposed the establishment of academic institutions that provide advanced education in the foundations of public health along with the mastery of essential skills, such as pathogen identification, epidemic situation analysis and transmission law research, and field epidemiological investigation (9). Thus, the Chinese government has acknowledged the fundamental role of advanced public health education in the vigorous cultivation of future leaders who will manage public health issues and play an essential role in preventing and controlling infectious diseases (10), translating academic knowledge and skills into practical results in the field.

The cultivation of advanced scholarship combined with leadership and applied practice skills among healthcare professionals has become an essential goal in public health policy development (11). The doctorate in public health represents the most advanced level of formal education available in the field (12). Graduate students in public health at the doctoral level include the Science degree doctoral education (Ph.D.) and the professional degree (DrPH). Ph.D. focuses on training research-oriented talents in a certain field of public health to solve scientific problems arising from basic public health research, while DrPH focuses on training leaders in the field of public health to solve practical problems arising from public health (13). Among them, the DrPH graduate, who has received a comprehensive multidisciplinary education encompassing academic, applied public health, and leadership training, has been prepared to lead transformational organizational and societal efforts in public health and health care (14).

However, at the time of publishing, China had not yet established a national DrPH program, although Chinese universities are exploring various DrPH programs (11). For example, in 2020, Xi'an Jiaotong University, Peking University, Fudan University, Zhejiang University, and other universities jointly proposed the establishment of a Chinese DrPH degree program (15). In this paper, we focus on the case study of a unique advanced academic degree in public health and crisis management offered by a Chinese medical school that was developed to cultivate knowledge and skills at the doctoral level in the practice of public health with a special focus on crisis management. Graduates of this program have been among the leaders of the prevention and control measures in the COVID-19 pandemic in China. This case study has implications for scholars and public health policy makers in the development of the similar advanced multidisciplinary academic programs in the fields of public health and health care.

MATERIALS AND METHODS

Setting

In 2011, the Academic Degrees Committee of China's State Council issued the Opinions on the Pilot Program of Personnel Education to Serve the Special Needs of the State. According to these opinions—which outlined China's urgent need for scholarly and practical excellence in public health policy and health care—the law provided for a pilot doctoral degree program at several advanced academic institutions in China, called the Talent Education Program for National Special Needs, with doctoral degree granting. Although this was not a DrPH program, the State Council granted Weifang Medical University, Weifang, Shandong Province, permission to offer a public health curriculum with a focus on crisis management—the Doctoral Training Program of Public Health-Crisis Management (DrTP-PHCM). The recruitment of full-time doctoral students began in 2013. At the time of publishing, 54 students have been enrolled in the University's DrTP-PHCM, including 16 graduates and 38 students currently attending the school.

Methods

The data sources of this study mainly include: (1) The system documents of DRTP-PHCM are sorted out, mainly including the education plan and curriculum setting. From the education plan, the education objectives of the program are sorted out, and the main curriculum setting is introduced. (2) The basic information of Ph.D. students recruited by DRTP-PHCM since its establishment is collected, mainly their scientific research, internship and international exchange, and graduation destination are sorted out and analyzed.

RESULTS

Education Objectives

Figure 1 shows the education objectives of DrTP-PHCM. The DrTP-PHCM of Weifang Medical University offers a

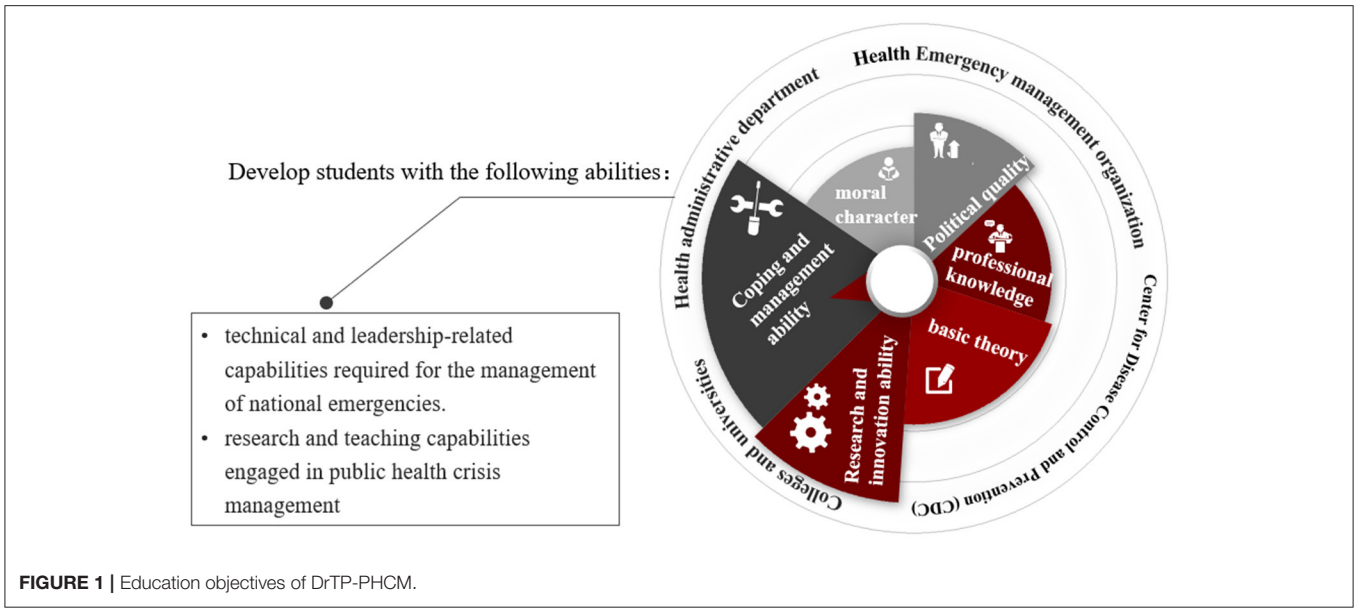

FIGURE 1 | Education objectives of DrTP-PHCM.

multidisciplinary degree based upon the theoretical knowledge of crisis management, supported by advanced training in the foundational concepts, theories, and practices of public health, and the study of management and psychology which provides the theoretical support for developing the cultivation of comprehensive professional skills of public health crisis management. As shown in **Figure 1**, DrTP-PHCM graduates develop the technical and leadership-related capabilities required for the management of national emergencies, as well as the research and teaching skills needed to engage in public health crisis management. The students can serve not only in universities and scientific research institutions, but also in health administration departments, health crisis management departments and disease prevention and control institutions.

The educational objectives of the DrTP-PHCM are consistent with China's national public health security needs, and the Program offers students the opportunity to deepen areas of expertise and build skills in three specific areas—public health crisis management theory and policy research, public health crisis prevention and response, and public health crisis psychological intervention. Since the establishment of the Program, up to 5 students have been enrolled in each study area annually.

Curriculum

To achieve the objectives of China's Ministry of Education, the DrTP-PHCM developed a curriculum that meets specific educational requirements. Doctoral students are required to take a minimum of 24 credits during the full program. The Program has constructed a curriculum integrating public health and crisis management foundation courses, professional core courses, hands-on experiential courses, and courses designed to promote innovative thinking (**Table 1**). Professional foundation courses and professional core courses cover public health policy, public health and crisis management, and other related educational objectives. The experiential courses include simulation exercises, applied practice, and case studies. The courses to develop innovative thinking include lecture participation, scientific research training, and studying abroad. Regarding student assessment, public courses, and professional foundation courses and elective courses generally require comprehensive examinations, experts evaluate hands-on practical training, and a dissertation is part of the graduation requirements.

TABLE 1 | Curriculum system of DrTP-PHCM.

Category	Course	Assessment method
Public Courses	Marxism in Chinese, English Reinforcement, English Thesis Writing, etc.	Examination
Professional Foundation Courses	Read Some Classic Works of Public Health Management, Sociological Research Methods, Health Security System and Reform, etc.	Examination
Professional Core Courses	Public Health Policy, Overview of Public Health Crisis, Early Warning and Crisis Management, Methods and Techniques of Public Health Field Investigation, Social Psychology of Disaster Response from an International Perspective, etc.	Examination
Experiment and Practice Course	Innovative Experiment, Simulation Exercise and Base Practice, Case Study, etc.	Diversified Test
Innovative Course	Frontier Lectures and Seminars, Scientific Research Training, Academic Exchange, Studied Abroad, Subject Implementation, Thesis Writing, etc.	Diversified Test

Scientific Research

Since the establishment of the DrTP-PHCM of Weifang Medical University, teams of doctoral advisors and candidates have conducted scientific research about public health and crisis management. In their role as doctoral advisors, members

TABLE 2 | Scientific research of DrTP-PHCM.

Specific areas (number of dissertations)	Dissertation topic	Research direction	Focus problem
Public Health Crisis Management Theory and Policy (5 dissertations)	Public health security strategy of China	Public health Security	National public health security
	Research on the risk early-warning of China total expenditure on health	Public health burden	Risk identification of total health expenditure
	Research on risk of government health expenditure in China	Government public health expenditure	Risks of government health expenditure
	Research on the Relationship between Health Input and Health Output in OECD Countries from the Perspective of Public Risk	Government public health input	Relationship between health input and health output
	Research on the competency model of public health rapid response team and intervention based on emergency exercise	Public health leadership	National health emergency manpower competence
Public Health Crisis Prevention and Response (6 dissertations)	Research on vulnerability of village clinic doctors in Shandong province in the context of the new medical reform	Primary public health workforce	Vulnerability of rural doctors
	Research on emergency management capability of hospital infection outbreak in third-level general hospital	Public health emergency management of tertiary general hospital	Emergency response capacity of nosocomial outbreak in Tertiary General Hospital
	Development and empirical study of leadership evaluation tools for infectious disease prevention and control managers	Public health leaders	Leadership evaluation of infectious disease prevention and control managers
	Research on the development characteristics and countermeasures of internet public opinion on public health emergencies	Response to public health emergencies	Network public opinion on public health emergencies
	Research on evaluation and optimization strategy of Shanghai infectious disease prevention system	Public health emergency management	Evaluation of infectious disease prevention and control system
	Research on community resilience evaluation and adaptive Governance of the emergence of major infectious diseases	Community resilience to sudden major infectious diseases	Community resilience evaluation and adaptive management of sudden infectious diseases
Public Health Crisis Psychological Intervention (4 dissertations)	Research on psychology crisis vulnerability of community residents	Psychological crisis intervention in public health emergencies	Psychological crisis of community residents
	The genetic basis of impulsivity and the neuroelectrophysiological mechanism of inhibitory function in depression patients with suicidal ideation and intervention strategies	Psychological crisis intervention in public health emergencies	Suicide ideation in patients with depression
	Cognitive reappraisal intervention for anxiety and depression in breast cancer survivors with post-traumatic stress symptoms	Psychological crisis intervention in public health emergencies	Post-traumatic stress symptoms, anxiety, and depression in breast cancer survivors
	The effect of forgiveness and social connectedness in adolescents' depression severity on suicidal ideation: a mechanism and intervention study	Psychological crisis intervention in public health emergencies	Adolescent depression and suicidal ideation

of the University faculty have cooperated with the Chinese Center for Disease Control and Prevention, the Chinese Health Development Research Center, and other institutions. To address major societal risks in the fields of public health and health care, these teams assessed public health vulnerability, crisis early warning mechanisms, individuals' psychological status, and emergency strategies and countermeasures that deal with public health crises.

The DrTP-PHCM degree requires that graduate students' dissertations be oriented to meet China's national public health and crisis management needs, and thus can directly support government decision-making, or guide epidemic prevention and control strategies. Since the establishment of the Program, graduate students' dissertations have focused on the three aforementioned study areas—public health and crisis management theory and policy, public health crisis prevention and response, and public health crisis psychological intervention—and as of September 2021, 16 doctoral candidates had completed their dissertations (**Table 2**).

Hands-On Training

The University's DrTP-PHCM allows doctoral candidates to select a personalized training programs based on individual interests and qualifications. In the Program, doctoral students are required to have at least 6 months of overseas learning experiences, international academic exchanges, or professional practice experiences under the guidance of a faculty member. At present, except for first-year students studying professional foundation courses, students have completed or are participating in hands-on training to develop their professional practical skills.

The Program requires doctoral students complete practical training in health emergency response institutions, disease

TABLE 3 | Hands-on training of DrTP-PHCM.

Practical Form	Institutions	Practice contents
Professional Practice Experience	CDC, Health Emergency Response Office of the National Health Commission, China Armed Police General Hospital, National Health Development Research Center of the National Health Commission, Center for Health Development Strategy of Fudan University, etc.	Learn the techniques of public health crisis monitoring, early warning, disposal, protection and management
Overseas Learning Experience	Manchester Metropolitan University, UK	Learn about the current system of PHCM in the UK and learned from the experience of foreign PHCM
	Ebendorf Medical Center, University of Hamburg, Germany	Research on public health issues such as adolescent bullying
	World Health Organization Western Pacific Region	Participate in the risk assessment of new public health emergencies
	University of South Wales, UK	Learn about PHCM theory
International Academic Exchange	Yale University	Presented conference report entitled regional comparative study of medical resource allocation efficiency in various community health service stations in Shandong Province
	Health Technology Assessment International Conference	Study on process of China's Essential Medicine System based on Smith-Model
Social Service	Chinese CDC	Psychological intervention of typhoon "Lekima" flood disaster (2018)
	Chinese CDC	Collation of domestic and foreign information, data analysis and report writing. Handle other urgent tasks (2020)
	Shandong CDC	Participated in volunteer services for COVID-19 prevention and control in Shandong province (2020)
	Gansu Working Group of The State Council Joint Prevention and Control Mechanism	Epidemiological survey of public health crisis (2021)

prevention and control institutions, and other practice institutions for at least 6 months. The University has established joint doctoral training bases with the Chinese Center for Disease Control and Prevention (CDC), the Health Emergency Response Office of the National Health Commission, and the Research Center for Health Development of the National Health Commission. The University cooperates with the Health Commission in Shandong Province, Fudan University, and Harbin Medical University to jointly train students and has hired part-time tutors and practical training instructors for the foundational programs. In addition, the University's students can participate in exchange programs with the University of South Wales or can apply to other foreign universities with programs related to their majors. **Table 3** shows the practical training of doctoral students. At present, all current and previous students have participated in internship training; however, due to the impact of COVID-19, few students have participated in overseas studies or international academic exchanges.

In addition, doctoral students practice and develop skills while engaging in hands-on projects that allow them to actively contribute to public health, healthcare, or crisis situations. For example, in August 2018, flood disasters occurred in Shouguang and Qingzhou in China's Shandong Province. In a widely praised initiative, the University's DrTP-PHCM teams organized psychological crisis intervention experts and doctoral students conducted post-disaster psychological assistance in the disaster areas. On January 19, 2020, eight DrTP-PHCM doctoral students participated in a COVID-19 epidemiological group investigation and other related work of the Chinese CDC, which subsequently sent a letter of commendation praising the doctoral students for their COVID-19 prevention and control activities. On October 19, 2021, the severe COVID-19 situation in China's Gansu Province led the National Health Commission to select Weifang Medical University faculty members and DrTP-PHCM doctoral students to join the State Council Joint Prevention and Control Gansu Working Group to conduct an investigation of the COVID-19 epidemic in the Province. Through hands-on practical experience, doctoral students can master the crisis management technologies of monitoring, early warning, disposal, and protection, and meet the national demand for high-level public health crisis management. The specific practices are shown in **Table 3**.

Graduate Career Paths

Since the inception of the DrTP-PHCM in 2013, 15 doctoral students have been employed in public health crisis management. **Figure 2** shows graduates' career paths. Three are engaged in emergency management research at post-doctoral research facilities of well-known universities in China, 11 are engaged in teaching and research about public health and crisis management in universities, and one is engaged in public health management in hospitals. The graduates' professional abilities, research competencies, and leadership qualities have been well-received by leaders and colleagues in the fields of public health policy, public health care, and crisis management.

DISCUSSION

The development of an advanced public health workforce is a powerful weapon in dealing with national emergencies and major public health crises (16), and the DrTP-PHCM of Weifang Medical University is well-positioned for the response and management needs of major public health crises, including the current prevention and control measures of the

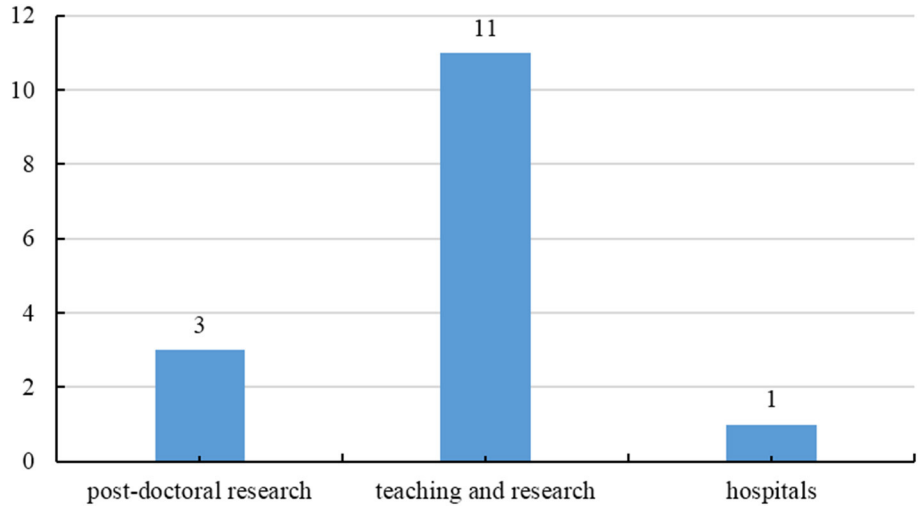

FIGURE 2 | Graduate career paths of DrTP-PHCM.

COVID-19 pandemic. The Program's graduate students have demonstrated that they can play an important role in the response to and management of public health emergencies—eight Weifang Medical University students working on the COVID-19 epidemiology team at the Chinese CDC have received a letter of commendation from the CDC, and the objectives of the program have been widely recognized by China's National Public Health Department and Society, validating the vision and execution of the Program.

The consensus is that the training of public health manpower should attach importance to practical application (5, 17). Public health and health care policy-makers and leaders worldwide attach great importance to the development of doctors' practical abilities. For example, the School of Public Health of the University of Kentucky requires that every student complete 9 weeks of education in one or more public health places (18), and has established a positive relationship with these institutions, providing doctoral students the opportunity to learn advanced health emergency competencies, including epidemic situation analysis and the study of the regular transmission pattern of infectious diseases, field epidemiology investigation, epidemic data collection and analysis, practical ability, practical ability of health emergency and rescue. At the same time, applied practice provides an important, hands-on opportunity for students to implement classroom learning of public health knowledge and skills in a real-world setting, such as participating in front-line COVID-19 pandemic prevention and control activities.

With the frequent occurrence of public health emergencies, the population's demand for public health services has been increasing, and public health policy and health care professionals have had to perform at increasingly higher levels (19). DrPH graduate students have contributed to improving public health policy and health care by applying knowledge and skills in executive leadership positions; measuring, monitoring, and promoting the operation and performance of international health service organizations; promoting social and organizational change; and becoming outstanding public health leaders (13). Many countries in the world have established a perfect DrPH training mode while establishing academic doctoral training. For example, the United States was the first country to award a DrPH, when Harvard University awarded a DrPH in 1911 (8). Some universities in China have experimented with DrPH training. Xi 'an Jiaotong University and Peking University started DrPH cultivation pilot programs in 2015 and 2016, respectively. According to the feedback of the graduates, they believe that their practical ability and interpersonal communication ability have been significantly improved during the training process, and their ability to actively discover, analyze and solve public health problems has been improved through social practice (15).

The initiatives of Weifang Medical University in conducting doctoral education in public health and crisis management has been of significance to policy makers, leaders, and scholars in the fields of public health and health care (20). At time of publication, there is no DrPH program in China, so the DrTP-PHCM can only educate doctoral students and provide academic degrees—which is the biggest limitation of the Weifang Medical University program. So the result is that most graduate students of DrTP-PHCM work in research institutions and colleges or continue their studies in institutions. Few are in executive management positions in national or local disease control centers or health departments. If a DrPH education plan can carry it out, the program's education mode and various settings may be more orderly. Chinese scholars have repeatedly proposed that China establish a professional doctoral education program in public health policy and health care (15, 21).

This study had a few limitations. First, this study only introduces the DrTP-PHCM of Weifang Medical University as a case, and does not compare with similar programs. As

mentioned in the previous materials and methods section, the program was set up with a special national policy background. At the same time, public health crisis management is a non-traditional public health major, but was set up to meet the major social needs of public health crisis response and management in China. Second, the program has only been in operation for 8 years from 2013 to now. During this period, the experience and lessons accumulated by the project are co-existing. Therefore, this study hopes to absorb more suggestions and opinions through the exhibition of the program to help the development of doctor education of public health in China.

CONCLUSIONS

The advanced education of highly qualified public health policy and health care professionals is critical to effectively dealing with major global public health crises. The DrTP-PHCM—the public health crisis management program of Weifang Medical University introduced in this paper—meets current epidemic prevention and control needs and should be considered by public health policy makers, leaders, and scholars in the discussion of advanced public health policy and health care education in China, including the development of an internationally recognized Doctor of Public Health program.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

WC and QG conceived the idea, investigated and analyzed the data, and wrote the initial draft of the paper. RG, QJ, CW, NH, and WL participated in discussion and revision in this study. XS conceived the idea and revised the manuscript. All authors contributed to the final manuscript and agreed on the final version.

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Interventions for the Current COVID-19 Pandemic: Frontline Workers' Intention to Use Personal Protective Equipment

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Background: Frontline workers (FLWs) are at a higher risk of COVID-19 infection during care interactions than the general population. Personal protective equipment (PPE) is regarded as an effective intervention for limiting the transmission of airborne viruses. However, research examining FLWs' intention to use PPE is limited.

Objectives: This study addresses this research gap and also contributes by expanding the conceptual mechanism of planned behavior theory by incorporating three novel dimensions (perceived benefits of PPE, risk perceptions of the epidemic, and unavailability of PPE) in order to gain a better understanding of the factors that influence FLWs' intentions to use PPE.

Method: Analysis is based on a sample of 763 FLWs in Pakistan using a questionnaire survey, and the structural equation modeling approach is employed to evaluate the suppositions.

Results: Study results indicate that attitude, perceived benefits of PPE, and risk perceptions of the epidemic have positive influence on FLWs' intention to use PPE. In comparison, the unavailability of PPE and the cost of PPE have opposite effects. Meanwhile, environmental concern has a neutral effect.

Conclusions: The study results specify the importance of publicizing COVID-19's lethal impacts on the environment and society, ensuring cheap PPE, and simultaneously enhancing workplace safety standards.

Keywords: interventions–psychosocial/behavioral, infectious diseases, frontline workers, behavioral intentions, personal protective equipment (PPE), COVID-19

INTRODUCTION

The novel coronavirus (SARS-CoV-2) has produced devastating effects worldwide (1, 2). Nearly every country has been seriously impacted by this epidemic (3–5). On March 11, 2020, the World Health Organization (WHO) designated coronavirus 2019 (COVID-19) a global epidemic (6). According to the WHO, frontline workers (FLWs) account for 10% of all COVID-19 clinically confirmed cases worldwide (7). FLWs had higher chances of getting COVID-19 infection compared to the general population. This higher infection rate has been ascribed largely to the lack of appropriate personal protective equipment (PPE) (8). While some evidence suggests that the type of PPE may influence their level of protection against the COVID-19 infection (9, 10), there is widespread agreement on the importance of using PPE (surgical masks, gloves, eye protection, helmets, and gowns) when caring for COVID-19 patients (11). PPE is thus a crucial component of the response to the COVID-19 pandemic.

On February 26, 2020, the Pakistani Health Ministry confirmed the first COVID-19 case in the country. Within 2 weeks, COVID-19 patients increased to 20, with Sindh province dominating the other provinces (12). The COVID-19 cases are rapidly growing, and the situation is deteriorating (13). Official data exposed that the COVID-19 positive cases reached 1,289,049, with 28,830 causalities in Pakistan (14).

Former research mainly focused on scrutinizing the environmental impacts of COVID-19 (15). In this context, the first batch of studies concentrated on COVID-19 epidemiology (16, 17). The second batch of studies recognized the essential factors that impact pandemic control (18, 19). The third batch of studies evaluated the current state of disease profiles to develop precautionary measures (20, 21), whereas the fourth batch of studies examined the effect of climatic variables on pandemic transmission (22, 23). Despite former scholars' deep interest, assessing FLWs' intentions to use PPE is of prime importance. What makes FLWs different from health workers and paramedical staff in this study is the selection of respondents. Our sample of FLWs consist of respondents from Police, Rescue emergency service, non-profit organizations, and disaster management volunteer organizations. The rationale of targeting this specific segment is that there have already been many studies conducted examining the intention of health workers and paramedic staff regarding the acceptance and use of PPE (24–27). In this vein, FLWs is the only segment which has never been considered and studied in any context before. According to the authors' best knowledge, no research has been done in the perspective of Pakistan and this study is the first of its kind to examine FLWs' intention to use PPE. Thus, the findings generated based on such a sample provide a fair representation of the FLWs. The country is equipped with fewer infrastructure and healthcare resources than developed economies (28). The country is the fifth most populous in the world (29). The WHO reports that Pakistan may become the next COVID-19 hotspot unless adequate measures are taken (30). Considering this discussion, this study investigates FLWs' intentions to use PPE in relation to the following critical questions: (i) What are the potential factors that might influence FLWs from using PPE during the COVID-19 epidemic? (ii) How do these factors manipulate the intention of FLWs to use PPE? Another reason for doing this research is to advance scholarly analysis of the COVID-19 outbreak, which other researchers have not extensively examined from the Pakistani viewpoint. To do this, three more elements have been added to the conceptual framework of the theory of planned behavior (TPB).

This study makes three distinct contributions. Firstly, we were inspired by research gaps to contribute to the existing body of knowledge by identifying and analyzing the factors influencing FLWs' intention to use PPE. Secondly, the current study has added three novel aspects to the conceptual mechanism of TPB, as these aspects were never explored as potential determinants of FLWs' intention to use PPE in any context before. Finally, though the COVID-19 cases have decreased recently in Pakistan, the country is still facing several challenges to control the outbreak, including inadequate medical equipment, the high price of PPE, and the dependence on foreign countries for importing PPE. Other emerging countries are expected to face similar issues with the COVID-19. In this respect, Pakistan's situation would be seen as a representative framework for the rest of the nations to comprehend this prodigy. Additionally, the research outcomes will help other economies develop effective guidelines for the deployment of PPE in their own territories. To summarize, the current investigation preserves unique research findings in comparison to the existing pool of literature.

METHODS

Research Framework

Public acceptance of a product is a multifaceted procedure involving a range of elements. To comprehend the dynamic character of this process, many scholars have put forward several theoretical frameworks, i.e., reasoned action theory, social cognitive theory, self-efficacy theory, and TPB (31). Among these theories, TPB has successfully scrutinized behavior, and researchers in the healthcare area have widely used it to explain and anticipate FLWs' behavior (32). TPB specifies that individuals' behavioral intentions determine behavior. Once individuals assess the implications of their actions, the behavior is carried out, resulting in the desired outcome (33).

TPB has generated a considerable amount of empirical research on health behavior. Numerous researchers hypothesize that a variety of factors impact the acceptability of a specific product or service in different contexts (34). FLWs are anxious about environment, risk perceptions, safety procedures, cost, and PPE supply. Consequently, we extended the conceptual structure of TPB by introducing three new considerations. With the

Abbreviations: ATD, Attitude; AVE, Average variance extracted; BPPE, Perceived benefits of personal protective equipment; CFA, Confirmatory factor analysis; COVID-19, Novel Coronavirus disease 2019; CPPE, Cost of personal protective equipment; ECO, Environmental concern; CR, Composite reliability; FLWs, Frontline workers; ITU, Intention to use; MSV, Maximum shared variance; PKR, Pakistani rupees; PPE, Personal protective equipment; RPP, Risk perceptions of the pandemic; UPPE, Unavailability of personal protective equipment; TPB, Theory of planned behavior; VIF, Variance inflation factor; WHO, World health organization.

addition of new considerations, this research framework would help analyze FLWs' intentions to utilize PPE comprehensively. The research framework is depicted in **Figure 1**.

Hypotheses Formulation

Attitude (ATD)

In behavioral literature, ATD is defined as FLWs' positive or negative reactions to society's health issues. Walter et al. (35) opined that public ATD during the epidemic informs mitigation methods as well as enables future epidemic preparation planning. According to previous research, there is a positive linkage between attitude and intention to use PPE. Zhang and Mu (36) concluded that people had a favorable attitude on the possibility of reducing exposure to airborne viruses with the use of PPE. Johnson and Hariharan (37) took a survey to find the attitude and behavior of people toward PPE during the Swine Flu outbreak. The results unveiled that people show high acceptance of using PPE, receiving H1NI medication, maintaining social distance, adhering to public health precautions, avoiding public transit, and keeping them away from diseased persons. These conclusions led to the formulation of 1st hypothesis as:

H1: *ATD positively influences FLWs' intention to use PPE.*

Environmental Concern (ECO)

The level to which FLWs are aware of and committed to resolving environmental issues is termed as ECO. It is a major element influencing FLWs' decision to use PPE. Schraufnagel et al. (38) specified that FLWs with a positive ECO closely monitor the health status of others and keep a positive behavior about the use of PPE. They expect and grasp that keeping good health is a self-declared obligation. Li et al. (39) stated that current health emergencies affected the propensity to utilize PPE. Another study reported a beneficial effect of ECO on the acceptance of PPE (40). The 2nd hypothesis is devised based on these assumptions as:

H2: *ECO positively influences FLWs' intention to use PPE.*

Cost of PPE (CPPE)

Cost is a frequently used factor to determine the financial damage associated with the purchase journey (41). Research demonstrates the negative linkage between cost and the intention to use PPE. For instance, Weiss and Palmer (42) shows that cost is the primary impediment to purchasing PPE. Kesselheim (43) examined the association between high CPPE and life-cycle management. The findings indicated that elevated costs put individuals under strain, resulting in severe health consequences. While the cost of PPE has decreased in recent years, it still remains high than the affordability of FLWs in underdeveloped countries. These assumptions enable us to formulate the 3rd hypothesis as follows:

H3: *CPPE negatively influences FLWs' intention to use PPE.*

Risk Perceptions of the Epidemic (RPP)

RPP has a beneficial effect on public acceptance of PPE. Public acceptance increases as people become aware of their benefits to the epidemic's severity. If infection risk is high, a more rapid public response in terms of adopting preventive behaviors will occur (32). Previous research has established that risk perceptions significantly influence individuals' decisions to adopt PPE. In this respect, MacIntyre and Chughtai (44) examined the factors influencing public intention to use PPE in China and found that risk perceptions have a favorable effect on public intention. In another study, Barati et al. (45) scrutinized public behavior toward the acceptance of PPE to avoid respiratory diseases. The findings indicated that individuals are persuaded to use PPE based on the risk of contracting acute diseases. These inferences led to the formulation of the 4th hypothesis as:

H4: *RPP positively influence FLWs' intention to use PPE.*

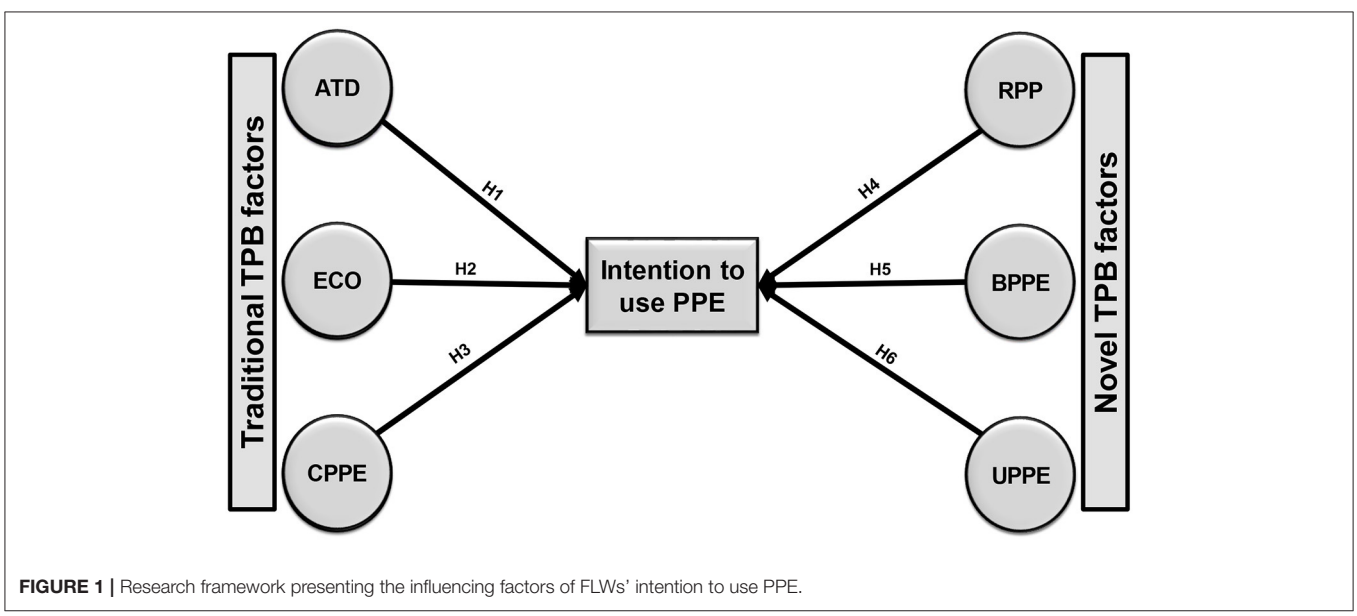

FIGURE 1 | Research framework presenting the influencing factors of FLWs' intention to use PPE.

Perceived Benefits of PPE (BPPE)

BPPE refers to FLWs' information and knowledge of the benefits of PPE in managing and preventing the spread of infectious viral disorders (46). They believe that PPE will help prevent the virus from spreading during public gatherings and also serve as a reminder to maintain social distancing (47). Hansstein and Echegaray (48) examined the motives of using PPE among Chinese FLWs and noticed that the knowledge of climate concerns and health effects has increased in response to poor air quality in China. As a result, individuals have developed favorable beliefs toward the benefits of PPE. Based on these findings, the 5th hypothesis is stipulated as follows:

H5: *BPPE positively influences FLWs' intention to use PPE.*

Unavailability of PPE (UPPE)

UPPE is associated with FLWs' difficulties procuring PPE (44). Previous research has established that the UPPE has a negligible effect on individuals' decisions to use PPE. Many scholars reported that UPPE negatively influences public intentions of using PPE. For instance, Tang and Wong (47) analyzed the factors affecting the intention to use PPE in the Chinese context. They opined that UPPE is a critical barrier, which negatively influences their intentions to use PPE. Similarly, MacIntyre and Chughtai (44) examined the individuals' intentions regarding PPE acceptance. Research outcomes highlighted that low acceptance is related to the UPPE, which is inefficient in preventing and treating respiratory infections. Taking these findings into account, we formulate the 6th hypothesis as follows:

H6: *UPPE negatively influences FLWs' intention to use PPE.*

RESULTS

Survey Region and Sample Selection

We administered an inclusive questionnaire survey in Punjab and Sindh provinces and Pakistan's federal capital territory (Islamabad) during July and August 2021. The surveyed respondents belonged to Federal Police, Rescue 1122 emergency service, Elite Police, and disaster management volunteer organizations (Aman Foundation, Green Crescent Foundation, and Edhi Foundation). Department of Federal Police is located in the Federal capital Islamabad. Rescue 1122 is the emergency service available in the Punjab province of Pakistan. Elite Force is a special branch of Punjab Police involved in risky operations. All the three stated disaster management volunteer organizations are located in Karachi city of Pakistan's Sindh province. These are non-profit organizations working across the country. Whenever there is some disaster anywhere in the country, these organizations play their volunteer role to cope with the chaotic situation. The fundamental rationale for selecting the FLWs is their frequent exposure to COVID-19 suspects and patients since FLWs have difficulties with social distancing measures. One of the reasons for the sample selection is that Islamabad is the capital city containing individuals belonging to all provinces, thus providing a heterogeneous population mix. Further, Punjab is the most populous province and involves more law enforcement agents to deal with COVID-19 containment. Besides, most welfare organizations and disaster management volunteer organizations operate from the Karachi city of Sindh province. Questionnaires were delivered to 950 FLWs, and a complete description of all questionnaire components was supplied to them (see **Appendix A**). A total of 763 responses were gathered, representing 80.15% of the total responses.

Demography of the Participants

Figure 2 represents the demographic attributes of the participants. The lower-middle age group (40.4%) accounted for the largest proportion of participants in the survey. Females were 51.13% compared to males (48.87%) in our sample. 35.03% of the participants belonged to the middle-income class, with earning between Pakistani rupees (PKR) 35,001 and 45,000 each month. Additionally, we classified participants according to their educational degrees. 40.96% of them hold a master's degree. Most of the participants (47.46%) were married, and 28.25% had more than 20 years of professional experience.

Statistical Summary and Discriminant Validity Analysis

The authors used SPSS and AMOS software to analyze the data and proposed hypotheses. All items were assessed on a 5-point Likert scale, as 1 indicating "strongly disagree" and 5 indicating "strongly agree." Correlation analysis was conducted to ascertain the relationship among constructs. Discriminant validity was verified by employing the average variance extracted (AVE) square root. Discriminant validity is validated by the results, as the AVE values are greater than their association with other constructs (32). We further confirmed the discriminant validity, as all constructs' AVE values are greater than their maximum shared variance (MSV) values. Next, we looked into convergent validity by utilizing AVE values. The analysis indicated that the AVE values for all constructs were higher than 0.50, specifying that all constructs retained a minimum of 50% of the variance. The findings are reported in **Table 1**. Item's reliability was determined using Cronbach-α. The outcomes verified reliability as the values of Cronbach-α exceeded the minimum acceptable level of 0.70 (49). Next, we performed composite reliability (CR) test to ascertain the items' consistency across all constructs. The findings indicated that the CR values exceeded the minimum permissible value of 0.70 (50). **Table 2** summarizes the results.

Hypotheses Results and Structural Model

Confirmatory factor analysis (CFA) was used for the purpose of model identification. The validity of the measurement model was established, as each item was loaded on its respective construct (see **Figure 3**). Strong f-values were generated for all constructs, suggesting that the relationships are linear. The R^2 value of 0.68 was more than the suggested threshold of 0.35 (51), indicating a substantial interpretation. We further test the multi-collinearity in the proposed model linear regression analysis. The analysis indicates that the model is free from multicollinearity since the variance inflation factor (VIF) values are within the suggested range (52). The results are presented in **Table 3**.

The schematic diagram of SEM is shown in **Figure 4**. We tested the influence of critical factors on FLWs' intention to use

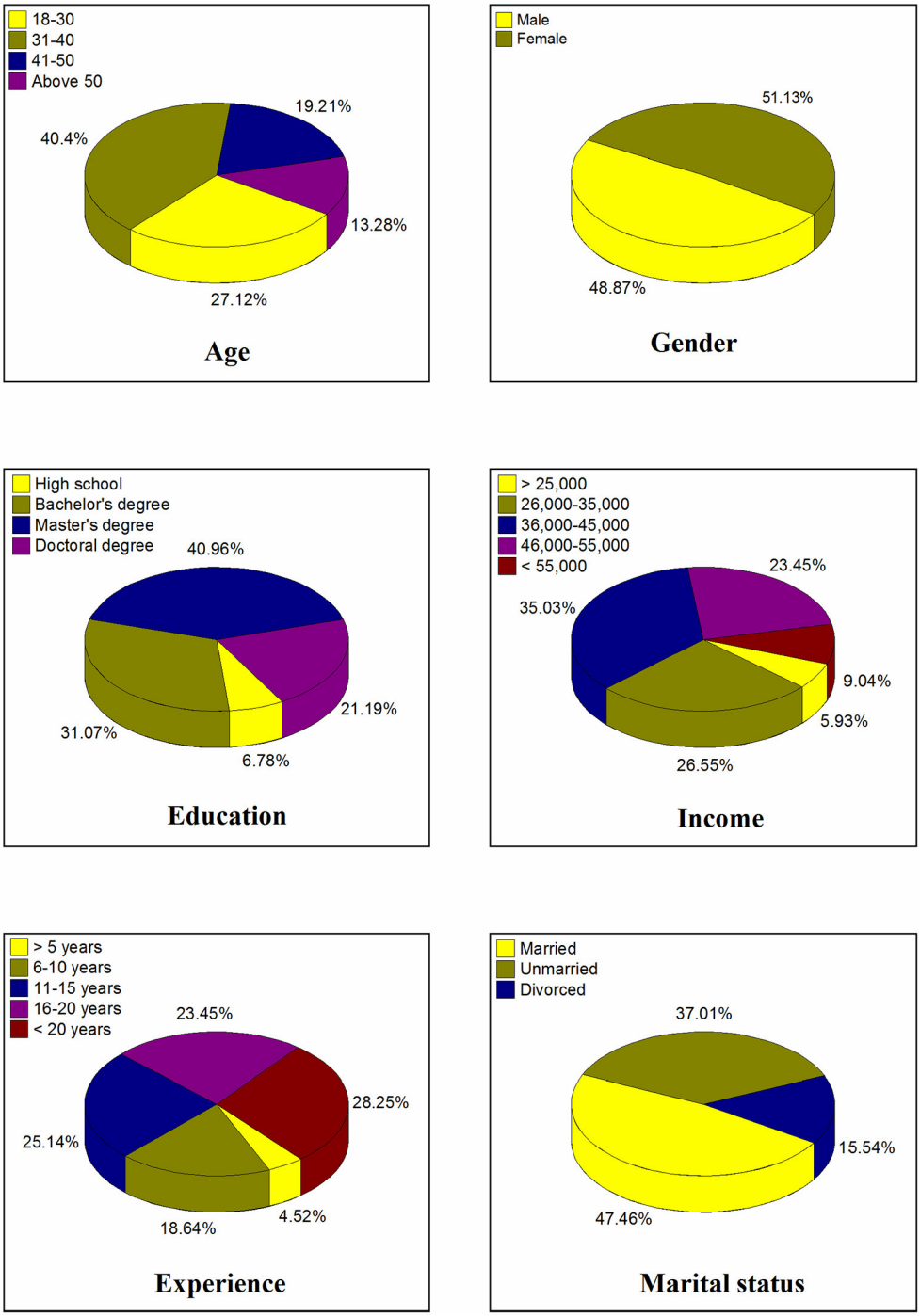

FIGURE 2 | Demographic attributes of FLWs.

PPE using path analysis. Additionally, various fitness tests were performed to guarantee that the data was correctly fitted to the structural model. The results revealed that the values of all fit indices are according to the recommended criteria (53). The structural paths of the constructs, such as ATD (*H1*; $\beta = 0.10$, $p < 0.01$), RPP (*H4*; $\beta = 0.09$, $p < 0.05$), and BPPE (*H5*; $\beta = 0.20$, $p < 0.01$) stipulate that ATD, RPP, and BPPE significantly influence FLWs' intention to use PPE. Thus, we accepted hypotheses 1, 4, and 5. The constructs CPPE (*H3*; $\beta = -0.05$, $p < 0.01$) and UPPE (*H6*; $\beta = -0.01$, $p < 0.001$) negatively affects FLWs' intention to use PPE. Accordingly, we accepted hypotheses 3 and 6. Contrary to the formulated supposition, the structural

TABLE 1 | Correlation, convergent, and discriminant validity findings.

Variables	Mean	Std. Dev	ECO	BPPE	ATD	RPP	CPPE	UPPE	ITU	AVE	MSV
ECO	3.630	0.590	**(0.712)**							0.507	0.125
BPPE	2.811	1.509	0.270	**(0.822)**						0.676	0.276
ATD	3.324	0.154	0.353	0.525	**(0.754)**					0.569	0.276
RPP	3.919	0.574	0.293	0.471	0.367	**(0.859)**				0.738	0.289
CPPE	2.603	0.661	0.170	0.416	0.305	0.538	**(0.781)**			0.609	0.524
UPPE	2.906	1.563	0.343	0.176	0.330	0.230	0.222	**(0.837)**		0.701	0.118
ITU	2.472	0.367	0.296	0.506	0.418	0.519	0.724	0.237	**(0.738)**	0.545	0.524

The bold values represents the square root of AVEs.

path failed to support hypothesis 2 (*H2*; $\beta = 0.59$), because the construct "ECO" does not have a significant influence on FLWs' intention to use PPE and thus rejected (see **Table 3**).

DISCUSSION

Results supported the first hypothesis that ATD positively influences FLWs' intention to use PPE, implying that FLWs acquainted with the COVID-19 epidemic possess a greater propensity to use PPE. Zhang and Mu (36) concluded that people exhibit an optimistic attitude that PPE may help minimize the risk of viral respiratory infections. In the same vein, Johnson and Hariharan (37) uncovered a favorable impact of attitude on the intention to use PPE. The results of these studies comply with our findings. Due to the current COVID-19 outbreak, most FLWs recognize that PPE can assist reduce disease transmission and aid in managing health dilemmas. In Pakistan, knowledge of the new SARS-CoV-2 virus is increasing, which will have a greater impact on FLWs' intention to use PPE in the future. However, in some under-developed countries, people do not have adequate knowledge about the severity and the consequences of the pandemic. Consequently, they are less concerned about the viral infections and possess an unfavorable attitude toward PPE usage. This aspect is in line with the study of (54), as they found that 52% of the nurses in their sample neglected to use PPE.

Literature (40) identified that ECO positively influences intentions to use PPE. We predicted a similar pattern among Pakistani FLWs as well. However, the current study's findings have a negligible effect. A possible reason might be linked to the intentions for which FLWs use PPE. Unlike economies that focus on combating climate change and contribute actively to improving the environment (55, 56), Pakistani people attach low priority to ecological problems during purchase decisions (57–59). Another reason for this behavior is the lack of an effective policy structure. The government barely seeks to encourage residents to become conscious of environmental issues, their obligations, and active participation in environmental improvement. On the flip side, Ambigapathy et al. (60) noticed that, as the COVID-19 continues to evolve, the understanding of the pandemic is increasing among the general practitioners in Malaysia. This understanding leads to a positive environmental concern, ultimately shaping their intention to use PPE.

The likelihood of FLWs' intention to use PPE decreases with a faith about the extra cost linked with the purchase of PPE. Research findings validated the hypothesis because cost negatively influences FLWs' intention to use PPE. Previous studies have established that cost has a detrimental effect on accepting new developments in the health industry (43). In this perspective, Weiss and Palmer (42) revealed that cost influences FLWs' decision to utilize PPE. One possible explanation is that PPE is affordable in developed countries than in Pakistan. Therefore, a middle-income FLW in Pakistan is unable to pay the hefty expenses and is hesitant to buy.

Our findings reveal that RPP positively influences FLWs' intention to use PPE. Former research has established the critical impact of risk perceptions in determining public behavior during epidemics (45, 61), which is consistent with our findings. Ahmad et al. (32) examined the perception-based elements that influence individuals' intentions to endorse COVID-19 prevention measures. The findings specified that risk perceptions significantly affect individuals' behavior to undertake outbreak control measures. This shows that improving awareness of the infection's seriousness, propensity, and lethality will increase their willingness to pursue epidemic preventive solutions. Hamamura and Park (62) contrasted PPE usage by Chinese, Japanese, and American respondents. The study concluded that Chinese and Japanese individuals utilize PPE more frequently than Americans. The likely reasons that may motivate FLWs to use PPE include a perceived risk of contracting the novel epidemic and preventing viral infections. The more acute FLWs' impressions of the pandemic's fatal elements are, the easier it will be to influence their decision to use PPE. On the contrary, Izhar et al. (63) conducted a survey in Pakistan to examine the risk perceptions of COVID-19 and satisfaction with preventive measures among maternity care providers in Pakistan. The authors obtained some contrasting findings, as the risk perception of the pandemic was low among their sample. These respondents opined that COVID-19 is less contagious than tuberculosis, flu, and food poisoning. One major reason for this behavior might be that Pakistan is a developing country where tuberculosis is rampant and safe drinking water is not readily available.

Results further specify that BPPE significantly influences FLWs' intention to use PPE. These findings support earlier researches in which scholars identified that people make

TABLE 2 | Factor loadings of measurements model.

Variables	Items	Standard loadings	CR	Cronbach-α
Attitude			0.902	0.914
	ATD1	0.551		
	ATD2	0.822		
	ATD3	0.715		
	ATD4	0.656		
	ATD5	0.910		
	ATD6	0.925		
	ATD7	0.622		
Environmental concern			0.804	0.815
	ECO1	0.730		
	ECO2	0.747		
	ECO3	0.680		
	ECO4	0.673		
Cost of PPE			0.886	0.880
	CPPE1	0.870		
	CPPE2	0.953		
	CPPE3	0.701		
	CPPE4	0.680		
	CPPE5	0.518		
Risk perceptions of the pandemic			0.933	0.927
	RPP1	0.743		
	RPP2	0.793		
	RPP3	0.947		
	RPP4	0.980		
	RPP5	0.796		
Perceived benefits of PPE			0.936	0.948
	BPPE1	0.644		
	BPPE2	0.828		
	BPPE3	0.804		
	BPPE4	0.856		
	BPPE5	0.853		
	BPPE6	0.824		
	BPPE7	0.908		
Unavailability of PPE			0.921	0.907
	UPPE1	0.732		
	UPPE2	0.790		
	UPPE3	0.906		
	UPPE4	0.858		
	UPPE5	0.869		
Intention to use PPE			0.827	0.834
	ITU1	0.656		
	ITU2	0.711		
	ITU3	0.635		
	ITU4	0.560		

purchases by looking the advantages of the goods they select to buy (64, 65). FLWs agree to use PPE by recognizing the benefits associated with its use (46). One possible explanation is that, as Pakistani FLWs' understanding of environmental and health issues is growing, they are mounting positive beliefs toward PPE as a means of resolving these issues. On the other hand, certain barriers, including lack of awareness, social norms, self-effectiveness, impede PPE usage intentions. Besides, lack of advertisement form government on the comprehensive benefits of PPE usage during the pandemic also impact public BPPE.

The research findings indicate that UPPE has a detrimental effect on FLWs' intention to use PPE, which is consistent with the previous research of (44). Among the various factors discouraging FLWs from using PPE are the complexity and efforts associated with getting PPE in the specific FLWs' workplace region. In addition, because PPE acceptance and usage are still in their infancy in the country, FLWs are hesitant to adopt them. The convenience and availability of PPE would serve as important dynamics in fostering more trust in PPE usage. The previous understanding of using PPE may affect the FLWs' intentions in a manner that a pleasant experience (in the form of easy access) permits the acceptance of PPE, whereas a bad experience leads to rejection.

CONCLUSIONS

This study assesses occupational safety behavior by assessing the factors that influence the intentions of Pakistani FLWs to use PPE. Potential motivators and deterrents of PPE usage have been recognized and evaluated. Three additional aspects have been added to the conceptual framework of TPB. The analysis is based on a sample of 763 FLWs in Pakistan using a questionnaire survey. The proposed hypotheses were analyzed using structural equation modeling. The results indicate that ATD, BPPE, and RPP have significant effects on FLWs' intention to use PPE. CPPE and UPPE have negative effects, whereas ECO shows an insignificant effect. By giving an emphasis on occupational safety behavior, this work will help as a practical guideline for governments, policymakers, and experts in the health sector by understanding the linkage among all possible factors that may influence FLWs' intentions of PPE usage.

Research results highlight the need for practitioners to be aware of the four major reasons that are making the sustainable utilization of PPE a challenging task in Pakistan. Firstly, the country has a poor economic condition. The import of expensive PPE has placed a substantial burden on the national economy. Besides, there is high uncertainty about the future supply of PPE, especially if a new outbreak happens in the country. Secondly, as evidenced by research results, FLWs in Pakistan give little priority to environmental concerns, making it very difficult to accept and utilize PPE. Thirdly, the country has an integrated social system where all ethnic groups have a shared system of meaning, language, and culture. Consequently, people mostly follow the ideas of peers, celebrities, friends, and social groups. Finally, contrary to countries where people have experienced severe outbreaks like the SARS-CoV epidemic in China, H1N1 swine flu in North America, and the Chikungunya epidemic in Italy, Pakistani people have never faced such critical circumstances before. Therefore, awareness among FLWs regarding the benefits of using PPE is low compared to these countries. The use

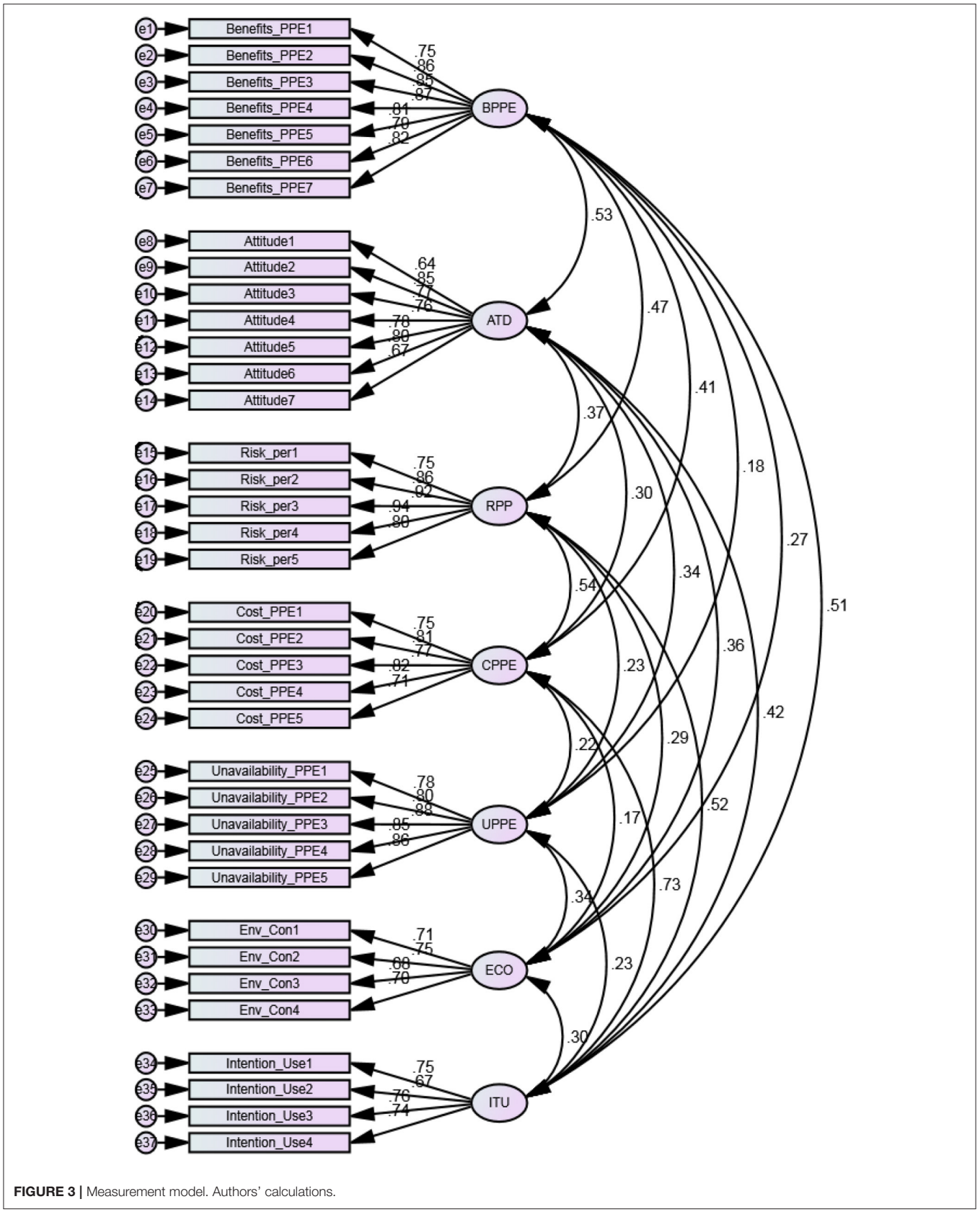

FIGURE 3 | Measurement model. Authors' calculations.

TABLE 3 | Hypotheses' findings.

Hypotheses	Hypotheses paths	β-value	f-value	Result	VIF	R^2
H1	ATD → ITU	0.10**	216.6***	Accepted	1.634	0.68
H2	ECO → ITU	0.59	367.5***	Rejected	1.871	
H3	CPPE → ITU	−0.05**	120.4***	Accepted	1.783	
H4	RPP → ITU	0.09*	204.8***	Accepted	1.376	
H5	BPPE → ITU	0.20**	229.4***	Accepted	1.282	
H6	UPPE → ITU	−0.01***	108.6***	Accepted	1.809	

***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

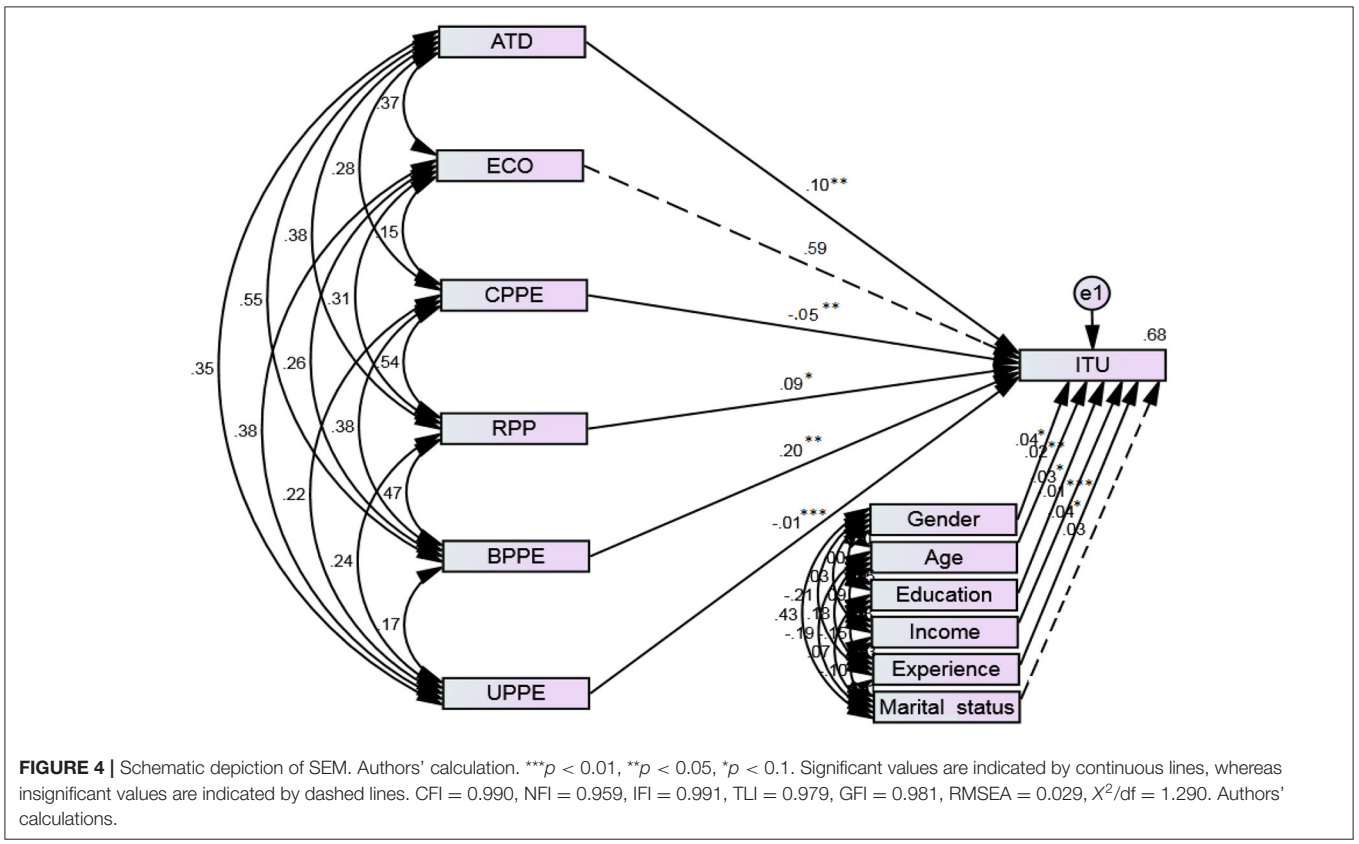

FIGURE 4 | Schematic depiction of SEM. Authors' calculation. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Significant values are indicated by continuous lines, whereas insignificant values are indicated by dashed lines. CFI = 0.990, NFI = 0.959, IFI = 0.991, TLI = 0.979, GFI = 0.981, RMSEA = 0.029, X^2/df = 1.290. Authors' calculations.

of print and electronic media to stress COVID-19's deadly characteristics might be handy in this respect. Due to less supply, PPE is costly in the country, and pharmacies demand exorbitant rates. The government should ensure that PPE is available at a fair price, give financial assistance, and conduct frequent price monitoring.

Though the results of this study are generally consistent with the theoretical predictions and have important implications for practitioners, the present work is not without limitations. Firstly, the questionnaire survey has missed a principal fraction of FLWs, i.e., Health workers, Paramedic staff, etc. Potential researchers can make their survey more representative by including this fraction in subsequent studies. Secondly, the data collection is carried out only in the federal capital and two provinces of the country without considering less developed and rural regions. Socio-economic characteristics, such as education, and income, differ considerably between urban and rural regions. This limitation can be overcome by including rural FLWs as participants in future studies. Finally, the linkage between attitude and perceived benefits of PPE was not found in the current study. Scholars can tackle this issue by directing studies to see this vital linkage.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

This study was approved by the Ethics Committee of the Beijing Institute of Technology, China (No. 543-1). The

patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MI: conceptualization and writing—original draft. MI and MA: data curation. MI, SS, and ÁA-D: formal analysis. SS: funding acquisition. SS, ÁA-D, FA, AR, KA, and CI: writing—review and editing. 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.2021.793642/full#supplementary-material

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Self-Reported Patient Compliance With Physician Advised Lifestyle Behavior Changes Among Adults With Musculoskeletal Conditions

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Introduction: Approximately half of adult Americans suffer from musculoskeletal disorders (MSD). Significant risk factors for musculoskeletal disorders include poor diet, obesity, and insufficient physical activity. Studies show that lifestyle change education and interventions reduce MSD risk factors. However, little is known about the relationship between physician advice for behavior change and reported behavior change by MSD patients. This study explored the association between physician advice for lifestyle change and reported change in MSD patients, as well as the effects that patient education levels have on compliance.

Methods: This study used data from the 2017 National Health Interview Survey, a nationally representative cross-sectional survey of non-institutionalized US adults. The research team limited analysis to adults who reported a limitation due to musculoskeletal problems (n = 2,672). Outcomes included physician recommendations to increase physical activity, reduce fat/calories, or lose weight, and whether they enacted these behavioral changes. Adjusted logistic regression models examined whether compliance with doctor's instructions differed by education level.

Results: Adjusted models show patients advised to change physical activity, diet, and weight were more likely to report attempted behavior change. Education was positively associated with likelihood of complying with physician advice to increase physical activity. Among patients not advised to change behaviors by a physician, education was positively associated with current behavior change attempts.

Conclusion: This study suggests that physician recommendations are relevant predictors of reported behavior change in individuals with MSD. Although education plays an important role in this association, the relationship is complex and multifaceted. Future studies should explore how compliance may be impacted by other factors, such as physician message type.

Keywords: lifestyle medicine, education, compliance, behavior change, musculoskeletal disorder (MSD)

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INTRODUCTION

Musculoskeletal disorders (MSDs) affect ∼124 million adult Americans, which accounts for one in every two adults, greater than the prevalence of cardiovascular and respiratory diseases combined (1). MSDs also have large economic implications, costing the US $213 billion in 2011 through lost productivity and more than $300 billion in 2009 through lost work earnings and health care costs (2). Pain and disability from MSDs are significant barriers to independent living in the community. Interventions need to include both clinical and population-based approaches to improve the prevention and treatment of MSDs for a better quality of life.

One of the most important areas for prevention and treatment is modifying risk factors (3). Numerous risk factors are associated with musculoskeletal conditions, including MSDs. Smoking, unhealthy diet, obesity, sleep deprivation, stress, and inactivity all contribute to a higher risk of developing MSDs (4). Minimizing the occurrence of these factors is well-accepted in reducing the risk and severity of MSDs as well as decreasing pain (5–7). However, long-term behavioral changes are essential for risk reduction and management of MSDs (8). Therefore, individuals need to focus on developing healthy choices with their physicians and maintaining them in their absence. Physician advice that is complemented with resources, such as community health programs, may improve prevention and risk factor management strategies (9).

Studies have shown that physicians play a significant role in educating and promoting healthier lifestyles in their patients (10, 11). Educational interventions in individuals with MSDs demonstrated effectiveness in reducing risk factors, improving productivity, and reducing pain and anxiety (12–14). However, non-compliance thwarts many effective treatment plans regardless of disease (15). Poor compliance is widespread, exhibited by ∼30–50% of all patients and accounting for between $100 and $300 billion of avoidable health care costs (16). The relationship between physician advice for lifestyle change and MSD patient compliance has not been well-established. Appreciation of the factors that affect patients' decisions to perform and comply with advice is useful for healthcare providers and public health messaging to develop more efficient methods to maximize compliance and decrease risk factors in their patients. Further, an extension of compliance in the clinical setting can be applied to how people understand and respond to health initiatives in the community setting (17). In other words, the ability to understand the causes that help patients make better decisions with their physicians may also be a target for prevention strategies in the community.

One such factor is patient education level, which is a major social determinant of health essential for understanding and following a healthcare professional's advice (18–21). There is limited knowledge on how patient education levels are associated with compliance to healthcare providers' advice for lifestyle change to treat MSDs. Understanding this relationship may serve as a platform for further discoveries, such as determining how educational interventions affect lower educated patients (22). This may also aid the design of community outreach programs that help bring more attention to lifestyle choices and preventative measures. This study aimed to explore the association between patient behaviors for increasing physical activity, eating healthier, and enrolling in a weight loss program and physician advice for these lifestyle changes in MSD patients. Secondly, we examined the effects that background education level has on this compliance. We hypothesized a positive association between physician advice for behavior change and self-reported engagement in those behaviors and a positive association between education levels and compliance with physician's advice.

METHODS

This study analyzed data from the 2017 National Health Interview Survey (NHIS). The NHIS is a nationally representative cross-sectional survey of non-institutionalized US residents conducted yearly (23). Respondents aged 18 and up were used for this study, with data merged from the Person and Sample Adult files of the 2017 NHIS. The Sample Adult survey was administered to a subsample of the full NHIS sample, resulting in a sample size of 26,742. These respondents were asked, "What condition or health problem causes you to have difficulty with activities?" Those who answered that musculoskeletal or connective tissue problems caused such limitations represent the subpopulation of interest for the study ($n = 2{,}672$).

Outcomes of interest included respondent self-reports that a physician has instructed the person to participate in a weight loss program, increase physical activity, or reduce fat or calories. Additionally, the respondent self-reported if they are currently engaging in those three activities. Education was coded into four categories based on reported years of education completed: less than high school, high school diploma, some college, and college or more. Control variables included age group, race/ethnicity, gender, body mass index, marital status, and employment status.

The research team conducted the analysis using Stata 16.1. Chi square tests compared categorical variable distributions between education level and physician recommendations or health behavior efforts. The six binary outcomes in this study, including three self-reports of physician recommendation and three self-reports of current health behavior activity, had prevalence well above 10% in the population of interest. As such, these outcomes were not appropriate for logistic regression, which may overestimate effect size when the outcome occurs more than 10% of the time (24). Therefore, this study applied Poisson regression with robust error variance (calculated using population weights in Stata) to estimate the relative risk of each outcome (25, 26). Given that language of "risk" may be less palatable for discussing an outcome of favorable health behaviors, we report these as prevalence ratios (27). Although the prevalence of individuals saying they are currently engaged in a weight loss program is slightly <10% in the subpopulation (9.2%), prevalence ratios were reported for all outcomes for consistency. Population weights, using the "svy" command in Stata, were used to account for NHIS complex survey design. Statistical significance was set at alpha <0.05.

RESULTS

This study focuses on the 8.9% (n = 2,672) of 2017 adult NHIS respondents reporting that musculoskeletal or connective tissue problems cause limitations in activities. The average age for this subpopulation was older than the rest of the NHIS sample (56.4 years compared to 46.5 years, respectively). The MSD subsample was also more likely to be female than the rest of the NHIS sample (61.1 vs. 50.8%, respectively). The sample was also disproportionately non-Hispanic white relative to the rest of the NHIS sample (72.1 vs. 63.4%, respectively).

The proportion of adult respondents with MSD who reported being told by a physician to reduce fat and calories in their diet significantly differed by education level, where 48.73% with less than high school education reported receiving this advice, compared to 33.07% with a college degree or higher (**Table 1**). Education level was not associated with physician advice to increase physical activity or participate in a weight loss program.

Education and self-reports of current efforts to increase physical activity were positively associated, with 49.78% of adults with less than a high school degree reporting increased physical activity attempt, compared to 65.83% of adults with

TABLE 1 | Education effects on the proportions of adults with musculoskeletal disorders receiving physician advice for behavior change and reporting performing those changes.

	<HS	HS diploma	Some college	College or more		
	N (%)	*N* (%)	*N* (%)	*N* (%)	Chi-square*	*p*-value
Told to increase physical activity, past 12 m	175 (51.35)	360 (50.06)	416 (50.27)	329 (47.58)	18.140	0.767
Told to reduce fat/calories in diet, past 12 m	164 (48.73)	293 (40.81)	329 (40.71)	231 (33.07)	261.883	0.001
Told to participate in weight loss program, past 12 m	49 (15.14)	86 (13.14)	117 (15.02)	86 (12.07)	36.416	0.533
Currently increasing physical activity	181 (49.78)	408 (55.36)	502 (61.14)	463 (65.83)	322.767	0.001
Currently reducing fat/calories in diet	179 (54.87)	399 (53.90)	516 (60.92)	406 (58.67)	94.078	0.114
Currently participating in weight loss program	21 (7.71)	46 (6.14)	87 (10.74)	81 (11.67)	170.282	0.024

**Chi-square tests difference in educational attainment and Yes/No answer to engaging in each of the above categories.*

TABLE 2 | Adjusted prevalence ratios predicting physician recommendations for behavior change in individuals reporting musculoskeletal disorders.

	Told to increase physical activity		Told to reduce calories		Told to participate in weight loss program	
	PR (se)	sig	PR (se)	sig	PR (se)	sig
Female	1.19 (0.06)	***	1.05 (0.06)		0.83 (0.1)	
Age (ref = 18–29)						
30–39	0.77 (0.1)		0.88 (0.16)		1.01 (0.42)	
40–49	0.9 (0.11)		0.98 (0.15)		1.13 (0.43)	
50–64	1.07 (0.12)		1.21 (0.17)		1.34 (0.45)	
65+	0.99 (0.11)		1.17 (0.17)		1.02 (0.35)	
Race/ethnicity (ref = NH white)						
Hispanic	1.17 (0.1)		1.25 (0.11)	*	1.53 (0.34)	
NH black	1.03 (0.08)		1.07 (0.09)		1.27 (0.23)	
Other	1.32 (0.16)	*	1.38 (0.19)	*	1.22 (0.42)	
Education (ref = Less than HS)						
HS diploma	1.02 (0.08)		0.89 (0.07)		0.93 (0.19)	
Some college	1.00 (0.08)		0.85 (0.07)		1.01 (0.2)	
College or more	1.03 (0.09)		0.78 (0.08)	*	1.01 (0.21)	
Married	1.14 (0.05)	**	1.02 (0.06)		1.05 (0.13)	
Employed	0.93 (0.06)		0.99 (0.06)		0.93 (0.13)	
BMI (ref = 18.5 to <25)						
Overweight	1.68 (0.16)	***	2.08 (0.3)	***	2.13 (0.82)	
Obese	2.29 (0.2)	***	3.68 (0.48)	***	7.09 (2.5)	***
N	2,541		2,542		2,543	

**p < 0.05; **p < 0.01; ***p < 0.001.*

PR, prevalence ratio; se, standard error; NH, non-Hispanic; ref, reference group; BMI, body mass index; HS, high school; sig, significance.

college or greater degrees (**Table 1**). A similar trend was true for respondents participating in a weight loss program, where 7.71% with less than a high school degree participated compared to 11.67% of college graduates. Education was not associated with current efforts to reduce fat or calories.

Adjusted prevalence ratios predicting physician recommendations for behavior change show few significant associations (**Table 2**). Education was not associated with physician recommendations except in the case of calorie reduction, where those with a college degree exhibited a lower prevalence of being told to reduce calories compared to those with less than a high school degree (OR = 0.78, 95% CI−0.64–0.95).

Education was positively associated with alignment of behavior change efforts and self-reported physician recommendations to increase physical activity (**Table 3**). Significant interaction effects demonstrate that efforts to increase physical activity vary by education level and self-reported physician recommendations (**Figure 1**). There was also a positive trend between education level and the likelihood of attempting physical activity among those who were not advised to do so by a physician. The physician recommendation group exhibited

TABLE 3 | Adjusted prevalence ratios predicting current behavior change efforts in individuals reporting musculoskeletal disorders.

	Currently increasing physical activity		Currently reducing calories		Currently in weight loss program	
	PR (se)	sig	PR (se)	sig	PR (se)	sig
Female (ref = male)	0.09 (0.05)		0.12 (0.05)	**	0.31 (0.20)	*
Age (ref = 18–29)						
30–39	−0.08 (0.08)		0.16 (0.14)		−0.01 (0.48)	
40–49	−0.18 (0.08)	*	0.26 (0.15)	*	0.23 (0.52)	
50–64	−0.08 (0.07)		0.23 (0.13)	*	0.84 (0.88)	*
65+	−0.23 (0.06)	**	0.18 (0.13)		0.3 (0.53)	
Race/ethnicity (ref = NH white)						
Hispanic	0.05 (0.07)		0.12 (0.07)		−0.54 (0.17)	
NH black	0.08 (0.06)		0 (0.06)		−0.42 (0.19)	
Other	0.09 (0.11)		0.23 (0.12)	*	0.0 (0.30)	
Education (ref = Less than HS)						
HS diploma	0.30 (0.22)		0.24 (0.19)		−0.30 (0.20)	
Some college	0.45 (0.23)	**	0.50 (0.25)	***	0.19 (0.30)	
College or more	0.57 (0.27)	***	0.51 (0.24)	***	0.26 (0.32)	
Married	−0.01 (0.04)		0.06 (0.04)		−0.09 (0.12)	
Employed	0.02 (0.04)		0.09 (0.05)		0.33 (0.22)	*
BMI (ref = 18.5 to <25)						
Overweight	0.17 (0.08)	**	0.25 (0.09)	***	0.58 (0.47)	*
Obese	0.12 (0.07)		0.28 (0.08)	***	0.66 (0.49)	**
Told to increase physical activity	0.59 (0.29)	***				
Told to reduce fat/calories			0.90 (0.35)	***		
Told to participate in weight loss					1.74 (0.91)	***
Interaction terms						
HS diploma X told to increase physical activity	−0.29 (0.14)					
Some college X told to increase physical activity	−0.36 (0.12)	*				
College degree X told to increase physical activity	−0.43 (0.11)	*				
HS diploma X told to reduce fat/calories			−0.26 (0.13)			
Some college X told to reduce fat/calories			−0.47 (0.10)	**		
College degree X told to reduce fat/calories			−0.53 (0.09)	***		
N	2,541		2,540		2,543	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

PR, prevalence ratio; se, standard error; NH, non-Hispanic; ref, reference group; BMI, body mass index; HS, high school; sig, significance.

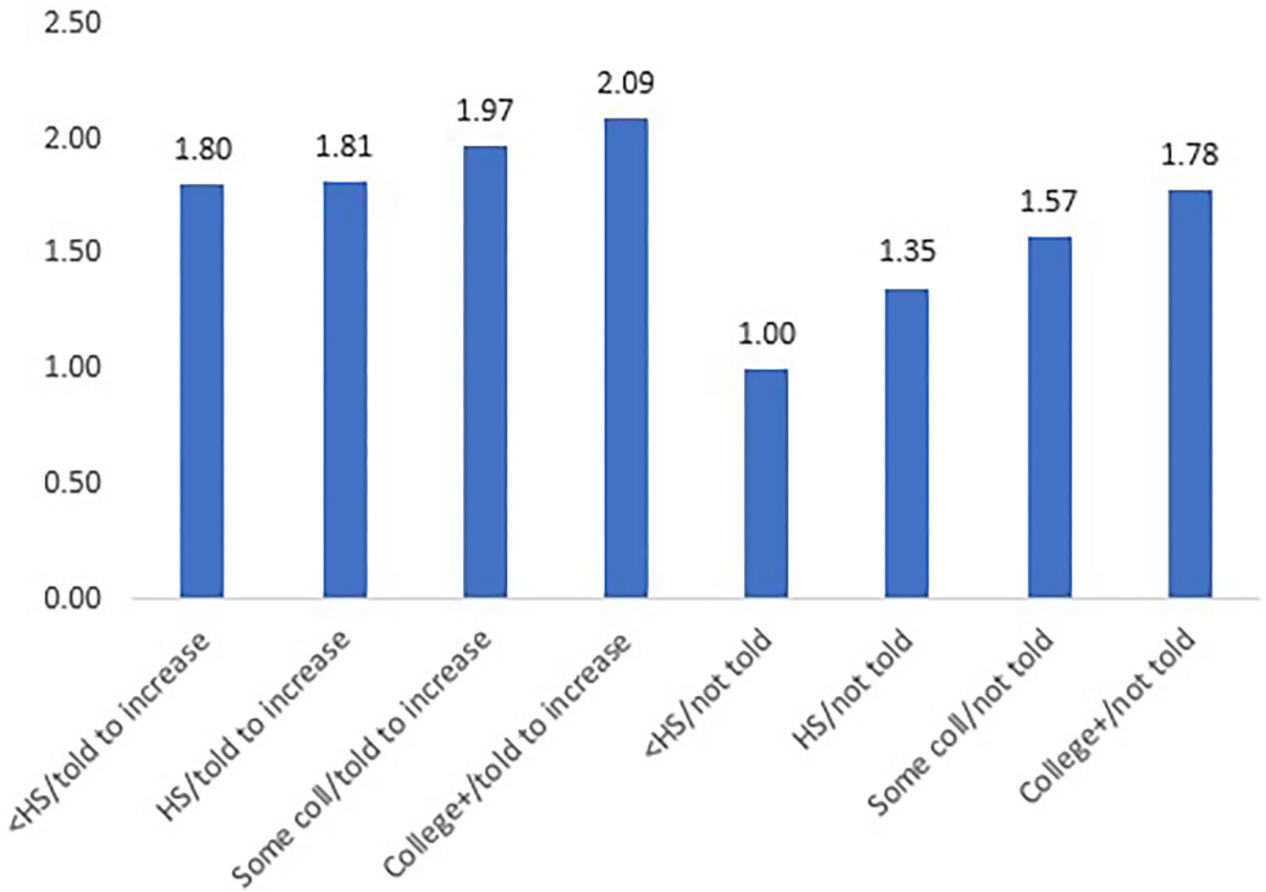

FIGURE 1 | Prevalence ratios of attempting to increase physical activity, by education and whether doctor advised to increase physical activity. <HS, less than high school diploma; HS, high school diploma; Some coll, some college; College+, college degree or higher; Prevalence ratio for each bar derived from interaction of poisson regression coefficients between doctor's recommendation to increase physical activity and education level; Reference group, less than a HS diploma who were not told to increase physical activity.

overall higher efforts to increase physical activity and narrower disparities between high and low education groups.

Education was also positively associated with self-reported attempts to reduce calories, although the interaction effects demonstrate that this relationship was primarily rooted in the group not told to reduce calories (**Table 3**). The MSD group told to reduce calories by a physician exhibited no meaningful differences by education level (**Figure 2**). Interactions between education and physician recommendations for participation in a weight loss program were not statistically significant and were dropped from the final model. Individuals who self-reported that their physician recommended a weight loss program were 1.74 times more likely to report participating in one.

DISCUSSION

This cross-sectional study highlighted the modest, yet meaningful, role of physician advice for behavior changes among MSD patients. Those who were advised to exercise more, participate in weight loss programs, and reduce calories and fat were more likely to do so compared to patients who were not. These findings are consistent with previous research addressing non-musculoskeletal patient compliance to similar health promoting behavior changes (10, 11, 28). For increasing physical activity and reducing calories, physician recommendation for behavior change was an important factor that attenuated educational disparities in these behaviors.

Physicians have a vital role in counseling patients and have the opportunity at each encounter to educate their patients. In a study using National Health and Nutrition Examination Survey, Pool et al. reported that patients who had their obesity addressed by their physicians were two times more likely to report a 5% weight loss compared to patients whose physicians did not (29). The current study shows that about half of respondents report that their physician has told them to increase physical activity, whereas about 12–15% report their physician has recommended a weight loss program. This suggests that some physicians may be missing opportunities to advise MSD patients on the benefits of lifestyle changes or patients are not receiving messages that are conveyed to them. More comprehensive dissemination of these

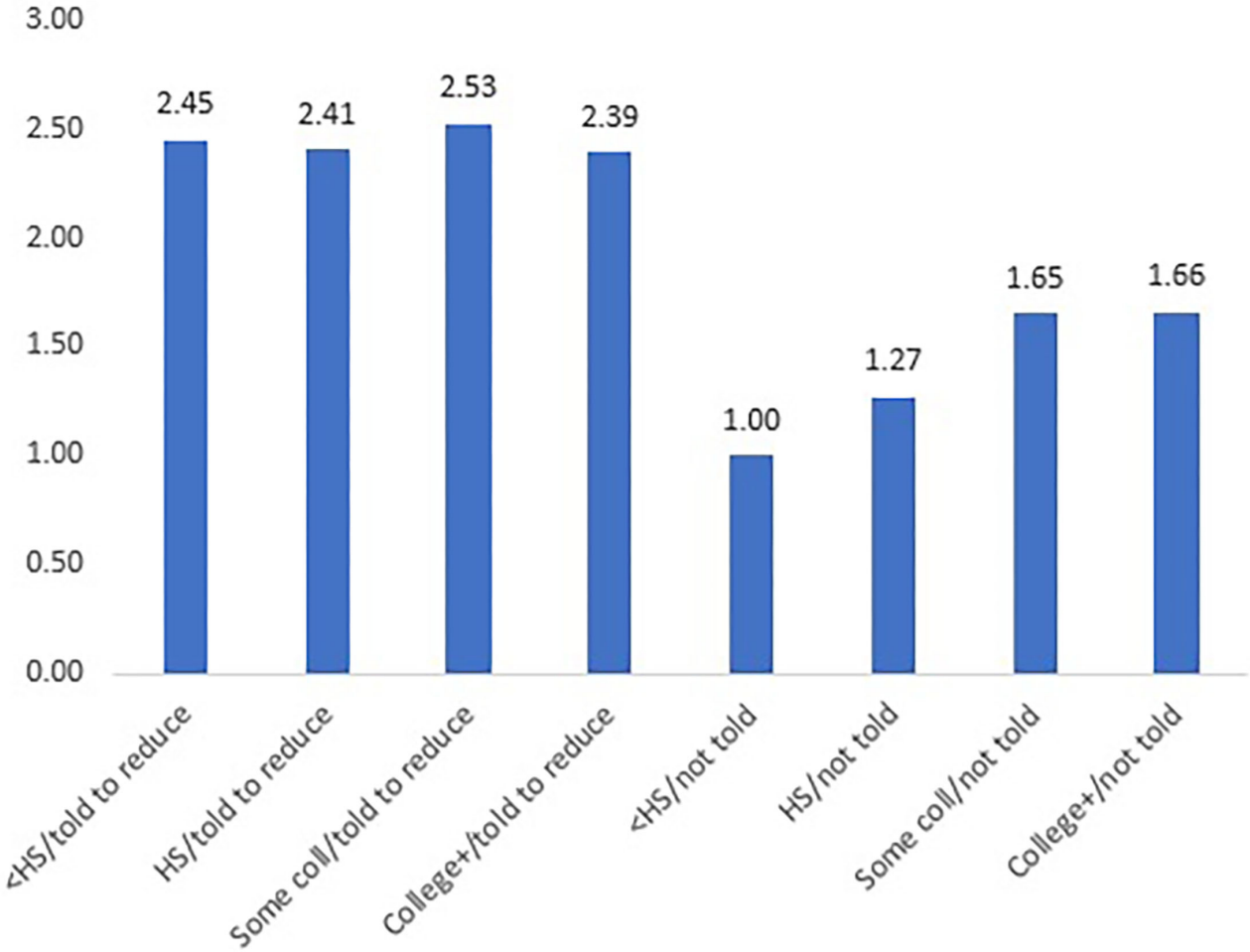

FIGURE 2 | Prevalence ratios of attempting to reduce calories, by education and whether doctor advised to decrease calories. <HS, less than high school diploma; HS, high school diploma; Some coll, some college; College+, college degree or higher; Prevalence ratio for each bar derived from interaction of poisson regression coefficients between doctor's recommendation to reduce calories and education level; Reference group, less than a HS diploma who were not told to reduce calories.

recommendations can produce significant risk factor reductions and thus serves as an important method for helping prevent and treat MSDs (5–7, 30).

Several studies have supported that educational interventions mitigating risk factors help prevent workers from developing MSDs (12–14). The current study supports the idea that the educational baseline of patients has an impact on compliance with physician advice. However, this association is complex and further investigation is needed to understand the factors that may cause the positive trend between educational background and compliance. For example, if misunderstanding of advice or patient distrust with their doctors are different among the education groups, which may impact compliance (31, 32). More targeted approaches based on education level may increase the efficacy of physician recommendations for behavioral change.

Patient perception also complicates compliance relationships. Whereas, healthcare providers may prioritize compliance, patients may have higher priorities such as controlling symptoms, preventing medical emergencies, maintaining financial stability, or enjoying a quality lifestyle (33). Lifestyle behavior change recommendations for patients suffering especially from chronic diseases may not all align with their best interests (33). Variations in patient perception for what is best for them may help explain why there was a significant impact of education on increasing physical activity and decreasing fat/calories, but not enrolling in a weight loss program. Further investigation is needed to understand the patient perspective on following advice and how educational attainment may impact how patients perceive what is best for them. As our models indicate, understanding reported patient compliance with physician recommendation may also be impacted by gender, race/ethnicity, and age. Previous investigations have indicated that men exhibit a lower degree of medical compliance compared to women (34). Additionally, race/ethnicity analyses showed that European Americans reported significantly better compliance

than Asian Americans and Hispanics (34). Such factors add to the complexity of understanding patient perception and thus compliance.

This study is limited by its survey-based self-report nature, and therefore, recall bias may be possible in relation to patient recall of doctor's recommendations and patient reports of health behaviors. The cross-sectional nature of this study does not allow us to establish causation among reported advice, reported behavior change, or education level, as we do not know the timing of the recommendation relative to the report of attempted behavior change. Additionally, other factors such as age, race/ethnicity, and gender may impact the efficacy of behavior change recommendations and deserve exploration in future studies. Lastly, patients may have received more than one behavior change advice. Separating the three advice categories such that there was no overlap in advice given to subjects was not possible due to issues with sample size. The strength of this study is that the subpopulation of individuals whose musculoskeletal symptoms cause difficulty with daily activities is derived from a large, nationally representative sample of non-institutionalized US adults. As such, the sample may be more representative of US adults broadly experiencing such symptoms, including those actively being treated and those who have not or will not seek treatment for their symptoms.

The findings suggest that physician advice for risk factor management to prevent MSDs and improve patient outcomes should not be discounted. Doctors should strive to provide their patients with a sufficient understanding of the benefits of a regimen and how to follow the proposed regimen. This compliance may also apply to beyond the clinic. Spreading awareness of modifying behaviors to reduce risk factors in the community may greatly reduce the prevalence of musculoskeletal conditions. The educational background of a patient should also be considered when treating for MSD, and different approaches may be needed when addressing differently educated patients to maximize their compliance and understanding of advice.

CONCLUSION

Physician advice for lifestyle behavior change increased the likelihood for MSD patients to increase physical activity, decrease fat and calories, and participate in a weight loss program. Additionally, education differences were attenuated when patients were told by their physician to increase physical activity or decrease fat and calories. This demonstrates the importance of physician communication with their patients for advocating healthy behaviors, regardless of education level. Compliance with advice was affected by education for increasing physical activity. This relationship is complex and warrants future investigation for possible explanations.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found at: https://www.cdc.gov/nchs/nhis/nhis_2017_data_release.htm.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JC: conceptualization, methodology, validation, investigation, writing—original draft, and writing—review and editing. JD: conceptualization, methodology, formal analysis, investigation, writing—original draft, and writing—review and editing. JS: conceptualization and writing—review and editing. C-LS: conceptualization, writing—review and editing, and supervision. All authors contributed to the article and approved the submitted version.

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Practical COVID-19 Prevention Training for Obstetrics and Gynecology Residents Based on the Conceive–Design–Implement–Operate Framework

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Background: The spread of COVID-19 poses a challenge for obstetrics and gynecology (O&G) residents. In order to improve the theoretical knowledge and practical skills of residents in epidemic prevention and control, reduce work pressure and improve professional skills,effective and sound training models are required to improve the protection of O&G residents from COVID-19.

Method: A total of 38 standardized training O&G residents working in Shengjing Hospital of China Medical University in March 2020 was selected. They were randomly divided into intervention and control groups. The control group underwent a protection theory exposition according to the traditional training method, while the intervention group adopted a conceive–design–implement–operate (CDIO) mode, arranged training courses in combination with the O&G specialty, and completed four modules of CDIO. After the training, the theoretical knowledge and practical operation were assessed, and the work stress and occupational identity scales were assessed. The assessment results and scores of the two groups of residents were analyzed.

Results: Compared with the scores of the residents in the control group, the theoretical and technical scores of the residents in the intervention group significantly improved ($P < 0.05$). In the evaluation of organizational management, workload, interpersonal relationship, and doctor–patient relationship pressure, the scores of the intervention group were lower than those of the control group, with a statistical difference ($P < 0.05$). For the intervention group, the job stress and professional identity evaluation scores were significantly higher than those of the control group ($P < 0.05$).

Conclusion: The CDIO model can effectively enhance the theoretical knowledge and practical skills of O&G residents in COVID-19 epidemic prevention protocols to reduce work pressure and improve professional identity. In addition, it provides new ideas, methods, and approaches for future clinical practice training.

Keywords: COVID-19, CDIO model, engineering education model, infectious disease protection, practical skills training, resident standardized training, working pressure, professional identity

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INTRODUCTION

COVID-19 has been declared an "International Public Health Emergency" by the World Health Organization (WHO) because the virus is extremely contagious and has spread globally. The COVID-19 pandemic has profoundly changed the academic and clinical learning environment of obstetrics and gynecology (O&G) in many ways. The rapid development of virus variants affects patients, doctors, and medical students (learners). This calls for unprecedented collaboration and rapid and profound readjustment, practically every day.

Residents undertake a lot of responsibility in medical clinical work, including ward duty, medical records, operation assistance, outpatient care, and emergency support. Medical institutions have conducted regular training on infection management and COVID-19 protocols for residents in the initial stage of the epidemic (1). However, owing to the lack of clinical experience and the limitations of responding ability (2), minimal theoretical teaching cannot sufficiently induce an awareness of the importance and key points of epidemic prevention and control. In addition, because of the specialty of O&G, the diagnosis and treatment of pregnant women during the epidemic remained the same (3). Therefore, the prevention and control of the epidemic in the outpatient clinic and ward of O&G residents are extremely important. Furthermore, it is vital to conduct standardized training, implement standard protective protocols, establish training programs for infectious disease protection, and perform strict, efficient, timely, and professional practical training for O&G residents. Traditional (teacher-centered) teaching methods were adopted in early COVID-19 obstetric training sessions. After lectures on COVID-19-related knowledge and demonstrations on personal protective equipment (PPE) operation, the residents passively received theoretical instruction. When the residents were sent to the epidemic area to actually work, they only mechanically completed relevant operations in the infected environment, and their subjective initiatives failed to be stimulated in a short time. After the training of resident physicians, the level of mastery of O&G knowledge and the combination of clinical practice in the infectious environment could not meet the needs of the cultivation and development of clinical practice ability. Effective and sound training models are required to improve professional practical skills and epidemic response ability.

O&G residents have to face high intensity and high risk of work pressure, long-term high load, irregular work and rest time, and need to deal with sudden disease changes at any time. They are prone to tension, anxiety and other emotions, because the body is constantly in a state of high stress. With China's medical reform, women have increasingly higher requirements for the quality of medical services, and higher expectations for disease treatment. The lack of effective communication skills and the tension between doctors and patients caused great mental pressure to O&G residents. At the same time, residents also have to face with pressure from career development, interpersonal relationship, career interest and external environmental factors.

Professional identity refers to the psychological identity of one's own career and the ability to positively perceive and evaluate related aspects of the career. The higher the professional identity, the higher the work enthusiasm and efficiency. Medical staff with low professional identity are prone to work pressure, job burnout or resignation thoughts. O&G residents are new to clinical work, busy work and low salary which inevitably lead to doubts about their career. Improving the professional identity of medical staff can promote the work efficiency and physical and mental health of medical staff.

The theory of conceive–design–implement–operate (CDIO) is based on "learning by doing". It is the latest achievement in international engineering education reform[1]. It considers product research and development using the whole life cycle of the product operation as the carrier and realizes the organic combination of initiative, realization, and courses, to improve students' comprehensive quality, such as their engineering system abilities, teamwork abilities, personal abilities, and basic engineering knowledge (4). This model emphasizes "student-centred" teaching, in which the students participate in the conception, design, implementation, and operation of the project and turn the theoretical knowledge into a tool to solve problems (5). The CDIO model has been gradually applied in medical vocational education systems (6). Teachers use CDIO in various resident trainings, such as physical examinations, auxiliary examinations, information integration, diagnoses and identification, treatment plans, and education, by constructing simulation scenes and presenting cases. Clinical practice confirmed that this model had positive significance in training innovative and comprehensive medical talent.

This study explored the application effect of the CDIO model in the practical training of O&G residents during the COVID-19 pandemic, and evaluates the psychological status of O&G residents using the Job Stressor Scale and Professional Identity.

MATERIALS AND METHODS

Subjects

A total of 38 residents who receive standardized training in the O&G base of Shengjing Hospital of China Medical University in March 2020 was selected. Based on the actual situation, the residents were randomly divided into two groups for training depending on the ward as a unit. There were 18 and 20 residents in the control and intervention groups, respectively. There were no statistically significant differences in gender, age, educational structure, and training duration between the groups ($P > 0.05$), as shown in **Table 1**.

Traditional Training Methods

A specialist from the Department of Infection Prevention and Control provided an intensive exposition on COVID-19 protection theory, including the following: ① grading standards of self-protection; ② correct wearing of PPE; ③ diagnoses and treatment procedures for patients with fever in wards, outpatient, and emergency; ④ diagnoses and treatment procedures for O&G

[1] Available at: http://www.cdio.org/.

TABLE 1 | Characteristics of residents in the two groups.

Items	Control group ($n = 18$)	Intervention group ($n = 20$)	Statistics	*P*
Age	24.63 ± 1.48	25.11 ± 1.12	$t = -1.134$	0.264
Gender [*N*, (*n*%)]			$\chi^2 = 0.257$	0.612
Male	1	2		
Female	17	18		
Education [*N*, (n%)]			$\chi^2 = 0.368$	0.544
Undergraduate	15	18		
Postgraduate	3	2		
Training duration [*N*, (n%)]			$\chi^2 = 0.326$	0.572
6 months	12	13		
18 months	3	4		
30 months	3	3		

operations during the epidemic; ⑤ prevention, control, and referral procedures for suspected or confirmed patients. The specialist provided a step-by-step demonstration of the basic use of PPE to the residents. After the demonstration, the residents practiced independently, and an assessment was conducted.

CDIO Professional Training

The intervention group adopted the CDIO professional training model. Training courses were arranged according to the characteristics of O&G, and the theoretical content was written by specialists from the Department of Infection Prevention and Control. The specialists uniformly studied professional CDIO training courses online prior to the training and clarified the CDIO training model. According to the "Novel Coronavirus Prevention and Control Technical Guide (First Edition) in Medical Institutions" and "The Guidelines on the Scope of Use of Common Medical Protective Articles in the Prevention and Control of *novel coronavirus*-infected *pneumonia* (Trial)" issued by the National Health Commission in China, the preparation of lesson plans and operation and implementation plans were uniformly conducted.

The specific content of the epidemic prevention practice programme for the residents in the intervention group is shown in **Table 2**. For example, the specific training process for the simulation scenario "emergency room reception of suspected COVID-19 cases in labor" is as follows.

Step 1, Conceive (C): Two days prior to the training, the specialists selected practical cases in line with the current pandemic, and proposed specialized protection problems for emergency O&G were sent out via WeChat. For example, a 31-year-old female primipara was admitted with the chief complaint of "vaginal bleeding for 10 h and fever for 1 h". The patient developed a large amount of vaginal fluid 10 h earlier without induction, abdominal pain, and vaginal bleeding and felt fever 1 h earlier with a self-measured body temperature of 37.2 °C. The patient was rushed into the emergency room by an emergency ambulance. History: Her husband went out for dinner a week ago, accompanied by unknown people, not excluding contacts from other provinces. An emergency physical examination revealed the following: body temperature, 37.3 °C; heart rate, 104 beats/min; respiratory rate, 28 breaths/min; and blood pressure, 130/80 mmHg. An obstetric examination revealed the following: uterine height, 41 cm; abdominal circumference, 105 cm; fetal heart, 164 beats/min; the cervix was soft and dilated in the center. A pH test was conducted, and the paper turned blue. The fetal heart monitoring revealed a reactive type with no evident contractions. Certain problems related to emergency obstetric protection were proposed, as shown in **Table 2**. The residents were required to consult relevant literature and discuss them in groups.

Step 2, Design (D): After listening to the discussion and analysis of each group, the specialists designed work items for obstetric emergency epidemic prevention and control as follows. ① Isolation mechanisms for doctors attending emergencies (preparation of medical supplies for clinical reception, isolation method when receiving patients, handover and cooperation with an emergency ambulance, isolation of the clinical history collection, and transportation protection when completing auxiliary examination); ② cooperation and protection of emergency nurses during obstetric examination (disinfection and isolation of obstetric examination instruments, protection during obstetric examination, treatment of medical waste, disinfection of examination bed, and therapeutic department); and ③ protection scheme of patients' family and inspectors in relevant auxiliary departments. In addition to professional PPE, emphasis was placed on the cultivation of the residents' and nursing team's abilities to deal with problems, communication skills, critical thinking, and comprehensive knowledge application.

Step 3, Implement (I): The team completed the scenario simulation according to the design. Each group comprised four residents, who functioned as the emergency physician, emergency room attending physician, emergency room nurse, and ward attending physician, respectively. Each resident performed situational simulation drills according to his/her role setting, focusing on PPE wearing and taking off, isolation management techniques, and protective management of patient handover tasks. During the simulation process, if there was any question or practice bottleneck, the residents communicated with the specialists.

Step 4, Operate (O): Finally, each group summarized the entire process of case reception, treatment, and transfer in the form of flow charts or mind maps. The specialists commented on and modified the advantages and disadvantages of the plan and provided a detailed rectification in line with practical scenarios.

Training Effect Evaluation

After the training, unified COVID-19 prevention and control papers were used for testing, and theoretical scores were compared for the two groups. The full score of the paper was 100 points, including 80 points for single-choice questions and 20 points for four short-answer questions. Concurrently, the evaluation standard of the PPE protective operation provided by the hospital was used as the scoring basis to evaluate the operation of residents in the two groups.

TABLE 2 | Epidemic prevention practice training programme for residents in the intervention group using the CDIO model.

Steps	Items	*Teaching* contents	*Teaching methods*	*Teaching* goals
Conceive, C	*Construction of professional thinking*	1. Introduction of cases of suspected COVID-19 patients in obstetric emergency rooms prior to the training, leading to problems related to emergency protection. 2. Residents consulted references and discussed in groups. 3. Define a series of protection procedures and plans based on the case.	*Case*-based *teaching* *CBL teaching*	1. Cultivate specialized thinking of infectious diseases. 2. Improve the literature retrieval ability of residents. 3. Enhance the basic professional knowledge of residents.
Design, D	Project module design	1. Protective articles preparation: personal and patient protective items, doctor–patient environmental isolation, and clinical family resettlement. 2. Medical cooperation in the emergency room: cooperation during obstetric examinations, disinfection of related examination items, establishment of medical aseptic barriers, and shift and management of staff. 3. Emergency-ward transport process: isolation and disinfection during transport, protection of transport personnel and items, and ward reception plan.	Participatory teaching	1. Improve residents' professional practical ability in obstetrics and gynecology. 2. Establish awareness of infection prevention and control in emergency reception and transportation. 3. Enhance the overall prevention and control concept of medical cooperation.
Implement, I	Project practice	1. The group completed the scenario drill according to the design. 2. Coordinate with each other and be corrected under the guidance of the trainer.	Simulation training Role-playing	1. Train residents in communication and coordination skills; 2. Enhance residents' team awareness.
Operate, O	Results show	1. The team completed the emergency flow chart of cases and reported it 2. Trained teachers to complete comments and summaries	Multimedia teaching	1. Improve the ability of residents to find and solve problems. 2. Exercise residents' ability to explore knowledge in practice.

The Chinese Physician's Job Stressor Scale (CPJS) (7) was used to evaluate the residents. The scale has seven dimensions, including organizational management, career interest, workload, career development, interpersonal relationship, doctor–patient relationship, and external environment, which were divided into 31 items. Each item was divided into four answers: strongly disagree, somewhat disagree, somewhat agree, and strongly agree, and they were assigned points of 1–4, respectively. The higher the score, the greater the work pressure. The Cronbach's α coefficient for the scale was 0.881.

The professional identity of the residents was scored using a scale published by Li (8). This scale comprised 13 items regarding professional identity. These items were assessed on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree) (**Table 3**). The total scores ranged from 13 to 65, with high scores indicating high professional identity among the residents. Scores of 13–17 indicated a low level of professional identity, 18–33 indicated a medium level of professional identity, and $\geq$ 34 indicated a high level of professional identity.

Statistical Analysis

Data were entered into Epidata (version 3.1) and analyzed using SPSS (version 21.0). The counting data were expressed in frequencies and percentages, and the measurement data were expressed as mean ± standard deviation ($\bar{x}\pm$ s). Prior to the statistical analysis, the comparison data were normally distributed. Subsequently, count data were compared using χ^2 tests, and measurement data were compared using the independent sample t-test for the two groups. A p-value < 0.05 was considered statistically significant.

RESULTS

Theoretical and Skill Assessment Scores for the Two Groups

After the training, the score of protection theory for the intervention group was 92.76 ± 4.38, which was significantly higher than that of the control group ($t = 5.861$, $P < 0.001$). In the skill assessment, the average score of residents in the intervention group was 87.33 ± 4.90, and that in the control group was 80.84 ± 2.65. The score of residents in the intervention group was significantly higher than that in the control group ($t = 4.996$, $P < 0.001$).

Job Stress Scores for the Two Groups

A total of 38 questionnaires were issued, and 38 valid questionnaires were recovered, with an effective recovery rate of 100%. According to the different dimensions of the questionnaires, the assessment results of job stress and professional identity of the residents in the two groups were statistically analyzed. Compared with the control group, the evaluation of organizational management, workload, interpersonal relationships, and doctor–patient relationships significantly improved in the intervention group ($P < 0.05$). The results are listed in **Table 4**.

Professional Identity for the Two Groups

After different training modes, the residents of the two groups were evaluated using a professional identity scale. The intervention group scored higher on average than the control

TABLE 3 | Professional identity assessment scale in the two groups.

Items	Control group ($n = 18$)					Intervention group ($n = 20$)					χ^2/t	*P*
	Strongly disagree *n* (%)	Strongly disagree *n* (%)	Neutral *n* (%)	Somewhat agree *n* (%)	Strongly agree *n* (%)	Strongly disagree *n* (%)	Strongly disagree *n* (%)	Neutral *n* (%)	Somewhat agree *n* (%)	Strongly agree *n* (%)		
1. When referring to my profession, I usually say "we" rather than "they".	2 (11.11%)	6 (33.33%)	8 (44.44%)	1 (5.56%)	1 (5.56%)	0 (0.00%)	1 (5.00%)	2 (10.00%)	12 (60.00%)	5 (25.00%)	102.21	<0.001
2. I consider my success the success of healthcare workers.	2 (11.11%)	5 (27.78%)	9 (50.00%)	0 (0.00%)	2 (11.11%)	0 (0.00%)	0 (0.00%)	2 (10.00%)	9 (45.00%)	9 (45.00%)	106.18	<0.001
3. I care very much about other people's views on my career.	2 (11.11%)	4 (22.22%)	10 (55.56%)	2 (11.11%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	3 (15.00%)	9 (45.00%)	7 (35.00%)	99.97	<0.001
4. The praise my profession receives from people = the praise I receive.	1 (5.56%)	4 (22.22%)	11 (61.11%)	1 (5.56%)	1 (5.56%)	0 (0.00%)	2 (10.00%)	1 (5.00%)	10 (50.00%)	7 (35.00%)	102.97	<0.001
5. If there are criticisms about my career from the media, I will feel ashamed and embarrassed.	1 (5.56%)	5 (27.78%)	10 (55.56%)	1 (5.56%)	1 (5.56%)	0 (0.00%)	0 (0.00%)	2 (10.00%)	11 (55.00%)	7 (35.00%)	105.40	<0.001
6. My job is important/I believe in the importance of my job.	0 (0.00%)	7 (38.89%)	9 (50.00%)	1 (5.56%)	1 (5.56%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	11 (55.00%)	9 (45.00%)	112.33	<0.001
7. I am confident in my ability to work.	2 (11.11%)	1 (5.56%)	10 (55.56%)	3 (1.67%)	2 (11.11%)	0 (0.00%)	1 (5.00%)	1 (5.00%)	10 (50.00%)	8 (40.00%)	97.55	<0.001
8. My job will improve patients' conditions.	1 (5.56%)	3 (16.67%)	9 (50.00%)	4 (22.22%)	1 (5.56%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	12 (60.00%)	8 (40.00%)	103.58	<0.001
9. My job is meaningful.	3 (16.67%)	3 (16.67%)	9 (50.00%)	1 (5.56%)	2 (11.11%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	9 (45.00%)	10 (50.00%)	105.36	<0.001
10. I have the necessary qualifications and skills for my job.	4 (22.22%)	4 (22.22%)	7 (38.89%)	2 (11.11%)	1 (5.56%)	0 (0.00%)	0 (0.00%)	2 (10.00%)	11 (55.00%)	7 (35.00%)	102.59	<0.001
11. I understand the responsibilities and requirements of my work.	3 (1.67%)	5 (27.78%)	5 (27.78%)	4 (22.22%)	1 (5.56%)	0 (0.00%)	1 (5.00%)	2 (10.00%)	9 (45.00%)	8 (40.00%)	95.00	<0.001
12. Healthcare work suits me.	2 (11.11%)	6 (33.33%)	5 (27.78%)	3 (16.67%)	2 (11.11%)	0 (0.00%)	1 (5.00%)	1 (5.00%)	12 (60.00%)	6 (30.00%)	96.40	<0.001
13. I know my role.	3 (16.67%)	5 (27.78%)	5 (27.78%)	4 (22.22%)	1 (5.56%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	10 (50.00%)	10 (50.00%)	104.10	<0.001
Total Score	32.55 ± 6.54					84.00 ± 7.13					23.10	<0.001

group ($P < 0.01$) and exhibited a higher sense of professional identity, as shown in **Table 3**.

DISCUSSION

The Remarkable Effect of Epidemic Prevention Training in O&G Using the CDIO Model

Traditional infection prevention and control training employs a one-way infusion teaching method, focusing on explanations and demonstrations; however, it cannot effectively combine infection prevention and control and clinical thinking systematically. As a new method of education and training, CDIO (9) enables students to actively combine theory with clinical practice and is conducive for the training of lifelong knowledge acquisition abilities. O&G is a highly practical field and a first-line clinical high-risk discipline during COVID-19 and other infectious disease outbreaks (10). To improve the training level and clinical emergency ability of residents, a scientific teaching model is required. Using the CDIO model, training and guidance are conducted by instructors through group collaboration to solve clinical problems of O&G in practice. Here, after applying different teaching methods to complete the training, the performance of residents in the intervention group was significantly better than that in the control group in terms of theoretical and practical assessments ($P < 0.05$), suggesting that the CDIO teaching model can improve the training effect for residents. In addition, the integration of the CDIO model into the epidemic prevention and control training in O&G departments can effectively divide and integrate O&G departments with infection prevention and control, outpatient, and emergency

TABLE 4 | The Chinese Physician's Job Stressor Scale (CPJS) in the two groups ($\bar{x} \pm s$).

Items	Control group ($n = 18$)	Intervention group ($n = 20$)	t	*P*
Organizational management	2.72 ± 0.61	2.24 ± 0.69	−2.262	0.030
Career interest	2.19 ± 0.65	2.21 ± 0.68	0.089	0.927
Workload	3.55 ± 0.74	3.08 ± 0.58	−2.190	0.035
Career development	2.66 ± 0.59	2.71 ± 0.55	0.271	0.790
Interpersonal relationship	2.24 ± 0.64	1.64 ± 0.69	−2.769	0.009
Doctor–patient relationship	3.26 ± 0.64	2.74 ± 0.75	−2.286	0.028
External environment	3.58 ± 0.62	3.61 ± 0.56	0.157	0.876

departments; ward and medical care departments; and related auxiliary departments and expand the depth of the teaching system based on a multi-layer teaching platform, such that all levels connect and complement each other.

CDIO Model Is Beneficial in Relieving the Occupational Stress of O&G Residents During the Pandemic

The sudden outbreak of the pandemic was a majorly stressful event for residents who recently commenced clinical work. Although medical practitioners were aware of the severity of COVID-19, certain residents felt anxious at the beginning of the spread of the epidemic because the future was unclear (11). In particular, for the O&G residents at the front line of the clinical work, owing to the rigid demand in obstetrics, it was difficult to artificially control the number of patients and the intensity of work. In addition, they faced the pressure of dual medical security for pregnant women and newborns. Concurrently, at the clinical front line, they experienced severe outcomes due to viral infections and panicked at the possibility of iatrogenic transmission to relatives and friends (12). Traditional training methods adopt centralized teaching, resulting in a scattered knowledge of epidemic prevention and control, lack of overall understanding of professional protection, and relatively slow improvement in comprehensive protection ability. In addition, owing to the lack of scene fidelity, practical training projects for process development, and corresponding practical training methods, the practical training was disconnected from the real front-line protection work. This hinders residents from objectively viewing the current pandemic, calmly and properly dealing with problems and difficulties generated at the clinical front-line, thereby hindering the correct prevention and control education of Non-medical personnel around them (13). After adopting the CDIO model, teachers were trained to set up simulation scenarios and guide residents to follow the CDIO process to improve the evaluation, diagnosis, planning, measures, and evaluation of medical procedures through field cases. In addition to mastering knowledge points, resident doctors in training can clarify the context of knowledge according to simulated cases, systematically combine professional knowledge with epidemic prevention, and enhance their ability to flexibly deal with problems in practice. Therefore, in this study, the job stress of residents in the intervention group was lower than that in the control group in terms of organizational management, workload, interpersonal relationship, and doctor–patient relationship, and the difference was statistically significant ($P < 0.05$), particularly in the element of interpersonal relationship. However, for the career interest, career development, and external environmental factors, the effect of the CDIO teaching model was not significant. This may be related to the occupational risk factors of O&G and the uncertain trend of COVID-19, which requires further study.

CDIO Model Training Is Beneficial in Increasing the Professional Identity of O&G Residents

Each section of the CDIO model training requires close cooperation among residents, nurses, and medical auxiliary personnel (14, 15). Therefore, different roles need to be simulated in the group to negotiate and solve problems. This is helpful for residents to master the overall medical process, stimulate potential, and cultivate teamwork and communication skills. In addition, by role-playing in clinical cases, the field situation can be simulated to discover and solve problems in practice and improve the comprehensive ability of disease assessment, critical thinking, problem-solving, and professional identity. Here, the evaluation scores of residents in the intervention group for job stress and professional identity were significantly higher than those in the control group ($P < 0.05$), which indicated that the CDIO training model had an improvement effect on the professional identity of residents.

Limitations

The main limitation of this study is the small sample size. Single-center research is one reason and the number of O&G residents included is small each year, which is related to the size of the hospital. These make the statistical results of this study uncertain. Of course, on the other hand, this CDIO is carried out for the first time in the education of O&G residents, which is a predictive test in a small population. Future research needs to expand the study population, preferably by perfecting multi-center studies, with the expectation of widespread application.

CONCLUSION

In conclusion, the CDIO model can effectively enhance the ability of O&G residents to integrate theoretical knowledge and practical skills of COVID-19 prevention. It enhances the training effect, reduces the work pressure of residents, and improves their professional identity. When suddenly faced with COVID-19 and other similar infectious diseases, increase in clinical workload, and high risk of infection in medical care, the CDIO model provides manpower guarantee for specialized treatment and epidemic prevention for O&G patients. Finally, it provides new ideas, methods, and approaches for clinical skills and practical training in the future.

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

XW and DZ designed the study and drafted the manuscript. YZ, ZS, and YW designed the statistical analysis plan. XC and DZ reviewed the manuscript. All authors take responsibility for the appropriateness of the content.

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A Survey of College Students on the Preference for Online Teaching Videos of Variable Durations in Online Flipped Classroom

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In the spring semester of 2020, online flipped classroom was used to replace offline face-to-face teaching of the physiology course at Xiangya School of Medicine. In order to analyze the preferences and utilization of different teaching resources by students, registered questionnaire was applied to investigate the preference divergence of the students on the duration of different teaching videos used in the online flipped classroom model. One hundred forty-seven students of clinical medicine in grade 2018 of Xiangya School of Medicine were selected as the research objects. Three formal surveys were conducted in total. The results showed that there were significant divergences in preference of students for different durations in the first two surveys. 56.43 and 50.00% of the students preferred 15 min mini-video, whereas 43.57 and 50.00% preferred 45 min complete video. Meanwhile, students showed a significant preference for mini-video in active learning before class, with 65.00 and 59.29% watched only mini-video, 17.14 and 25.71% watched only complete videos, and 17.86 and 15.00% watched both mini and complete videos. Although most students preferred to watch mini-video in active learning before class, there was a significant proportion of students who watched complete video before class. The results suggested that the individualization of student in the online flipped classroom is prominent. Multiple logistic regression analysis showed that the selection of videos with different durations at different time points (before, in and after class) was significantly associated with the characteristics of the videos themselves. Therefore, the construction of online teaching resources and the application of teaching methods should consider the requirements of different student groups and provide a variety of online curriculum resources.

Keywords: online flipped classroom, medical education, physiology, medical student, learning preference

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INTRODUCTION

In recent years, with the progressive development of educational information technology, online classes become an essential way for students to acquire knowledge with better repeatability (1) and more personalized learning methods (2). With the superiority of distance learning, online course is a new paradigm in higher education (3–5). In particular, flipped classroom teaching based on online videos becomes an important form of active learning and is rapidly spreading

around the world (6). The flipped classroom reconstructs the learning process of students, in which students complete the "information transfer" by watching videos and other independent learning according to the predefined teaching objectives before the class. By understanding the learning difficulties in advance, teaching staff provide effective tutoring in the class and promote the mastering of knowledge by students through teacher-student and student-student communications (7, 8). In China, flipped classroom is widely used in medical education. Flipped classroom is very popular among students and demonstrated to improve academic performance due to its flexible learning time and increased student autonomy (9, 10).

The COVID-19 pandemic has a huge socio-economic impact globally, severely affected traditional classroom teaching structure. UNESCO recommended the distance learning and training programs and the open access platforms to reduce learning process disruption (11). As a result, online education achieved a rapid growth during the COVID-19 pandemic. For example, in China, Online education users reached 381 million in 2020 (12). Online learning is defined as "a form of distance education where technology mediates the learning process, teaching is delivered completely using the Internet, and students and instructors are not required to be available at the same time and place" (13). Available evidence suggests that online learning is at least as effective as traditional learning (14). Online Flipped Classroom (OFC) is a teaching method that combines asynchronous and synchronous online learnings (15) and is a new model for online learning in universities worldwide. It is one of the most popular educational methods during the COVID-19 epidemic and a promising alternative to teaching theoretical courses (16). Inspired by the traditional flipped classroom approach (17, 18), students were encouraged to watch video lectures (often augmented with quizzes) at home as a preparation before scientific meeting. However, unlike the traditional flipped classroom model, in OFC, students and teachers did not meet in a real classroom, but online. The time spent together was dedicated to active and collaborative learning (e.g., discussion, rather than lecturing) (19). As a widely recognized, effective, innovative, and improved strategy in the higher education of many countries, the OFC model has been recognized as an active educational approach in various fields, and more and more researchers and teachers are showing high interests in this strategy (20–22). Several studies evaluated the learning experience and learning outcomes of students in OFC, confirming that this self-directed learning model allowed students to interact with their peers or teachers, effectively stimulating their interest in learning and improving their learning efficiency (15, 19). However, we have not retrieved reports on students' preferences and needs of different instructional resources in OFC. Teaching resources directly influence the choice of teaching methods and learning experience of students, which further affects the learning efficiency of students, and ultimately manifests the learning outcomes of students (e.g., grades) (23). Therefore, investigating the teaching resources with different preference and need of students is highly beneficial to the design and construction of the teaching resources. Such investigation is an indispensable step to improve the current OFC implementation process.

Previous studies on traditional flipped classroom showed that most students prefer videos of short duration (24, 25). Students who watched short duration videos had higher participation rates and lower discrepancy compared with those watched long duration videos (26). Students showed highest attention in study when watching 10-min online instructional videos (27, 28). However, in OFC, since students and instructors did not meet physically and all teaching activities were performed online, whether students still preferred shorter duration videos is unknown.

The Department of Physiology, Xiangya School of Medicine, Central South University, recorded 72 complete videos (45–50 min/each) of traditional classroom lectures and 118 mini-videos (10–15 min/each) required for building MOOC in 2014 and 2017, both of which coverred the entire contents of physiology teaching. Both video types were taught by the same faculty teaching team. The mini-videos had the advantage of clear key points, but the disadvantage of fragmented contents. The complete videos provided a detailed and comprehensive description of the course contents, but the contents were not sufficiently highlighted and concised. The total length of mini-videos was about one-third of the total length of complete videos. Therefore, contents of one 45-min video were not equal to the contents of three 15-min videos, and they represented two completely different types of teaching resources (mini-videos were mainly on course highlights, while complete videos were more on comprehensive understanding of knowledge). Since these two different types of videos were offered in the OFC of physiology at Xiangya School of Medicine, we followed the course schedule and conducted three surveys to analyze the preferences and needs of students on the two types of instructional videos with different durations, in order to provide references for the provision and design of online instructional resources in the future.

MATERIALS AND METHODS

Research Objects

We chose 147 students majored in 5-year clinical medicine of Grade 2018, Xiangya School of Medicine, who studied physiology by the online flipped classroom during March to April 2020. We detailed the purpose of the survey and emphasized the confidentiality principle, which was known and agreed by all participants.

Questionnaire Design

Three formal surveys were conducted totally. The first two surveys mainly studied preference and usage of students on the teaching videos with different durations. The third survey was used to further discuss the underlying logic to the choice of students. The questionnaire was designed by the professors of department of physiology and statistician. In order to ensure the reliability of the questionnaire, 30 students were selected for the Pre-survey before the first formal survey, whose results showed that the Kronbach coefficient of the questionnaire was 0.839. The first two surveys included basic information and learning resource preferences of students. The first survey investigated the

network conditions of students' participation in online learning additionally. After coding and analyzing the data, we found that the network status of students was good and the difference was not statistically significant to the content of this study. Therefore, we deleted this question and added a question about adaption of students instead. The total number of questions in first two surveys' questionnaires was 20.

Research Methods

We used wjx (an online website for questionnaire survey) to investigate the preference of the students for different durations of teaching videos twice on 1st week and 5th week of the course. The third survey was designed based on the former results and completed on 6th week to supplement information on several notable points. The final analysis and conclusion were established through consideration of all three questionnaire surveys.

Models of Instruction

The department of physiology of Xiangya School of Medicine conducted this online physiology teaching based on the National Quality Resource of Sharing Courses and National Quality Resource of Open Courses on the i-Course platform.

National Quality Resource of Sharing Courses http://www.icourses.cn/sCourse/course_6701.html.

Seventy two complete videos. The video content is a recording of the instructor's lecture in the classroom. The edited video lectures are from 36 to 56 min in length, averaging 46.28 min, and contain all the teaching contents of physiology. These videos are similar to the traditional face-to-face classroom, with a moderate pace of lecture, better coherence of knowledge points, teacher-student interaction, expansion and extension of relevant knowledge points, and a good learning atmosphere, which is more conducive to concentration.

National Quality Resource of Open Courses http://www.icourse163.org/course/CSU-1001930016:

One hundred eight mini-videos. The lecture content is short "micro-lectures" given on specific topics by the instructor. These deliver as voice-over Powerpoint based videos, captured and edited by a specialized online video production company in the studio. The edited video lectures are from 10 to 15 min in length, averaging 11.03 min, and contain all the teaching contents of physiology. The videos were recorded and edited to move at a fast pace. Such videos obviously do not contain time for settling in, transitions, student questions, and other activities that are part of the normal lecture. However, these videos have the advantage of prominently given to the clear key points, saving students' learning time, and having better production quality.

Specific implementation processes in OFC are as following: ① Active learn before class: students watched the videos according to the learning objectives and learning requirements released by the teacher in advance. In this process, the teacher collects learning questions from students and selects those that are commonly asked and suitable for extensive discussion and makes a list available to the QQ group before class for students to think about and prepare. ② Discuss in class: the teacher asks guided questions in the QQ group, answers queries by students, leads teacher-student interaction and student-student interaction, and helps students to master the course knowledge. ③ Review after class: students use videos and other teaching resources for independent review.

Statistical Analysis

The data were coded, entered, and analyzed using the SPSS statistical package, version 25.0 (SPSS Inc., Chicago, IL). Descriptive statistics were performed using frequencies and percentages. The paired chi-square ($\chi 2$) test was used to compare the differences between the first and second surveys. Multiple logistic regression analysis was applied to assess the strength of association between the characteristics of two kinds of teaching videos and students' preference of watching time. A *P*-value of <0.05 was considered statistically significant.

RESULTS

Questionnaire surveys were carried out online and registered. The number of questionnaires collected in the first two formal surveys was 142 and 143, showing a coverage rate of 96.60 and 97.28%. Among them, 140 students filled in both first and second questionnaires were chosen to answer the third survey questionnaire; 119 students finished the questionnaire, and the coverage rate was 85.00%.

In the first survey about the quality of network for participating in online flipped classroom, students used wireless network [73.24% (104/142)], wired network [7.04% (10/142)] and mobile phone traffic [19.72% (28/142)] to watch the videos. 88.03% (125/142) students considered that network conditions were smooth enough for online flipped classroom. These results demonstrated that only 17 students thought their internet connection was not enough smooth occasionally, so the internet connection problem was excluded to influence the results.

In terms of preference and utilization, the percentage of students preferring 15 min mini-video in the first two surveys were 56.43% (79/140) and 50.00% (70/140), while 43.57% (61/140) and 50.00% (70/140) selected 45 min complete video (**Figure 1**). The paired chi-square test showed no statistical difference between the same student's preference of the teaching videos with different durations ($\chi^{2=}$ *1.641,P = 0.200*).

Because of the huge divergence among the preference of students on the teaching videos with different durations, the third survey was devised for the logic reasons. The reasons for selecting 15 min mini-video were prominently given to the clear key points, learning time saving, more focused in watching and better video quality. Correspondingly, the reasons for selecting 45 min complete video were higher coherence of the knowledge, better learning atmosphere, expansion to connected knowledge and more focused in watching (**Table 1**).

To study the preference of students on teaching video in active learning before class, the answers to relative questions in the first two questionnaires were analyzed. There were 17.14% (24/140) and 25.71% (36/140) of students watched 45 min complete video and 65.00% (91/140) and 59.29% (83/140) of students watched 15 min mini-video for active learning before class; while 17.86% (25/140) and 15.00% (21/140) watched both complete and mini-video in the first two surveys (**Figure 2**). So 82.9% (116/140)

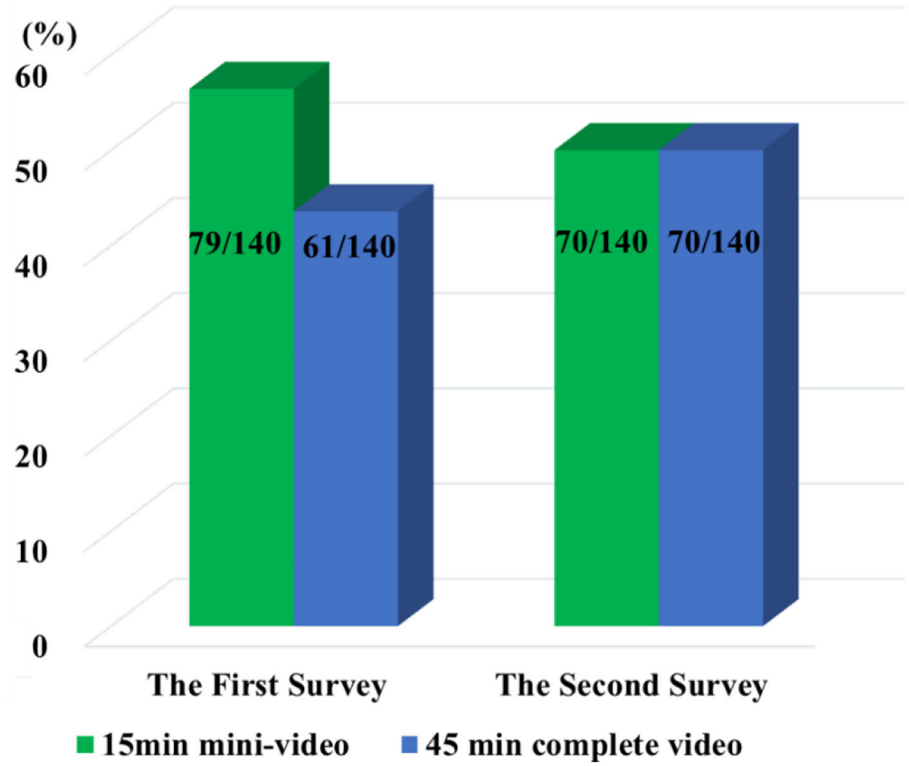

FIGURE 1 | Students' preference for the teaching videos with different durations in the two surveys ($n = 140$).

TABLE 1 | Percentage of students' reasons for choosing different videos.

Reasons for students chose different video	*n* (%)
15 min mini-video (*n* = 69)	
Prominently given to the clear key points	64 (92.75%)
Learning time saving	42 (60.87%)
More focused in watching	33 (47.83%)
Better video quality	22 (31.88%)
45 min complete video (*n* = 47)	
Higher coherence of the knowledge	46 (97.87%)
Better learning atmosphere	35 (74.47%)
Expansion to connected knowledge	32 (68.09%)
More focused in watching	21 (44.68%)

and 74.3% (104/140) students watched 15 min mini-video before class, while 35.0% (49/140) and 40.7% (57/140) students watched 45 min complete video. Although most students preferred to watch 15 min mini-video, quite a few students preferred to watch 45 min complete video. It is obvious that different students request different types of video for active learning before class.

To further investigate the factors influencing the time (before class, in class and after class) of students watching different duration videos, we used Multiple logistic regression analysis to analyze the association between video features of two different duration videos and the watched time point **(Table 2)**. The features including more focused in watching ($\chi^2 = 1.657$, $P = 0.437$), better video quality ($\chi^2 = 2.197$, $P = 0.333$) and time saving ($\chi^{2=}0.502$, $P = 0.778$) had no impact on the choices of students on selecting course stage to watch 15 min mini-video. Interestingly, the feature of the prominence given key points was the factor significantly affecting the choices of students on selecting course stage to watch 15 min mini-video ($\chi^2 = 8.861$, $P = 0.012$). As for students that didn't endorse 15 min mini-video have the prominence given to the key points, the possibility of them to watch for active learning before class were decreased by 97% [OR = 0.03, CI = 0.01–0.41, $P = 0.009$] compare to watch for review. As for students that didn't endorse watch 45 min complete video is more focus in, the possibility of them to watch for active learning before class were decreased by 85% [OR = 0.15, CI = 0.03–0.88, $P = 0.036$] compare to watch for review. However, the features of better learning atmosphere ($\chi^2 = 5.691$, $P = 0.058$), expansion about other connected knowledge ($\chi^2 = 1.917$, $P = 0.384$), high coherence of the knowledge ($\chi^2 = 4.367$, $P = 0.113$) had no statistical significance in attracting students when to watch 45 min complete video.

DISCUSSION

This study demonstrated that the preferences of students on instructional videos with different durations in OFC

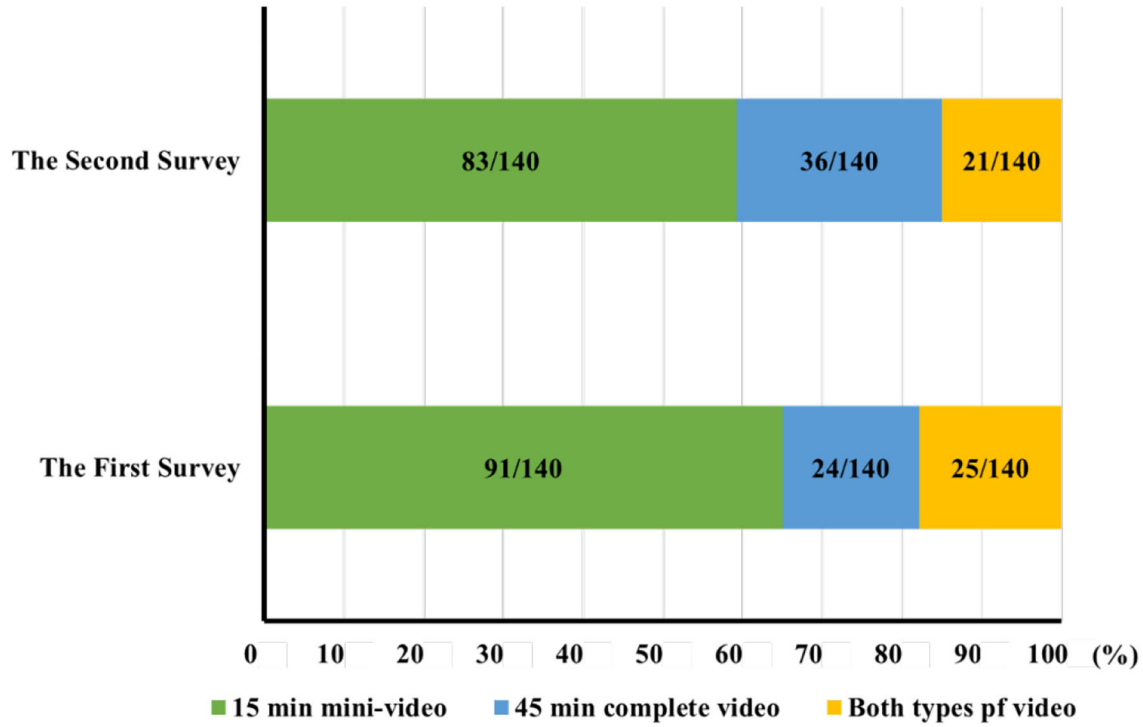

FIGURE 2 | Students' preference for video types in active learning before class (n = 140).

were largely affected by the individual variation. In both surveys, the number of students who preferred short 15 min mini-video and those who preferred 45 min complete video were about half each. In fact, 15 min mini-video and 45 min complete video were produced by the same teaching team and were of the same quality and highly comparable. Therefore, it may be argued that the above differences in preferences do not come from the quality of video production, but rather the different students in the OFC. This result differs from the results of previous studies on traditional flipped classrooms, in which most students preferred short videos (25–28).

This study further investigated the reasons why students preferred videos with different duration. The results clearly demonstrated that the top three reasons for preferring mini-video were the clear key points, short learning time, and easy focused during study. The top three reasons for choosing complete video were higher coherence of the knowledge, better learning atmosphere, and expansion to connected knowledges. In the Pre-course active learning phase, most students tended to use mini-video, which is consistent with the findings of previous studies (25, 26). However, about one-third of the students also used complete video during Pre-course active learning. This phenomenon is strongly related to the characteristics of both types of videos. 15 min mini-video shows a clear knowledge focus. The 45 min complete video, on the other hand, may better illustrate the connection between different knowledges, and avoid the shortcoming of knowledge fragmentation in mini-video; thus may help students to understand the teaching content with depth and detail. Due to the obvious differences in preference of students on teaching videos, it is suggested that in the construction of teaching videos, it is better to provide both mini-video and complete video to students. Furthermore, the teachers should dynamically observe preference of student groups on video types during the teaching process to implement specifically targeted teaching program.

According to the Self-Determination Theory (SDT), learners can be divided into two categories: academic learners are extrinsic motivated learners in school and social learners are intrinsic motivated learners (29). The above research shows the preference of academic learners. In order to understand the preference of video duration by social learners, we uploaded these two durations of videos for the society on Bilibili (a Chinese website for watching online videos) (mini-video website https://www.bilibili.com/video/BV1xW411q7jm?from=search, complete video website https://www.bilibili.com/video/BV1Et411D7qf?from=search). The users can play these videos freely, so the view count number of the video has the capacity to reveal the social preference for each type of videos. The average view counts of each video per month were collected for statistical analysis. Up to July 20th, 2020, when the spring semester came to an end, the count of 15 min mini-video was 73.89 and the count of 45 min complete video was 245.30, showing obvious difference. It is therefore suggested that the social learners prefer to watch 45 min complete video to satisfy

TABLE 2 | Factors influencing the time of students watching different duration videos.

Features	Watch Time	Attitudes about Video Features		χ^2	*P*	†OR (95% CI)	*P*
		Yes *n* (%)	No *n* (%)			No	
15 min mini-video							
More focused in watching	Before class	25 (46.30%)	29 (53.70%)	1.657	0.437	2.50 (0.40–15.62)	0.327
	In class	4 (57.14%)	3 (42.86%)			1.10 (0.11–10.93)	0.936
	After class	4 (50.00%)	4 (50.00%)			Reference category	
The prominence given to the key points	Before class	53 (98.15%)	1 (1.85%)	8.861	0.012*	0.03 (0.01–0.41)	0.009**
	In class	6 (85.71%)	1 (14.29%)			0.26 (0.02–4.35)	0.35
	After class	5 (62.50%)	3 (37.5%)			Reference category	
Better video quality	Before class	20 (37.04%)	34 (62.96%)	2.197	0.333	0.35 (0.04–3.49)	0.373
	In class	1 (14.29%)	6 (85.71%)			1.25 (0.57–27.29)	0.888
	After class	1 (12.50%)	7 (87.50%)			Reference category	
Time saving	Before class	32 (59.26%)	22 (40.74%)	0.502	0.778	1.32 (0.23–7.62)	0.757
	In class	5 (71.43%)	2 (28.57%)			0.72 (0.08–6.84)	0.780
	After class	5 (62.50%)	3 (37.50%)			Reference category	
45 min complete video							
More focused in watching	Before class	15 (48.39%)	16 (51.62%)	12.348	0.002*	0.15 (0.03–0.88)	0.036*
	In class	3 (100%)	0			1.86×10^{-9} (0.00-∞)	0.984
	After class	3 (23.08%)	10 (76.92%)			Reference category	
Better learning atmosphere	Before class	22 (70.97%)	9 (29.03%)	5.691	0.058	7.32 (0.852–62.89)	0.070
	In class	2 (66.67%)	1 (33.33%)			1.13×10^{-7} (0.00-∞)	0.987
	After class	11 (84.62%)	2 (15.38%)			Reference category	
Expansion to connected knowledge	Before class	22 (70.97%)	9 (29.03%)	1.917	0.384	0.34 (0.56–2.09)	0.373
	In class	2 (66.67%)	1 (33.33%)			1.45×10^{-6} (0.00-∞)	0.989
	After class	8 (61.54%)	5 (38.46%)			Reference category	
Higher coherence of the knowledge	Before class	31 (100%)	0	4.367	0.113	5.53×10^{-9} (0.00-∞)	0.997
	In class	3 (100%)	0			3.359×10^{-9} (3.359×10^{-9}-3.359×10^{-9})	<0.001**
	After class	12 (92.31%)	1 (7.69%)			Reference category	

*$P < 0.05$.
**$P < 0.01$.
† OR (odds ratio).

their learning requirement. Since academic learners and social learners have different learning motivations, the huge differences in the preference of video duration between the two types of learners may be related to the difference in motivation. It is suggested that the learning motivation may play a critical role in the preference for the duration of instructional video. The above results suggest that student groups with different learning motivations may have completely different preferences for instructional resources. Teaching staff should consider different motivation groups when building a library of teaching resources. It is suggested that the teaching resources should be enriched, and both short-term intensive lecture resources and complete teaching videos which was similar to traditional classrooms contents should be provided to meet the needs of people with different learning motivations.

CONCLUSIONS

This report demonstrates the differences in preferences of students on different lengths of learning videos in the online flipped classroom. Through analysis, the different features of the 15 min mini-video and the 45 min complete video may be a determining factor leading to the significant difference in preferences of students. Based on the significant difference presented by the student groups in this study, it is suggested that only providing 15 min mini-video or 45 min complete videos will not sufficiently meet the best educational demand. At the same time, the huge difference in the video preferences by different learning motivation groups suggests that the learning motivation may become an important factor determining preference of students on instructional videos.

This report reminds that the provision of online teaching resources and the design of teaching methods should base on different education stages and purposes. The needs of different student groups should be considered. In order to improve the quality of online teaching, a rich library of teaching video online resources of different durations and contents should be constructed.

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 authors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Central South University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

YX: questionnaire survey, data sorting, statistical analysis, and thesis writing. DF: questionnaire design and thesis writing. CC and ZL: research guidance, paper conception, and revision. All authors contributed to the article and approved the submitted version.

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A Study on the Relationship Between Adolescent Health Behavior, BMI, and Blood Physical and Chemical Properties

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In this study, the blood test index, demographic data, and health promotion behavior of adolescents were analyzed to provide a reference for early prevention and treatment of physical decline and abnormal biochemical indexes of adolescents. Using a cross-sectional study design, 1,436 valid samples were obtained by stratified random sampling, and the data were processed by SPSS21.0 statistical analysis software. The results showed that the overall health-promoting lifestyle of adolescents was good, and the interpersonal support behavior was the best, and the health responsibility and sports participation behavior were the worst; the interpersonal support and sports participation behavior of adolescents with normal weight were significantly better than those with overweight or light weight, while the overall health-promoting behavior of adolescents with high fasting blood glucose (FBG) before meals was poor, those with high glutamate pyruvate transaminase (GPT) had poor nutritional behavior and health responsibility behavior, while those with high uric acid (UA) had poor interpersonal support and stress coping behavior. The overweight rate and abnormal detection rate of UA and triglyceride (TG) in boys were significantly higher than those in girls, and the higher BMI of teenagers, the higher abnormal detection rate of GPT, UA, and TG, the better nutritional behavior, health responsibility behavior, and sports participation behavior, the lower abnormal detection rate of GPT, UA, and TG; the higher education level of parents, the better teenagers' sports participation and health responsibility behavior, the lower the incidence of overweight, the more time they spend playing online games and drinking sugary drinks on weekdays (or holidays), the higher the incidence of overweight.

Keywords: health behavior, body mass index, blood biochemical indexes, health promotion, adolescents, correlation analysis

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INTRODUCTION

In 1995, the Ministry of Education of China began to respond to the pilot work of the WHO on promoting health-promoting schools. It preferred 12 schools in Chifeng, Wuhan, and Beijing as practice units and began to carry out the comprehensive establishment of health promotion schools from different entry points, such as the prevention of tobacco use, vision decline, obesity

prevention, and nutrition (1, 2). After 2014, health promotion schools began to enter the national promotion stage based on the construction of health promotion counties and districts. In October 2016, the Fifth Plenary Session of the 18th CPC Central Committee put forward "Healthy China 2030 Planning Outline", which put forward "strengthening the integration of sports and medicine and non-medical health intervention and promoting the formation of disease management and health service mode of integration of sports and medicine". According to the spirit of "program", schools should bring health education into the national education system, let teenagers take physical exercise as a way of life, and focus on primary and secondary schools to establish a school health education promotion mechanism, so that the majority of teenagers can obtain the maximum health benefits (3–5).

As we all know, with the change of human disease etiology and health intervention mode from "disease treatment" to "disease prevention", the use of physical exercise for disease treatment and prevention has become a common means and method in the world. The core of the integration of sports and medicine in healthy China (National Health) and sports power (National Fitness) is to build a sports promotion health service system covering the whole population and the whole life cycle. Among them, the promotion of national fitness to health is mainly achieved by guiding people to form scientific fitness behavior and improving scientific fitness level, while the means and methods of national health are mainly achieved through medical intervention, health education, and behavior intervention, and creating a healthy environment. Health promotion behavior is an essential element of a healthy lifestyle. By actively establishing the concept of health promotion of all ages, we can comprehensively promote the positive health behavior of the people (6, 7). Compared with children and adults, adolescents are more suitable to guide healthy behaviors and carry out health promotion activities, to establish their healthy lifestyle (8). Because the root of many serious diseases in adulthood may come from the unhealthy life of teenagers, which may lead to chronic diseases, cancer, or premature death, and relatively increase the medical expenses (9, 10).

According to relevant research reports, in recent years, chronic diseases have gradually become younger, and some teenagers are even in the state of living with diseases (11). Chronic diseases are usually associated with obesity. Obesity in adolescence will increase the risk of obesity and chronic diseases in adulthood (12, 13). Overweight or obese adolescents are more likely to suffer from metabolic syndrome than normal-weight people, with abnormal blood glucose, fatty acid glyceride, cholesterol, and other biochemical abnormalities (14, 15). Therefore, from the perspective of three stages and five levels of epidemiological disease prevention, early and effective prevention of obesity can prevent or delay the occurrence of a variety of chronic diseases at the same time and maintain the physical and mental health of adolescents (16). At present, the lifestyle and obesity of adolescents in China have been considered as the most important factors affecting their health and illness. Therefore, it is the primary task to evaluate the early lifestyle of adolescents, such as diet, exercise, cleanliness, stress, sleep, and whether they have obesity and health problems caused by unhealthy health behaviors, and It is not only the primary task of implementing effective health promotion behavior but also the simplest way for teenagers to invest in health and health management (17). Based on this, to implement the provisions of the health promotion school plan, Chongqing Municipal Education Department has increased the supervision of youth health management and health examination and conducted a comprehensive physical examination every year when the primary and secondary school freshmen enter the school. Through random sampling of the experience data of junior high school freshmen in the winter of 2019, this study obtains the personal background and blood biochemical indicators of the relevant samples. Through analyzing the relationship between the health status, health promotion behavior, and physical indicators of teenagers, it is expected to find out the reasons that affect the health of teenagers, to take more effective measures to help teenagers to develop lifelong health behavior to provide a useful reference for the habit.

RESEARCH OBJECTS AND METHODS

Respondents

With the support and help of the school administration and the relevant departments of the Municipal Education Bureau, the research group finally obtained the health examination reports of junior middle schools (freshmen) in Chongqing. By adopting the stratified and class-based random sampling method, 30 classes (all students participated in the blood sampling) were selected by them, and 1,436 respondents were obtained. A questionnaire survey was conducted from September 2018 to October 2018.

Questionnaire Design

A structured questionnaire was designed, which consisted of four parts, which are as follows:

Demographic Data

Including personal and family life, such as age, gender, height, weight, family structure, history of the disease, education level of parents, diet, nature, and frequency of intake of sugary drinks, time of watching TV, surfing the Internet, and playing video games.

Adolescent Health Promotion Behavior Scale

It was first proposed by Pender and then modified by Walker in 1995. The Chinese version of the health-promoting lifestyle assessment scale was translated and widely used (18, 19). The original scale has 48 items and six dimensions. After the pre-test, through the division and internal consistency test, eight questions were eliminated. The number of items corresponding to the six dimensions is as follows: interpersonal support (7), stress response (6), nutritional behavior (6), life appreciation (8), sports participation (5), and health responsibility (8). Using the Likert five-grade scoring method, the higher the score, the higher the level of health promotion behavior. The results of the pre-test showed that the intrinsic consistency reliability of the total subscale was 0.81, and the α values of six dimensions were 0.85,

TABLE 1 | The influence of body mass index on health promotion behavior of adolescents.

Variable name	The average score of each question	Mean value of score index%	Underweight (A)	Normal weight (B)	Overweight and obesity (C)	Test (F)	LSD multiple comparisons
Interpersonal support	3.68 ± 0.91	73.51 ± 12.15	25.44 ± 4.89	26.15 ± 6.74	24.12 ± 5.12	**6.78****	b>a>c
Stress response	3.55 ± 0.84	72.74 ± 15.12	21.51 ± 4.06	21.95 ± 4.72	21.32 ± 4.74	1.54	a=b=c
Nutritional behavior	3.51 ± 0.81	70.89 ± 11.87	21.01 ± 3.91	21.46 ± 3.77	21.21 ± 4.85	0.81	a=b=c
Life appreciation	3.57 ± 0.89	70.17 ± 14.65	28.22 ± 8.15	28.77 ± 7.05	27.56 ± 7.21	1.58	a=b=c
Sports participation	3.25 ± 0.83	63.54 ± 14.69	15.54 ± 4.29	16.77 ± 4.15	14.84 ± 5.21	**5.09****	b>a>c
Health responsibility	3.09 ± 0.86	62.11 ± 13.17	24.31 ± 6.09	24.81 ± 5.58	24.45 ± 5.10	1.67	a=b=c
Total health promotion score	3.44 ± 0.89	68.82 ± 12.53	135.51 ± 24.47	138.97 ± 23.05	131.19 ± 25.47	**4.88****	a>b>c

calculation method of score index = (average score of all levels ÷ Full Score) × 100%; The "" and "**" indicates the significant level of 0.05 and 0.01 respectively; in multiple comparison of LSD, A = B =C means that there is no difference in certain health promotion behaviors among the three groups. On the contrary, if A > B >C, it means that a certain behavior of group A is better than group B, and group B is better than group C.*

0.83, 0.78, 0.80, 0.88, and 0.76, respectively. The corresponding Cronbach's α values from the official investigation and recovery data were also distributed between 0.77 and 0.86. It shows that the reliability of the test results is good.

Biochemical Index

The indicators were obtained from the physical examination reports of the students (blood sampling results and diagnosis report provided by the hospital after blood sampling examination). The blood biochemical indexes included fasting blood glucose (FBG, reference value 65–120 mg/dl), triglyceride (TG, reference value 35–165 mg/dl), total cholesterol (TC,reference value 120–200 mg/dl), creatinine (CRE, reference value 0.4–1.4 mg/dl), uric acid (UA, reference value 2.5–7.6 mg/dl), glutamate pyruvate transaminase (GPT,reference value 0–40 U/L).

Body Structure Measurement

Body mass index (BMI) was calculated. According to the definition of obesity in children and adolescents in China, the subjects were divided into four grades: light, normal, overweight, and obese.

Mathematical Statistics

SPSS 17.0 was used to establish and analyze the database, and the appropriate statistical methods were selected according to the research purpose. There were descriptive analysis, one-way ANOVA, Mann-Whitney U test, Kruskal-Wallis test, correlation analysis, and multiple logistic regression analysis. The significant level of all indexes was set as $\alpha = 0.05$.

RESULTS

Analysis of the Influence of BMI on Health Promotion Behavior of Adolescents

Table 1 shows:

(1) The average score of each item of the six dimensions of health promotion behavior is between 3.09 and 3.68. As for the overall health promotion behavior, the average score of each item is 3.44, which is higher than the median value of each item of 3, which belongs to the upper-middle level, indicating that the subjects' health promotion lifestyle belongs to the good condition.

(2) From the average score index of each dimension, the "interpersonal support" score was high(73.51%), the "health responsibility" score was the lowest (62.11%), followed by sports participation(63.54%).

(3) From the relationship between health promotion behavior and BMI, the total average score of six dimensions of health promotion behavior in the normal-weight group (138.97 ± 23.05) was significantly higher than that in the underweight group (135.51 ± 24.47), and that in the underweight group was significantly higher than that in the overweight group (131.19 ± 25.47). Furthermore, from the perspective of six dimensions, the performance differences of health promotion behavior only exist in social interpersonal support and sports participation behavior, and both show that the normal weight is better than the underweight, and the underweight is better than the overweight.

Analysis of the Relationship Between Blood Biochemical Indexes and Health Promotion Behavior in Adolescents

Table 2 shows:

(1) According to the classification of TG and TC, social interpersonal support, stress coping, nutritional behavior, life appreciation, sports participation, health responsibility, and overall health promotion behavior did not affect TG and TC.

(2) Fasting blood glucose before meals seems to be the most affected by adolescent health promotion behavior. The higher FBG, the lower social interpersonal support ($X^2 = 2.15$, $p < 0.05$), the lower stress coping ability ($X^2 = 3.27$, $p < 0.05$), the worse nutritional behavior ($X^2 = 2.94$, $p < 0.05$), the worse life appreciation ability ($X^2 = 2.56$, $p < 0.05$), and the worse sports participation behavior ($X^2 = 3.19$, $p < 0.05$), The worse the health responsibility behavior ($X^2 = 2.65$, $p < 0.05$), the worse the overall health promotion behavior ($X^2 = 3.57$, $p < 0.05$).

TABLE 2 | Analysis of the relationship between the five major blood biochemical indexes and health promotion behavior in adolescents.

		Interpersonal support		Stress response		Nutritional behavior		Life appreciation		Sports participation		Health responsibility		Total score of promotion	
		Mean value	X^2/z	Mean value	X^2/z	Mean value	X^2/z	Mean value	X^2/z	Mean value	X^2/z	Mean value	X^2/z	Mean value	X^2/z
#GPT	Normal	21.29	−0.12	25.65	−1.12	24.87	**−2.16***	27.89	−1.36	15.89	−0.76	22.39	**−2.43***	137.03	−1.83
	Overtop	21.45		24.39		22.33		26.86		15.01		19.91		128.44	
&FBG	Too low	21.31	**2.15***	24.89	**3.27***	24.32	**2.94***	27.78	**2.56***	15.74	**3.19***	21.32	**2.56***	134.15	**3.57***
	Normal	21.65		25.47		24.67		28.36		16.54		21.77		135.95	
	Overtop	16.47		13.66		12.51		20.25		8.85		14.63		91.77	
&UA	Too low	18.16	**5.77****	28.19	**1.98***	21.12	1.73	31.69	0.69	15.09	1.59	18.61	1.35	129.06	0.36
	Normal	22.65		25.77		23.17		29.77		15.61		21.32		135.85	
	Overtop	23.17		23.15		24.49		28.85		14.92		22.11		136.05	
&TG	Too low	21.58	0.38	25.00	0.51	25.56	0.57	28.29	0.15	17.62	1.56	21.74	0.90	138.25	0.59
	Normal	21.21		25.26		24.39		28.31		16.21		21.43		137.65	
	Overtop	22.06		26.23		24.56		28.99		15.87		22.24		149.77	
&TC	Too low	21.19	0.71	24.87	0.78	24.46	0.39	27.09	1.52	15.79	0.05	20.91	0.89	133.95	1.33
	Normal	21.55		25.39		24.33		28.88		15.73		21.60		126.56	
	Overtop	20.60		24.61		24.81		27.91		15.59		22.01		134.74	

*For blood indexes GPT, FBG, UA, TG, TC, "#" means using two independent samples of non-parametric test, Mann-Whitney test, Z statistics; "&" multiple independent samples of non-parametric test, Kruskal-Wallis test, chi square value; *$p < 0.05$, **$p < 0.01$, **$p < 0.001$.*

(3) Glutamate pyruvate transaminase was only affected by the two dimensions of nutritional behavior and health responsibility behavior. The higher the GPT, the worse the nutritional behavior ($z = -2.16$, $p < 0.05$) and health responsibility behavior ($z = -2.43$, $p < 0.05$).

(4) Uric acid was only affected by social interpersonal support and stress-coping behavior. The higher UA, the better social interpersonal support behavior ($z = 5.77$, $p < 0.01$), and the worse stress-coping behavior ($z = 1.98$, $p < 0.05$).

Analysis of the Relationship Between Daily Living Habits, Leisure Time Arrangement, and Health Promotion Behavior of Adolescents

Table 3 shows:

(1) In terms of living habits, the time spent in watching TV or playing online games was negatively correlated with the six dimensions of health promotion behavior and the total score of health promotion behavior in most cases. It was also significantly correlated with BMI (positive or negative), which seems that the longer the time of watching TV and playing games, the lower the scores of nutritional behavior (r distribution range $-0.17^{**} \sim -0.25^{**}$), social interpersonal support (r distribution range $-0.11^{**} \sim -0.17^{**}$), health responsibility behavior (r distribution range $-0.15^{**} \sim -0.24^{**}$), and life appreciation behavior (r distribution range $-0.15^{**} \sim -0.24^{**}$) and the lower the scores of exercise behavior (r distribution range $-0.13^{**} \sim -0.21^{**}$), stress coping behavior (r distribution range $-0.10^{**} \sim -0.15^{**}$), and overall health promotion behavior (r distribution range $-0.13^{**} \sim -0.24^{**}$) were.

(2) The more times adolescents eat breakfast or dinner with their family each week, the more positively correlated with the 6-dimension score of health promotion behavior and the overall score of health promotion behavior (r distribution interval: 0.09^{*} to 0.29^{**}), but also negatively correlated with BMI (r distribution interval: -0.11^{*} to -0.15^{**}).

(3) The more times and quantity of sugary drinks the adolescents drink per week, the more negative correlation with the 6-dimension score of health promotion behavior and the overall score of health promotion behavior(r distribution interval: -0.10^{*} to -0.28^{**}), but which has a significant positive correlation with BMI ($r = 0.15^{**}$).

Predictive Analysis of Background Factors, Living Habits, and Health-Promoting Behaviors on BMI and Biochemical Factors in Adolescents

Many factors are influencing the BMI and blood biochemical indexes of adolescents, such as genetic factors, family factors, personal habits, extracurricular leisure time allocation, and health promotion behavior. If we want to find out the key factors from these factors, logistic multiple regression analysis is the best way. Because the application premise of the logistic method is that the dependent variable type is classified variable, and

TABLE 3 | Statistical table of correlation matrix between daily living habits, leisure time arrangement, and health promotion behavior of adolescents.

	Interpersonal support	Stress response	Nutritional behavior	Life appreciation	Sports behavior	Health responsibility	Overall promotion	BMI
Daily TV time (h)	−0.17**	−0.15**	−0.25**	−0.13**	−0.21**	−0.20***	−0.24***	0.06
Holiday TV time (h)	−0.11**	−0.06	−0.17**	−0.06	−0.16**	−0.16***	−0.13***	0.08*
weekdays online games time (h)	−0.14**	−0.12**	−0.21**	−0.10*	−0.13**	−0.15***	−0.18***	0.08*
Holiday online game time (h)	−0.16**	−0.10*	−0.23**	−0.11**	−0.15**	−0.24***	−0.17***	0.14***
Breakfast with family every week (Times)	0.13**	0.12**	0.29**	0.10*	0.13**	0.22***	0.19***	−0.15**
Weekly dinner with family (Times)	0.11**	0.10**	0.21**	0.14**	0.09*	0.15**	0.15***	−0.11**
Drink sugary drinks every day (Times)	−0.16**	−0.14**	−0.28**	−0.15**	−0.13**	−0.22***	−0.21***	−0.04
Drink sugary drinks every time(cups)	−0.12*	−0.05	−0.10**	−0.02	−0.04	−0.16**	−0.13*	0.15**

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 4 | Statistical table of multiple regression model of adolescent background factors, living habits, and health promotion behavior on BMI and biochemical factors.

	Regression model 1 (BMI) Overweight/non overweight		Regression model 2 (GPT) Abnormal/normal		Regression model 3 (UA) Abnormal/normal		Regression model 4 (TG) Abnormal/normal	
	β	OR	β	OR	β	OR	β	OR
Constant	−1.47		−7.50		−0.86		−2.48	
Gender	0.710	**2.034****	0.007	1.007	1.457	**4.293****	0.654	**1.923****
Parents' education level	0.620	**1.859****	0.013	1.013	0.012	1.012	−0.701	**0.496****
Family structure	0.040	1.041	0.011	1.011	0.008	1.008	−0.018	0.982
Body mass index (BMI)			0.209	**1.232****	0.194	**1.214****	0.181	**1.198****
Interpersonal support	−0.040	0.961	−0.003	0.997	0.034	1.035	−0.022	0.978
Stress response	−0.050	0.951	−0.007	0.993	−0.065	0.937	−0.036	0.965
Nutritional behavior	−0.073	0.930	−0.127	**0.881****	−0.113	**0.893****	−0.205	**0.815****
Life appreciation	−0.034	0.967	−0.013	0.987	−0.004	0.996	−0.047	0.954
Sports behavior	−0.461	**0.631****	−0.121	**0.886****	−0.105	**0.900****	−0.178	**0.837****
Health responsibility	−0.113	**0.893****	−0.144	**0.866****	−0.126	**0.882****	−0.052	0.949
Daily TV time (h)	0.030	1.030	0.003	1.003	0.081	1.084	0.061	1.063
Holiday TV time (h)	0.040	1.041	0.010	1.010	0.039	1.040	0.033	1.034
Weekdays online game time (h)	0.201	**1.223****	0.007	1.007	0.057	1.059	0.119	**1.126****
Holiday online game time (h)	0.187	**1.206****	0.001	1.001	0.041	1.042	0.026	1.026
Breakfast with family every week (Times)	0.014	1.014	−0.002	0.998	0.002	1.002	0.001	1.001
Weekly dinner with family (Times)	0.022	1.022	−0.003	0.997	0.006	1.006	−0.008	0.992
Drink sugary drinks every day (Times)	0.234	**1.264****	−0.043	0.958	0.030	1.030	0.215	**1.240****
Drink sugary drinks every time (cups)	0.007	1.007	−0.032	0.969	0.071	1.074	0.154	**1.166****

*$p < 0.05$, **$p < 0.01$.

the influencing variable (independent variable) can be either continuous variable or classified variable, and the requirements of influencing factors do not have to meet the independent, normal, and other conditional assumptions.

According to the distribution characteristics of biochemical indexes, the biochemical indexes of subjects can be classified as "abnormal" or "normal", and BMI can be classified as "overweight" or "non-overweight", so all the predictive variables become typical binary variables. Due to the number of subjects with abnormal FBG and TC being less than normal, they were not included in the regression analysis. It is assumed that the dependent variable y follows a binomial distribution, and the value of the binomial distribution is (1,0), $y = 1$ (that is abnormal). In this study, 18 independent variables, such as gender, parents' education level, and family structure, are selected, and the forced introduction method is used for two classifications logistic regression, and four regression equations are obtained. The results are shown in **Table 4**, from which it is not difficult to find:

(1) In the BMI regression model, only seven of the 17 variables in the regression equation reached a significant level. From the odds ratio (OR), it is not difficult to find that the risk of being overweight for boys is 2.034** times higher than that for girls; the risk of being overweight for their children will increase to 1.859** times of the original level when their parents' education level is reduced by one level; the risk

of overweight will decrease to 0.631** times and 0.893** times of the original level, respectively, when their scores of sports participation behavior and health responsibility behavior increase by one point. If the time of playing online games on weekdays and holidays increased by 1 h and the time of drinking sugary drinks increased by one time, the probability of overweight was increased to 1.233**, 1.206**, and 1.264** times of the original level, respectively.

(2) Among the three predictive models of biochemical indexes, only four of the 18 variables in the GPT model reached a significant level. Among them, the risk of abnormal GPT will increase 1.232** times following BMI of teenagers increases one unit; the risk of abnormal GPT will decrease 0.881**, 0.886**, 0.866** times respectively with the increase of one unit of nutrition behavior, sports participation behavior, and health responsibility behavior.

(3) Five of the 18 variables in the UA regression model reached the significant level, in which gender had the most significant effect, which showed that the risk of abnormal UA in boys was 4.293** times higher than that in women when BMI was increased by one unit, the risk of abnormal UA was increased by 1.214** times. while the scores of nutritional behavior, exercise behavior, and health responsibility behavior were increased by one point, the probability of abnormal UA in adolescents was decreased to 0.893**, 0.900**, and 0.882** times of the original level, respectively.

(4) Eight of the 18 variables in the total TG regression model reached a significant level, which showed that the risk of abnormal TG in men was 1.923** times higher than that in women. If the BMI of adolescents increases by one unit, the time of playing online games increases by 1 h, the number of sugary drinks increases by one time every day and the number of sugary drinks increases by one cup every time, the risk of abnormal TG will be increased to 1.198**, 1.126**, 1.240**, and 1.166** times of the original level respectively. While the score of nutrition behavior and sports behavior was increased by one point, the probability of abnormal TG was decreased to 0.815** and 0.837** times of the original level, respectively.

DISCUSSION

On the Factors Influencing BMI of Teenagers

This study shows that the obesity rate of male students is higher than that of female students, and the risk of being overweight is 1.93 times higher than that of female students. This result is similar to the research of many scholars at home and abroad (20–23), which means that in the current school health promotion plan in China, personalized promotion strategies should be developed for high-risk cases or gender differences. This study also found that when the parents' education level is reduced by one level, the risk of overweight of their children will be increased to 1.859 times of the original. According to the research of Gali et al. (24), it is also found that the overweight rate of children of parents with an education level below junior college is significantly higher than that of parents with a bachelor's degree or above. In addition, KuoLiong et al. (25) reported that the higher the education level, the better the score of nutrition knowledge. There are also inconsistent reports on the effect of parental education on overweight adolescents. Martin et al. found that (26) those whose mothers' education level is above junior college have a higher probability of abnormal TG of their children than those with low education level. The scholar explains that mothers with higher education pay more attention to their children's nutritional supplements and are more likely to eat delicate, high calorie, and high-fat meals, thus, increasing the incidence of abnormal biochemical indicators. It seems that more research is needed to confirm whether parents' education level has a positive or negative impact on their children's overweight or TG.

A large number of previous studies support the existence of a correlation between physical activity and obesity. Physical activity can indeed reduce body fat, maintain or avoid the loss of lean weight, and improve cardiopulmonary endurance (27, 28); and enhancing health responsibility behavior can increase the ability of individual weight control (29) and can effectively control the incidence of obesity in adolescence (30). This study found that every one-point increase in the scores of sports participation behavior and health responsibility behavior would reduce the probability of overweight to 0.631 times and 0.893 times of the original level, which further confirmed the findings of the above scholars. Regression model 1 also showed that whether it was weekdays or holidays, the risk of overweight was increased to 1.233, 1.206, and 1.264 times of the original level when the time of playing online games and drinking sugary drinks increased by 1 h every day. Similar research reports, such as trainer SS (31), found that the risk of overweight among adolescents who play games every day is 1.35 times that of adolescents who do not play games; Chen et al. (32) also found that overweight adolescents spend more time in watching TV and playing online games than non-overweight adolescents, and overweight adolescents perform less health promotion behaviors than non-overweight adolescents. In a word, teenagers' excessive static life and poor performance of health promotion behaviors are all related to their weight; while teenagers' overweight, the lower the implementation rate of health promotion behaviors, the more serious the static lifestyle, the more time they watch TV, play online games, and drink sugary drinks.

On the Factors Influencing the Blood Biochemical Abnormality of Teenagers

This study found that the common factors affecting the abnormal GPT, UA, and TG of adolescents are BMI, nutritional behavior, and exercise behavior. If BMI increases by one unit value, the probability of abnormal GPT, UA, and TG will increase by 1.232, 1.214, and 1.198 times the original level, respectively. When nutritional behavior and exercise participation behavior increase by one point, the probability of abnormal GPT, UA,

and TG will decrease to 0.881 and 0.893, 815 times and 0.886, 0.900, 0.837 times of the original level, respectively. According to previous literature reports, da Fonseca et al. (33) pointed out that about 25% of obese children have steatohepatitis, accompanied by abnormal liver function, liver fibrosis, and liver cirrhosis, and these children tend to live a static life with poor nutritional behavior. Kumar and Kelly (34) found that the values of cholesterol, TG, UA, insulin, and leptin in the blood of the obese group were significantly higher than those of the normal-weight group. Pantalone et al. (35) also found that obese children had poor sports participation behavior, and the blood low-density lipoprotein (LDL) cholesterol, UA, and GPT were higher than those of normal-weight children. Therefore, the findings of this study are similar to the previous research results.

In addition, the study also found that there was a significant gender difference in the incidence of abnormal UA and TG, and the risk of abnormal UA and TG in boys was 4.293 and 1.923 times higher than that in women, respectively. In particular, health responsibility behavior has a significant positive effect on GPT and UA. When the score increases by one point, the risk of abnormal GPT and UA will be reduced to 0.866 and 0.882 times, respectively; and the risk of abnormal TG is also affected by teenagers playing online games, drinking sugary drinks every day, and the number of sugary drinks every time

Among them, health responsibility behavior has a significant positive effect on GPT and UA. When the score increases by one point, the probability of abnormal risk of GPT and UA will be reduced to 0.866 and 0.882 times of the original level, respectively; and the risk of abnormal TG is also affected by teenagers playing online games, drinking sugary drinks every day, and the number of sugary drinks every time. However, studies on these aspects lack the support of more previous studies. From a small number of similar reports, if teenagers can improve their physical activity in sports, it can not only promote their health and physical fitness but also prevent osteoporosis, reduce blood pressure, improve blood composition, prevent and treat chronic diseases, promote psychological and social adaptation and many other benefits (22, 25, 36, 37). Because the biochemical indicators in this study are from the hospital physical examination data and limited by the sample size, the research results may underestimate or overestimate the OR of abnormal biochemical indicators in adolescents. In addition, there are not many kinds of literature at home and abroad that use this research perspective to explore, and the comparison of related results is not sufficient, and some aspects need more research to further explore.

CONCLUSION

(1) The heavier the weight of teenagers, the higher the proportion of biochemical abnormalities in their blood. The better the healthy behavior of teenagers, the better the biochemical indexes, and the lower the proportion of overweight.
(2) The static lifestyle and health-promoting behavior of adolescents are closely related to their weight, which showed that the heavier the weight, the worse the performance of health promotion behavior; the more prominent the static lifestyle, the more serious the performance of watching TV, playing online games, drinking sugary drinks.

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

This study was reviewed and approved by the Ethics Review Committee of Southwest University. However, this study does not involve human and animal experiments, and written informed consent is not required.

AUTHOR CONTRIBUTIONS

JP is mainly responsible for the design of the paper and the preparation of the questionnaire and participates in the writing of the paper. LY, KW, TZ, HL, and JY are mainly engaged in the distribution of the questionnaire and data processing and analysis. JL provided decision-making and financial support for this study. All authors contributed to the article and approved the submitted version.

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Application and Evaluation of the Flipped Classroom Based on Micro-Video Class in Pharmacology Teaching

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With the continuous development of information technology, new teaching resources "micro-video class" and teaching model "flipped classroom" have gradually attracted the attention of teachers. Whether and how they can be applied in pharmacology teaching has already become the focus of medical education research in recent years. This paper explores the application and evaluation of the flipped classroom based on micro-video class in pharmacology teaching in our college. Students in Class 1 and Class 2 majoring in clinical medicine of 2018 in Chengdu Medical College were randomly divided into experimental group and control group. The teaching model of flipped classroom based on micro-video class was used in the experimental group, while the traditional teaching model was used in the control group. Theory tests and questionnaires were carried out at the end of the course. The average scores of theoretical knowledge in experimental group were significantly higher than those in control group ($P < 0.05$). In addition, the results of the feedback questionnaire showed that the overall satisfaction of students participating in flipped classroom based on micro-video class was higher ($P < 0.05$), and students thought that their learning enthusiasm, learning efficiency, and abilities of autonomous learning and problem-solving were greatly improved compared with those of students taught applying the traditional teaching model. Flipped classroom based on micro-video class model successfully improved the outcome of pharmacology teaching. It is supposed to provide reference for the reform of pharmacology teaching in medical college.

Keywords: flipped classroom, pharmacology, medical education, feedback questionnaire, micro-video class

INTRODUCTION

With the rapid development of science and technology, society puts higher and higher demand for college students' abilities in all aspects. Educators pay more attention to the teaching effect and quality of colleges and universities. At present, the main problem of college teaching is that the traditional passive teaching mode is not conducive to cultivate the innovative thinking and autonomous learning ability of students. Therefore, flipped classroom is more and more applied to traditional teaching and widely recognized by students. This teaching method is constructively based on the student-centered teaching concept, and gives full play to students' subjective initiative. The basic premise of flipped classroom is require students to self-study lesson content before class, so that classroom time can be devoted to teaching and learning activities (1, 2).

However, it is difficult for students to achieve the teaching requirements only by self-study with textbooks. To overcome these issues, educational researchers have come up with an innovative teaching model that combines micro-video class with flipped classroom (3).

Micro-video class is to explain a certain knowledge point (key points, difficulties or doubts) with online short video. As the basic courseware resources of screen class, micro-video class has been welcomed by most college students because of its short and concise characteristics. And the new teaching model of flipped classroom based on micro-video class has been widely used in many medicine and pharmacy subjects (4–6). Pharmacology is a main compulsory course in clinical medicine and pharmacy majors. However, many students think that Pharmacology is boring and difficult to study (7). In order to improve the teaching effect of pharmacology, a flippedclassroom based on micro-video class teaching model for pharmacology course has been designed and implemented in clinical medicine major in our school. And the teaching effect of micro-video class combined flipped classroom was evaluated by the theoretical examination and questionnaire survey, and compared with traditional teaching model.

TABLE 1 | Teaching contents and micro class videos.

Chapter	Teaching content	Micro class video	Length of the video
1	Diuretics	High efficacy diuretics	10 min
		Moderate efficacy diuretics	9 min
		Low efficacy diuretics	5 min
2	Antihypertensive drug	Hypertension overview and drug classification	11 min
		First-line antihypertensive drugs	10 min
3	Antianginal drug	Pathophysiology of angina pectoris	4 min
		Nitroglycerin	8 min
		Other antianginal drug	6 min
4	Antiarrhythmic drug	Overview of antiarrhythmic drugs	12 min
		Commonly used antiarrhythmic drugs	11 min
5	Drugs for heart failure	Pathophysiology of heart failure	9 minutes
		Cardiac glycosides	10 min
		Other drugs for heart failure	10 min

STUDY PARTICIPANTS AND METHOD

Study Participants

The study is conducted by the School of pharmacy at Chengdu Medical College. The subjects are two parallel classes of senior undergraduates majoring in Clinical Medicine (class of 2018). 73 students from Class 1 are divided into experimental group (flipped classroom based on micro-video class), and 85 students from Class 2 are divided into control group (Traditional classroom). The students from the two classes are evenly assigned to parallel classes based on their college entrance examination scores, and take the same courses throughout college. All of the procedures in this study are approved by the Ethics Committee of Chengdu Medical College, and informed consent is obtained from the students.

Teaching Methodology

Both the control group and the experimental group are taught by the same teacher, and the teaching contents and periods of the two groups are the same.

Design of the Flipped Classroom Based on Micro-Video Class Teaching Model

The experimental group adopt the teaching method of micro-video class combined with flipped classroom.ive is formulated for each session. 3 class h (120 min) are allocated to each flipped classroom to complete a teaching content. A total of 13 knowledge points are made into micro class videos (**Table 1**).

Before class:

The pharmacology courses reform was built on the Chaoxing Campus Online Teaching Platform. The teacher uploads micro class videos and teaching objectives to the online platform three days in advance, and requires students to learn before class. The online platform allows students to watch micro-videos and communicate with teachers at any time. At the same time, students' online self-learning is continuously supervised by the platform. And teachers can check it at any time and guide students to learn.

In class:

First of all, knowledge review: The teacher systematically summarizes the key and difficult knowledge points of students' autonomous learning before class.

Secondly, classroom interaction: This session is mainly carried out in the form of flipped classroom. Based on the learning contents of the pre-class video, the teacher sets up some questions and case analyses. Students work in groups to discuss and analyze the questions and cases raised by teacher, and use the theoretical knowledge they have mastered to answer and solve the problems. At the same time, the teacher fully mobilizes students to think about questions and cases, and guide students to find problems and solve them flexibly and correctly.

Finally, In-class quiz:In order to evaluate students' mastering degree of the learning content, the teacher sets a in-class test and requires students to complete it independently.

Design of the Traditional Classroom Teaching Model

The control group adopt the traditional teacher-centered model of teachers' lecturing basically and students' learning passively. Students are also required to preview the teaching contents before class by textbook. And the same cases are analyzed in the control class, but not in the form of flipped classroom.

TABLE 2 | The average score of theory examination.

Groups	The number of students	Test score	Pass rate (%)
Experimental group	73	88.62 ± 2.65*	89.59 ± 2.08
Control group	85	81.29 ± 2.79	86.35 ± 2.44

*$p < 0.05$ vs. Control group.

Effect Evaluation

The Theory Test

At the end of each teaching content, about 10 choice questions are selected for in-class quiz. Answering correctly sixty percent of the test questions will be considered as passed. Finally, we compared the average test scores between two groups of students under different teaching methods.

The Questionnaire Survey

At the end of the course, a on-site questionnaire is distributed to students in the form of online electronic questionnaire. The students fill in the questionnaire independently in an anonymous way. The questionnaire is designed based on validated questionnaires of previous studies (8, 9). And the responses are scored using a 5-point Likert scale (rang from one strongly disagree to five strongly agree) to evaluate teaching and learning methods. The reliability of the scale is checked by Cronbach's alpha coefficient.

Statistical Analysis

The Wilcoxon signed-rank test is used to compare the questionnaire survey responses between the two groups. The distribution of the questionnaire score is skewed. The test score is presented as means ± standard deviation (SD) and analyzed by independent sample T-test. $P < 0.05$ is considered statistically significant. All statistics and data analyses are performed using SPSS 21.0 software (SPSS Inc., USA).

RESULTS

Theory Test

As shown in **Table 2**, the average test score of experimental group (88.62 ± 2.65) was significantly higher than those of the control group (81.29 ± 2.79) ($P < 0.05$). Meanwhile, the test pass rate in the experimental group also increased, but no statistical difference was observed between the two groups ($P > 0.05$).

Students' Questionnaire Results

158 copies of questionnaires were sent out, and 151 copies were received with a recovery rate of 95.57%. The questionnaire results were shown in **Table 3**. 84.06% of students in the experimental group were satisfied with the teaching and learning activities. And 79.71% of students in the experimental group agreed that flipped classroom based on micro-video class teaching method stimulated their learning interest in pharmacology. In addition, 89.86% of students in the experimental group thought that they could understand the teaching contents better, and more than 70% of students agreed that their autonomous learning, analyzing and problem-solving abilities were developed via flipped classroom based on micro-video class teaching model.

Furthermore, the Wilcoxon test showed that higher scores on all the five questions were obtained in the experimental group than that of the control group ($P < 0.01$) (**Table 4**). Compared with traditional teaching class, the satisfaction degree of students participating in flipped classroom based on micro-video class is significantly improved ($P < 0.01$). Its benefits include stimulating learning interest ($P < 0.001$), improving learning efficiency ($P < 0.01$), enhancing abilities of autonomous learning ($P < 0.001$), analyzing and solving problems ($P < 0.01$).

The above results revealed that the flipped classroom based on micro-video class teaching model was superior to the traditional teaching model in improving students' initiative and cultivating students' ability, and brought better teaching effect.

DISCUSSION

Pharmacology is a professional basic course for medical students, and also a discipline bridging basic medicine and clinical medicine. The course with boring and strong theoretical contents covers a wide range of disciplines (10). The traditional passive learning mode further reduces students' enthusiasm and initiative. As a result, students only want to cope with the exam, but can't actually understand and master the learning content, which is a major challenge to the teachers.

How to broaden teaching ideas and improve teaching methods to enhance the teaching effect is difficulty for every pharmacological educator. This study aims to explore how to apply micro-video class combined with flipped classroom model in pharmacology teaching to make the abstract and boring content vivid. So that students can activate thinking, give play to their subjective initiative, and improve learning effect. And the application effect of this teaching model is evaluated through theory test and questionnaire survey, and compared with the traditional teaching model. We select the chapters of drugs acting on the cardiovascular system as a pilot reform. These chapters are usually considered difficult for students to master and these drugs are commonly used in clinic. The results of theory tests indicated that the learning effect of students with flipped classroom based on micro-video class was significantly better than that of students with traditional teaching ($P < 0.05$). By self-learning the micro-video class through the online platform and efficiently participating in flipping classroom, students deeply understood and mastered the theory knowledge. Furthermore, the results of the teaching feedback questionnaire exerted that most of the students in experimental group satisfied with the micro-video class combined with flipped classroom teaching model, provided more positive evaluations and gave higher scores to the course ($P < 0.05$). Compared with traditional teaching classroom, the students who participated in flipped classroom based on micro-video class showed higher enthusiasm for learning in pharmacology, understood teaching contents more easily and remembered better. They believed that the novel teaching and learning model greatly stimulated their learning enthusiasm, developed their abilities in autonomous learning, analyzing and

TABLE 3 | Responses to questionnaire from students regarding the teaching and learning effects.

Statement number	Statement	Experimental group ($n = 69$)			Control group ($n = 82$)		
		SA/A (%)	U (%)	D/SD (%)	SA/A (%)	U (%)	D/SD (%)
Q1	You satisfied with the current teaching and learning model.	84.06	10.14	5.80	67.07	19.51	13.41
Q2	The current teaching and learning methods stimulate your learning interest in pharmacology.	79.71	13.04	7.25	47.56	30.49	21.85
Q3	The current teaching and learning methods improve the learning efficiency and enable you to understand rather than simply memorize the teaching content.	89.86	7.25	2.90	70.73	24.39	4.88
Q4	The current teaching and learning methods enhance your autonomous learning ability.	85.51	8.70	5.80	56.10	26.83	17.07
Q5	The current teaching and learning methods develop your ability to analyze and solve problems.	76.81	14.49	8.70	51.22	20.73	28.05

Values are percentage of students.
SA, Strongly agree; A, Agree; U, uncertainty; D, Disagree; SD, Strongly disagree.

TABLE 4 | Comparison of course evaluation scores between flipped classroom based on micro-video class and traditional model.

Statement number		Experimental group	Control group	z-value	p*-value
Q1	n (missing)	73 (4)	85(3)	−2.639	0.008
	Mean ± SD	4.12 ± *0*.81	3.73 ± *0*.93		
	M (IQR)	4.00 (4.00, 5.00)	4.00 (3.00, 4.00)		
Q2	n (missing)	73 (4)	85 (3)	−4.052	0.000
	Mean ± SD	4.07 ± *0*.88	3.41 ± 1.01		
	M (IQR)	4.00 (4.00, 5.00)	3.00 (3.00, 4.00)		
Q3	n (missing)	73 (4)	85 (3)	−3.198	0.001
	Mean ± SD	4.41 ± *0*.75	3.98 ± *0*.87		
	M (IQR)	5.00 (4.00, 5.00)	4.00 (3.00, 5.00)		
Q4	n (missing)	73 (4)	85 (3)	−4.190	0.000
	Mean ± SD	4.26 ± *0*.85	3.57 ± 1.05		
	M (IQR)	4.00 (4.00, 5.00)	4.00 (3.00, 4.00)		
Q5	n (missing)	73 (4)	85 (3)	−3.296	0.001
	Mean ± SD	3.99 ± 0.99	3.33 ± 1.26		
	M (IQR)	4.00 (4.00, 5.00)	4.00 (2.00, 4.00)		

**Based on Wilcoxon signed-rank test, $P < 0.05$ was considered significant.*

solving problems. It suggests that flipped classroom based on micro-video class teaching model is more recognized by students than traditional teaching model.

In previous studies, the teaching model of micro-video class combined with flipped classroom has been proved to achieve good teaching effects in several college courses, such as college English (11), Emergency Medicine (4), neurosciences (5), animal health (6). These studies indicate that flipped classroom effectively mobilizes students' learning ability and greatly improves the interaction between teaching and learning. Meanwhile, combined with the short online teaching videos before class, the shortage of class hours is effectively relieved, allowing class time to be more productively used for higher-level activities. Rather than providing answers directly, the teachers become a guider and a resource provider to help students arrive conclusions. This teaching model is more student-centered and gets more positive feedback from the students.

Our research shows that this teaching model is also effective in pharmacology teaching for clinical medical students. In pharmacology course, besides mastering basic concepts, acquiring pharmacotherapeutic skills and competencies also comprises the primary goal for clinical medical students. Flipped classroom based on micro-video class can help students achieve this goal. Since students have learned the basic theoretical knowledge of drugs through micro videos before class, the flipped class gives teachers more time for analyzing clinical cases, explaining how to use drugs safely and effectively, to help students establish clinical thinking. Students also make full use of classroom time for applied activities and learning, thus better gain competencies. At the end of the course reform, most students said that their understanding of drug interaction and clinical rational drug use had improved, and they were much more confident in discussing drug therapy with doctors in clinical clerkship teaching. In addition, the teacher also reported that the students in the experimental group were more active in class and asked more questions than those in the traditional teaching group. This novel teaching model enables students to demonstrate more comprehensive and critical thinking.

In general, the application of flipped classroom based on micro-video class in pharmacology course is beneficial to cultivate students' ability to comprehensively analyze and solve problems, enhance their autonomy and interest in learning.

Nonetheless, this teaching model is not without drawbacks. The main challenge is the increased pressure and preparation time for both teachers and students. For teachers, it is a large amount of time investment for designing and recording micro class videos, collecting clinical cases and designing creative classroom activities related to pharmacotherapeutic competencies to keep students' participation and interest. It is also very time-consuming to manage online teaching systems and supervise students' self-learning processes. In addition, students think more actively or have difficulties in self-learning, thus teachers need to spend more time answering questions outside class. Meanwhile, in order to meet the needs of current social development, teachers should not only be fully familiar with the theory, but also constantly update the teaching content and improve their teaching skills.

For students, it takes more time to self-study micro-video class, while flipped classes may increase their anxiety. In class, teachers review the knowledge points of the online micro videos through question-and-answer, rather than direct explanation. Moreover, a large amount of classroom time is used for student-centered activities. In order to participate in activities more effectively and pass the course assessment, students have to spend more time preparing outside class and thus feel anxious. This is why some students were dissatisfied with this new teaching mode at the beginning and were more accustomed to passive learning in traditional teaching. However, with the increasing participation in classroom activities, students realized that theoretical knowledge can be better connected with clinical application through the novel teaching mode, so they gradually accepted it.

In addition, students indicated that watching micro-video class through the online platform significantly improved the efficiency of self-learning compared with traditional preview lessons. Micro videos are considered most helpful online self-learning materials by students. However, it is not enough to simply convert the traditional lectures to online video, as the long-time teaching video will frequently distract students from the main point. The knowledge points need to be reasonably designed and divided to compress the lengthy teaching lectures into brief and to-the-point micro videos.

High-quality micro-video classes, highly interactive classroom activities, and leading questions provided before class can greatly increase the attraction to students, improve their self-learning efficiency and relieve their anxiety. Therefore, it is necessary to establish a teaching team to jointly participate in the production of micro videos, the design of classroom activities and extracurricular online answering questions, so as to share teachers' pressure and guarantee the quality of course construction. In this teaching reform, we sought to create high-quality and repeatable online resources and flipped classroom activities, which will continue to be applied to pharmacology course in the future. Since theoretical knowledge doesn't be taught repeatedly, teachers' workload is reduced, and they will prefer to this teaching mode.

Furthermore, although the questionnaire results show that most students are more satisfied with the teaching model of flipped classroom based on micro-video class. It is likely that some students prefer passive learning based on teachers' lectures, which explains the low satisfaction score given by some students (5.80%). Therefore, in addition to improving students' learning initiative via increasing the interest of teaching contents and activities, appropriate self-learning supervision and management is also necessary. In this teaching reform, teachers track students' pre-paration before class through the learning management system of the online platform, so as to effectively guide them to learn. In addition, scoring is also incorporated into pre-paration to encourage students self-learning.

In conclusion, flipped classroom based on micro-video class is a beneficial supplement to the traditional teaching model, and is worth applying and popularizing in pharmacology teaching. However, the potential limitations of this study are also existed. The teaching reform has not been implemented in the whole course of pharmacology, and the teaching effect and course quality is also lack of systematic evaluation, such as assessment of clinical competencies, longitudinal follow-up, experts' evaluation and so on. A more complete curriculum and evaluation system needs to be established for pharmacology course in the future.

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 Ethics Committee of Chengdu Medical College. The

patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Y-YW, SL, F-YZ, and XM contributed to conception and design of the study. F-YZ implemented the methods of the study in the two classes. XM supervised the execution of the study. QM performed the statistical analysis. Y-YW, SL, QM, Y-XZ, and SY contributed to the design of teaching content and micro class video. F-LL and F-YZ wrote the first draft of the manuscript. Y-YW and SL wrote the final manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Short- and Long-Term Influences of Flipped Classroom Teaching in Physiology Course on Medical Students' Learning Effectiveness

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The flipped classroom (FC) teaching has been increasingly employed in medical education. Many studies have shown this "student-centered" pedagogical model improves students' overall achievement in the course, with students showing more motivation and better self-directed learning skills when compared to the traditional classroom teaching. However, most of the previous studies have been evaluating the short-term effects of FC teaching conducted upon completion of the course. The retention of the promotion and the long-term effects on learning of students' subsequent courses deserve further attention and evaluation. By adopting and running FC teaching in the whole course of physiology, this study aimed to determine the short-term impact of FC teaching on students' learning of physiology course and also the long-term influences in students' learning of follow-up medical curriculums within 18 months after the completion of physiology course. 119 sophomore students majoring in clinical medicine from Central South University were recruited and they were assigned randomly into two groups: the control group (n =61) who received the traditional lecture (TL) teaching, and the experimental group (n =58), who received the FC teaching. In this study, students' final exam scores were used to assess their learning effectiveness and an independent samples t-test was conducted to compare scores between the two groups. Our study showed that FC teaching significantly improved the learning outcome of physiology in the experimental group compared with the control group ($P = 0.0001$) without obvious impact on the learning of other subjects conducted in the same period of time. Moreover, our results also demonstrated the long-term benefit of FC teaching, with students from the experimental group scoring higher in pathophysiology ($P = 0.006$), pathology ($P = 0.029$), pharmacology ($P = 0.0089$), diagnostics ($P = 0.01$) and internal medicine ($P = 0.0004$) than those from the control group. The study results indicate that FC is a promising teaching approach to increase students' learning effectiveness in physiology course, and the long-term effects of FC facilitate the learning of the follow-up medical courses. Furthermore, this study also demonstrates that although the time investment on physiology is increased by FC teaching, it does not weaken students' learning of other courses conducted in the same period of time.

Keywords: physiology, learning effectiveness, medical students, flipped classroom teaching, short- and long-term influences

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INTRODUCTION

With an increase in the amount of medical knowledge and the complexity of the health care system, it comes with great challenge for both the medical educators and the students, who have to juggle between increased curriculum content and reduced face-to-face teaching time. It is therefore necessary to make corresponding changes to the way we conduct medical education (1, 2). In recent years, the flipped classroom (FC) teaching method has been applied more often in medical undergraduate education. This teaching mode transfers the initiative of learning from teachers to students. Students are asked to do a basic learning through reading materials or videos before the face-to-face class, which is aimed to free up classroom time for knowledge application and higher-level thinking (2, 3). FC also provides students with sufficient time for discussion and interaction with their peers, which helps them develop critical and independent thinking and enhance their learning process (4–7). Many studies, either in preclinical or clinical settings, have demonstrated the advantages of FC over traditional classroom teaching, in improving students' course performance, and increasing their interest, participation and satisfaction with the course. So, this "student-centered" way of learning has been well-received by the students (7–9).

Learning effectiveness refers to any advancement in knowledge, skills, attitudes, and emotions after completing the course (10–12). Most of these studies have only investigated the short-term learning effectiveness in the course implemented with FC, by assessing the students' final examination results, students' participation and satisfaction with the curriculum, etc. A few studies looking at the long-term effects of FC, have however focused mainly on retention of the learned knowledge over a period of time, and their findings are rather inconsistent (10, 13–16). One important aspect of medical school training, besides retention of the learned knowledge, is to develop and enhance students' lifelong learning skills including clinical problem solving, and the ability to acquire new knowledge. Improvement of these lifelong learning skills would benefit the students in a longer term both in their study of other courses and later in their workplace (17, 18). Flipped classroom teaching, as a novel way of teaching, could potentially help students develop these lifelong learning skills by promoting the application of medical science knowledge, and stimulating critical thinking (1, 19, 20). Therefore, when evaluating the effects of FC teaching, we should include both the short-term and the long-term effects of FC by assessing students' learning effectiveness in both the current and the subsequent courses. However, there is currently a lack of reports on the long-term impact of FC. Our current study is aimed to explore the impact of FC on the learning outcomes of medical physiology and the long-term influences of FC on the learning of other courses conducted after the completion of medical physiology course. The choice of physiology course is because it provides the basic understanding on how our body functions under health and disease conditions, and it is known as "logic of life" (21). The understanding and mastery of physiological knowledge may affect the study of subsequent medical courses. In this study, we used learning effectiveness to reflect the influence of FC.

METHODS

Design

We conducted this quasi-experimental study in a physiology course at Xiangya School of Medicine, Central South University. Most of the medical courses adopt the traditional lecture (TL) teaching method. Physiology course is conducted in the fourth semester. In 2016, we randomly selected two classes, one of which was subjected to TL teaching (the control group) and the other one was subjected to FC teaching (the experimental group). The test results were used to evaluate the physiology learning effectiveness of students in these two groups to assess the short-term benefit of FC teaching. An anonymous questionnaire survey among the students of experimental group was conducted to determine students' opinion regarding the FC teaching at the end of the course. At the same time, the final grades of medical microbiology, medical immunology and medical parasitology, which were conducted simultaneously in the same semester, were also analyzed and compared between these two groups to assess the impact of FC teaching on learning of these courses conducted using TL. The grades of major basic medical courses including pathophysiology, pharmacology, and pathology in the fifth semester, the final exam scores of clinical courses including diagnostics and internal medicine in the sixth semester and surgery pandect in the seventh semester were also compared between these two classes, to assess the long-term effectiveness of FC teaching.

Settings and Participants

In China, after passing the college entrance examination, senior high school students enter medical school for 5 years of undergraduate education in clinical medicine according to their applications. There are about 300 students enrolled in clinical medicine major and they are divided into 5 teaching classes every year. This study subjects were sophomores enrolled in 2014 with clinical medicine major. Students had been organized into 5 classes by the Office of Medical Educational administration, and each class had about 60 students. We randomly selected two classes, which were comparable in their final scores of Marxist principles, advanced English and systematic anatomy completed in the third semester. If there were statistical difference in the average scores of any of the three disciplines between two selected classes, a new random selection would be performed. Between the two classes we randomly selected at first, no significant differences in their grades of the above-mentioned principles were observed (**Figure 1**). One of the two selected classes received the TL teaching and was assigned as the control group ($n = 61$); the other one received FC teaching and was designated as the experimental group ($n = 5\,8$).

Intervention

These two classes were both taught by the same experienced teachers. The entire physiology teaching process of the experimental group adopted FC teaching. The experimental group established a QQ Group, for communication between students and teachers after class. The tasks and requirements of autonomous learning including video links were delivered to the students 3 days prior to the classroom teaching through the

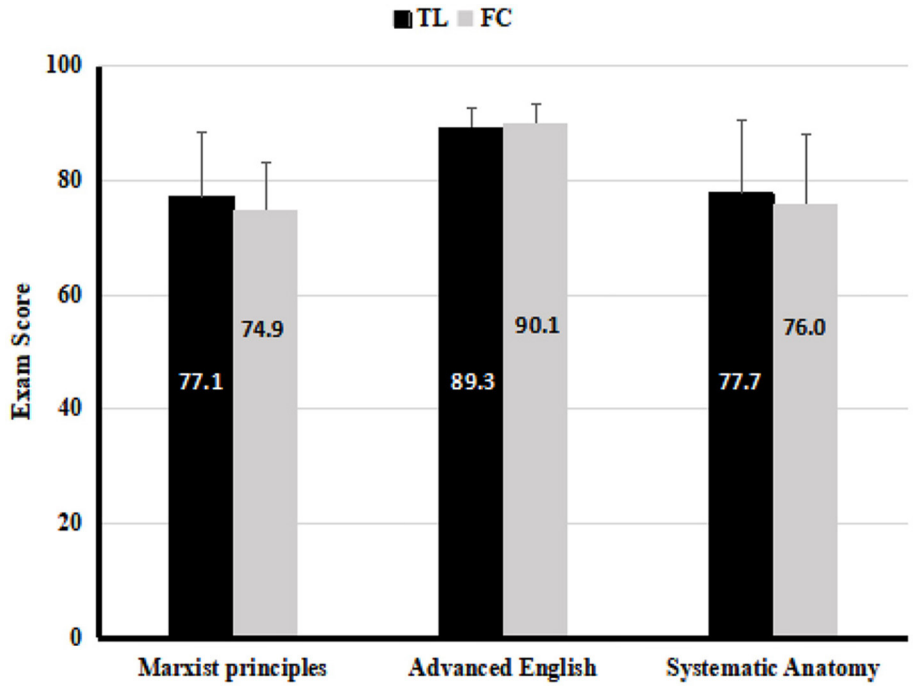

FIGURE 1 | The average exam scores of previous courses in the TL teaching class ($n = 61$) and FC teaching class ($n = 58$), analyzed by *T*-test. Values are means ± SD.

QQ Group. The reading materials for FC teaching in physiology come from iCourse (https://www.icourses.cn/home/), a learning platform established by the Higher Education Press of China. There are many shared resources for physiology from different medical universities in China on the iCourse platform, including one from Central South University created by ourselves (https://www.icourses.cn/sCourse/course_6701.html). Our physiology course resources include 72 classroom recorded videos, with durations between 36 to 56 min, [an average of 46.28 min per chapter (12 chapters in total)], 14 experimental teaching videos, 13 Chinese courseware and 12 English courseware (PDF version). These reading materials and videos cover all the teaching content of physiology, plus 12 sets of chapter test questions and 1 set of final test questions. Students can click the file and learn at their own pace. The experimental group students were required to follow the self-study guide by watching the instructional video on classroom learning, complete the exercises to consolidate the basic knowledge learned, write down the questions, and complete the preliminary transfer of knowledge. In the classroom, on the basis of explaining key points and difficult points incisively, a question-driven discussion teaching model was carried out, with interactive activities of "teacher asking questions - student discussion and answer - teacher induction and expansion." Since the basic concepts and knowledge had been pre-acquired through autonomous learning before the classroom teaching, FC gave the teachers more time for in-depth explanation of the key and difficult "knowledge." It also allowed the teacher to relate the knowledge to the history of discovery, to provide guidance for clinical application, and to answer the questions from the students submitted before class. During the interactive discussion session, teachers asked a series of questions which were vertically and horizontally expanded around 1–2 clinical cases. Students were divided into small groups (5–6 students/group) for discussion at the start of the class, and a representative from each group was selected to summarize and present the group's answer after the discussion. The teachers gave comments and elaborated further on the discussion and answers of the students. To ensure a balance between the discussion time and the lecturing time in the classroom, the discussion time for each teaching unit was controlled at about 30% of the total class duration. Throughout the course, three special clinical case studies with a total of 9 class hours, were arranged in stages to help students integrate and construct a complete physiology knowledge system. The choice of complex cases for group discussion (10–15 students/group) could encourage the integration of knowledge points in each system and complete the sublimation of "knowledge fragments" into the knowledge system. The control group, on the other hand, received the TL teaching, which was mainly in the form of lectures, without pre-class learning requirements and class discussions. Course content, number of classroom sessions and the duration of each class for the control group were the same as that of the experimental group. The control group also received three special clinical case studies, delivered in the same manner as for the experimental group. The control group also had a class QQ Group. Due to the difference in the course schedule, the communication between the two groups of students was limited. The physiology course lasted for 18 weeks. In week 20, students took the final closed-book examination. The

exam paper consisted of a total of 100 points were prepared carefully by experienced teachers who did not take on teaching tasks. The types of questions included single-choice questions, short answer questions, and open-ended case analysis questions, accounting for 50, 20, and 30% of the total score respectively. The questions were all from Question Bank constructed by the department of physiology previously. The difficulty index and the discrimination index of the test paper was 0.58 and 0.41 respectively, and the reliability and the validity were 0.87 and 0.745 respectively.

Data Collection

An online testing software program named AMEQP was used to review the physiology final exam papers. To eliminate the subjective deviation in the teacher's judgment, all subjective questions including short answer questions and open-ended case analysis questions, were marked by two independent blinded teachers, who did not know the name of the student, the identity of the other teacher and the grade given by the other teacher. The final score of each subjective question was the average of the scores from the two teachers. Grades of other courses were collected through the school educational administration achievement management system. Besides the exam scores, feedback from the experimental group students was also collected through an online anonymous questionnaire. The questionnaire was designed based on previous peers teaching researches in medical education (22, 23), consisting of five items of perceptions of active learning activities, academic engagement behavior, learning outcomes, interest, motivation, and aimed to assess students' perceptions of FC on learning and their attitudes toward FC on a Five-Point Rickett Scale. The responses include: strongly disagree, disagree, uncertain, agree and strongly agree. 58 questionnaires were received from the experimental group with a recovery rate of 100%.

Data Analysis

To analyze learning outcomes, a post-test design was used to compare the final exam scores of the two groups of students. Courses included physiology and concurrently conducted (microbiology, immunology, and parasitology), follow-up basic medical courses (pathophysiology, pathology, and pharmacology) and main clinical courses (diagnostics, internal medicine, and surgery pandect). Exam scores were expressed as mean ± standard deviations. An independent sample *t*-test was used to compare mean grades between the control and the experimental groups, with a *P*-value < 0.05 considered statistically significant. Survey data for questionnaires were reported as percentages.

Ethical Consideration

The study was reviewed and approved by the Ethics Committee of Central South University. Participants provided written informed consent to participate in the study.

RESULTS

Baseline Information of Students

As shown in **Figure 1**, there were no significant differences between the two classes selected randomly in the scores of Marxist principles ($P > 0.05$), advanced English ($P > 0.05$) and systematic anatomy ($P > 0.05$). Based on this result, these two randomly selected two classes were eligible for this study. There were 61 students in the control group, of which 52% were women and 48% were men. The average age of students was 19.8 ± 0.72 years. The number of students in the experimental group was 58 with 49% females and 51% males, and the average age was 19.7 ± 0.69 years.

FC Teaching Improves Students' Learning Effectiveness in Physiology Without Impacting Their Performance in the Other Courses Conducted in the Same Term

To determine the short-term impact on the student's learning effectiveness, students' test scores of the physiology course were compared between the control and the experimental groups. Our results showed that the average score of the students is significantly higher in the experimental group than in the control group ($P < 0.001$, see **Figure 2**), suggesting that the learning effectiveness was improved by the FC teaching. FC teaching required more preparation time from the students, we wanted to determine if this would impact the performance of students in the other 3 compulsory basic medical courses conducted in the same term. The final exam scores of the 3 courses carried out simultaneously with physiology were therefore compared between the control and the experimental groups. As shown in **Figure 2**, there were no significant differences between the two classes in the scores of microbiology ($P > 0.05$), immunology ($P > 0.05$), and parasitology ($P > 0.05$). Our result suggested that the learning of other courses in the same period was not significantly impacted by the FC teaching, which was consistent with previous study conducted in 2012 (24).

FC Has Long-Term Positive Effects on Students' Learning Effectiveness

To determine whether the positive effects of FC as seen in the physiology course would continue to improve students' learning effectiveness in a longer term, the final exam scores of 3 basic medical courses (namely, pathophysiology, pathology, and pharmacology) conducted in semester 5, the following semester after completion of FC teaching, were compared between the control and the experimental groups. Our results showed that the scores of pathophysiology ($P < 0.01$), pathology ($P < 0.05$) and pharmacology ($P < 0.01$) were significantly higher in the experimental group than in the control group (**Figure 3**).

We continued tracking students' learning through semester 6 and 7 conducted. The final examination scores of three main clinical courses: diagnostics, internal medicine in semester 6 and surgery pandect in semester 7 were compared between the control and the experimental groups. As shown in **Figure 4**, the academic performance of diagnostics ($P < 0.05$) and

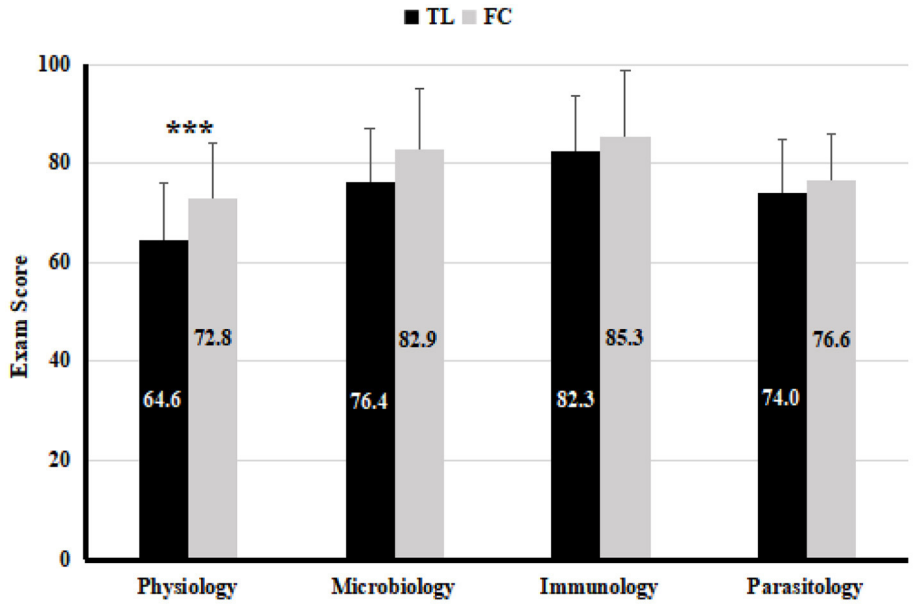

FIGURE 2 | The average exam scores of physiology and the courses offered in the same period in the TL teaching class ($n = 61$) and FC teaching class ($n = 58$), analyzed by *T*-test. Values are means ± SD. ***$P < 0.001$.

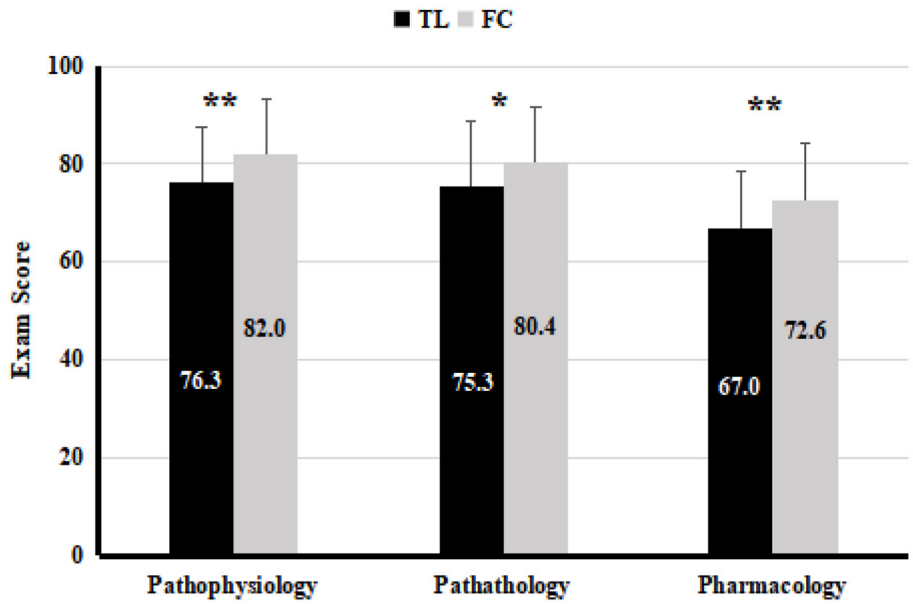

FIGURE 3 | The average exam scores of follow-up basic medical subjects with physiology in the TL teaching class ($n = 61$) and FC teaching class ($n = 58$), analyzed by *T*-test. Values are means ± SD. *$P < 0.05$, **$P < 0.01$.

internal medicine ($P < 0.001$) were significantly higher in the experimental group than in the control group. The scores for surgery pandect were however not significantly different between the two groups ($P > 0.05$). Our suggested that FC teaching had a long-term positive effect on the students' learning effectiveness in the courses conducted after the completion of FC teaching.

Students' Views on Flipped Classroom Teaching

All students in the FC experimental group ($n = 58$) were invited to fill out a questionnaire, and all students (100%) responded. The results showed positive attitudes toward FC instruction with broadly agreed (response categories 3–5), ranging from 84.5 to 91.4% (see **Table 1**). About 89.6% of students thought that

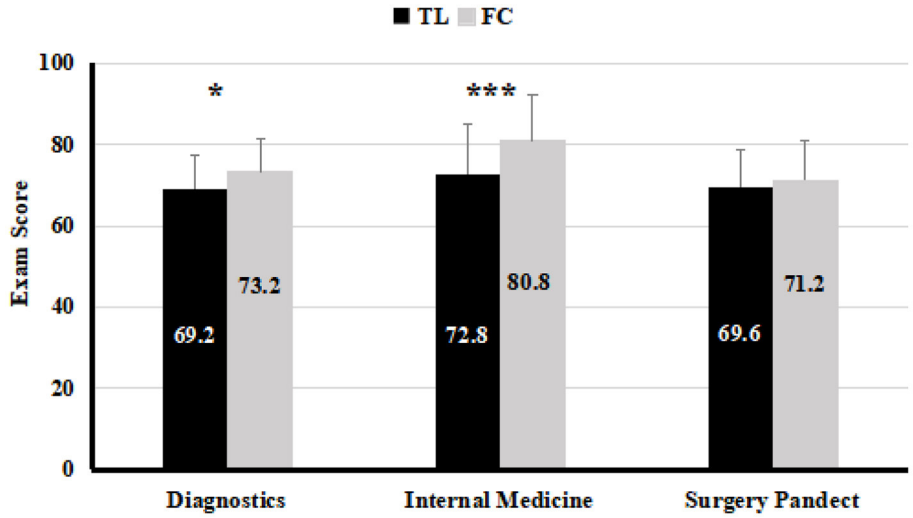

FIGURE 4 | The average exam scores of clinical main courses in the TL teaching class ($n = 61$) and FC teaching class ($n = 58$), analyzed by T-test. Values are means ± SD. $^*P < 0.05$, $^{***}P < 0.001$.

TABLE 1 | Students' perceptions of flipped classroom teaching in physiology ($n = 58$).

Questions	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
Discussions of questions in- class enhanced my logic ability	18 (31.0%)	20 (34.5%)	14 (24.1%)	3 (5.2%)	3 (5.2%)
It helped me to think critically	16 (27.6%)	20 (34.5%)	14 (24.1%)	4 (6.9%)	4 (6.9%)
I learned a lot taking this course	13 (22.4%)	24 (41.4%)	12 (20.7%)	4 (6.9%)	5 (8.6%)
Interactive, applied in-class activities enhanced my learning interesting	17 (29.3%)	18 (31.0%)	16 (27.6%)	5 (8.6%)	2 (3.5%)
It increased my motivation to study	26 (44.8%)	20 (34.5%)	7 (12.1%)	2 (3.5%)	3 (5.2%)
I was willing to recommend this course to another student	24 (41.4%)	18 (31.0%)	10 (17.2%)	3 (5.2%)	3 (5.2%)

FC teaching enhanced logical thinking ability and about 86.2% of them thought that it also improved their critical thinking ability. Over 60% of students strongly agreed or agreed that they had learned a lot through this teaching model. 91.4% students acknowledged that they took more initiative in learning with the FC teaching model, and 87.9% thought it had improved their interest in learning. Nearly 90% of students were willing to recommend this course to other students.

DISCUSSION

Our research on FC teaching of physiology has demonstrated that FC can promote the learning effectiveness of physiology, and it continued to improve the learning effectiveness of the follow-up basic medical and clinical medical courses. Although FC teaching increased students' time investment during the course, it did not affect students' learning of the other courses conducted at the same time. The questionnaire survey showed that the FC teaching in physiology was well-received by the students who participated.

The strengths of FC include promotion of learning, consolidation of learning, unlimited opportunity for learning, and interactive learning (25). In the FC teaching, students learn factual basics through digital learning materials before class and can access online study materials without time or place restrictions (18, 25–27). Furthermore, free discussion with teachers and classmates during the class, gave the students opportunities to apply what they learned from self-study to problem-solving, and encouraged in-depth understanding of knowledge. FC teaching hence cultivates students' comprehensive ability and higher-order thinking skills for analyzing and solving complex problems (2, 25, 28). In a study conducted by Rianne A.M. Bouwmeester, on the second-year medical students who are taking Hematology and Oncology courses, FC teaching was also shown to allow more time for asking, answering questions, and discussion in class compared to the TL teaching. FC teaching saves the teachers time for explaining factual information and the time saved can then be used for explaining in-depth knowledge and responding to student questions (14). This teaching method is particularly suitable for basic science course such as physiology, which requires a deep understanding on the working mechanism of various body organs, the regulation mechanism of organ functions and is very useful for analyzing and solving clinical problems. Medical physiology, known as the logic of life, is a compulsory course for all medical students. It provides a theoretical basis for subsequent courses such as pathophysiology and pharmacology and is closely related to all other clinical

subjects. Physiology is a discipline that requires high level of active and logical thinking. The learning content of physiology is abstract and logical, which is a challenging subject for students. In this study, we have shown that FC teaching improved the students' average test score in physiology by 12.7% compared to TL teaching. The findings from our study are consistent with previous studies which demonstrated improved performance of students by FC teaching in both preclinical and clinical courses (6, 18, 28–30). FC teaching has also been shown to help students develop and improve analytical thinking and problem-solving skills (28). Van Vliet's research demonstrates that the rate of correct answers to the exam questions, an indication of high-level cognitive thinking, is significantly higher in students receiving the FC teaching than those receiving the TL teaching (31). Chih-Cheng Lo's research found that flipped teaching enhanced students' motivation to learn and improved students' self-regulation ability (10). The results of the questionnaire in this study also showed the students' positive attitudes toward the FC teaching. The majority of the students agreed that FC teaching enhanced their logic and critical thinking skills. Students' interest in learning was greatly improved and their learning was more active. This study and the above researches suggest that FC teaching not only has a positive short-term promotion effect on learning effectiveness of this course, but more importantly, it enhances students' various learning abilities. Will the improvement of students' learning ability continue to promote students' performance in subsequent courses? Whether FC teaching can enable students to carry out high-level knowledge transformation and better performance, and whether it can enhance students' lifelong learning ability are questions yet to be answered (7, 9, 32). Therefore, it is necessary to follow and evaluate students' learning in their subsequent courses over a longer period of time after completion of FC teaching.

In our study, FC teaching was given to the experimental group in semester 4 and the learning effectiveness of students were followed and evaluated throughout semesters 5, 6, and 7. Except for one course, the surgery pandect, results of pathophysiology, pathology, pharmacology, diagnostics and internal medicine courses were better in students from the experimental group than those of the control group. This shows that the promotion effect of physiology FC teaching on students' learning effectiveness can remain to affect their subsequent course learning. Our study is among the few that are assessing the long-term impact of FC teaching on learning outcomes. Chih-Cheng Lo's research shows that students under the flipped teaching model make remarkable progress in the electronics course and the learning outcomes remains significant after a long period of time. The researcher believes that the FC teaching model can increase possibilities of long-term training or lifelong learning for students (10). A study showed that retention of knowledge in students taught by FC methodology were greater than those in the control group at 3 and 12 months after the completion of medical-surgical nursing course (12). However, findings on the knowledge retention were less consistent. Rianne A.M. Bouwmest's research has shown that students in FC have higher scores for self-efficacy. However, 10 months after the course, retention of knowledge and self-efficacy scores show no difference between control and FC teaching groups. The authors believed that although FC teaching did not prolong the retention time of knowledge, students receiving the FC teaching, were better in refreshing their knowledge when they were challenged to acquire knowledge on their own and were more proactive in class (14). It was also shown that the FC teaching was conducive for medical students to quickly adapt and complete tasks during the rotation of clinical departments (33, 34). This suggests that the positive effect of FC teaching on learning of subsequent course may not entirely be due to improvement of memory. FC teaching also helps promoting deep learning, strengthening the understanding and application of the acquired knowledge, and furthermore it trains students' logical, analytical and knowledge application skills. It is therefore not surprising that FC teaching is especially suitable for subjects which requires strong logical and active thinking skills, such as pathophysiology, pathology, pharmacology, as well as diagnostics and internal medicine (16, 35).

This study found that there was no significant difference in performance of surgery pandect between students receiving the FC teaching and those receiving TL teaching. This result is consistent with the findings by Whelan et al., which indicates that student-centered learning does not perform as well as those exposed to a more faculty-centered approach in anatomy laboratory exercises (36). FC teaching significantly improves students' ability to analyze material during final anatomical exams, but cognitive abilities related to memory is the same as that of traditional classroom teaching (37). This suggests that the effectiveness of the FC teaching on acquiring knowledge and skills at lower cognitive levels cannot be determined yet (9). It may also be that the content of the examination or assessment of surgery pandect and anatomy is related to a lower level of cognition and cannot comprehensively reflect changes in students' ability, or students taught in FC are likely to spend less time recalling and consolidating forgotten knowledge. All of the above requires further investigation.

The FC teaching requires students to spend a certain amount of time for self-study before each class, so it may increase the student's learning load (14, 26, 37, 38). Does this affect the study of other courses conducted simultaneously? To answer this question, the final exam results of subjects such as microbiology, immunology and parasitology that were carried out during the same period of time as the physiology were compared in our study. Our results found that FC teaching in physiology has no obvious impact on the learning of other courses conducted in the same period of time. Rianne A.M. Bouwmest's research has assessed this question from a different angle. Although students attending the FC spend about 2 more hours per week on homework than students in traditional education, they spent less time on the exam preparation compared to those receiving the TL teaching. The author believes that proper preparation and active participation in class will reduce the cramming learning before the exam (14). Future studies should therefore include the total time and time distribution among the different courses conducted in the same period. This will help determine the impact of the FC teaching on students' study-time management.

LIMITATIONS OF THE STUDY

The limitation of this study is that exam scores were used as the sole indicator of the long-term impact of FC teaching on students' learning effectiveness. In addition, FC teaching was still at its early days back in 2016, so the curriculum resources were not comprehensive. At that time, the length of the classroom recorded video was too long, which meant more pre-class preparation time and increased workload for the students. We have since re-recorded 109 micro-lecture videos, each with a duration of 10–15 min, which give the students more time to manage other courses conducted at the same time. Secondly, the examination questions in our study were prepared by the teachers who did not undertake teaching, so there are no questions selected and designed which have been discussed in the FC, to assess the correct rate difference of answers between the two groups of students. Lastly, the number of research subjects enrolled in this study was relatively small, so interaction in the classroom was more effective. It would be interesting to see how FC teaching could be extended to all students, which requires more collective and consistent efforts from the teachers (28).

CONCLUSIONS

The FC teaching in physiology has obvious positive influences on students' physiology learning effectiveness, and this effect can continue to improve the learning outcome of the follow-up basic medical and clinical medical courses. Furthermore, this study also demonstrates that although the FC teaching increases time investment for students during the course, it does not affect students' learning of other courses conducted in the same period of time. Therefore, the FC teaching can continuously influence the learning of other subjects and increase the possibility of lifelong learning. If FC were to be promoted on a larger scale, further studies would be required to assess students' compliance and find effective ways on motivating and guiding students during the pre-class preparation. Secondly, the training of teachers and the quality control of the teaching process are also the key issues to be considered.

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.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Central South University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MJ and ZL conceived, designed research, and approved final version of manuscript. MJ, ZL, DF, YX, and JX performed experiments. MJ analyzed data, prepared figures, and drafted the manuscript. DF, YX, and JX interpreted results of experiments. MJ, ZL, and DF edited and revised manuscript. All authors contributed to the article and approved the submitted version.

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REVIEW
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Enhancement of Online Education to the Teaching Paradigm: Taking Academic Medical Postgraduate Cultivation as an Example

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Background: The COVID-19 pandemic posed enormous challenges to postgraduate teaching in 2020. Large-scale and continuous online teaching explorations were introduced to cope with this difficult situation, which incidentally shifted the paradigm of postgraduate teaching.

Purpose: A review of the online teaching of local medical schools for postgraduates was performed to identify the success factors in realizing the practice.

Methods: We retrieved medical postgraduate online teaching publications mainly from the local database, the China National Knowledge Infrastructure (CNKI), *via* the keywords stated below and then performed a retrospective analysis.

Results: We analyzed key success factors in improving online learning engagement that were considered exclusive to offline classroom teaching, including emotional interaction, the immediacy of communication, and enthusiasm for participation. With these positive effects, the integration of online and offline teaching advantages is beneficial for the initiative of academic medical postgraduates and promotes the construction and development of medical postgraduate education.

Conclusion: Online education can overcome the limitations of time, space, and teaching frequency, with great advantages in terms of flexibility and mobility over traditional classroom teaching. It can effectively cope with difficulties in the education of academic medical postgraduates in challenging times. In the post-pandemic era, blended online and offline teaching approaches continue and will become the new normal pedagogy for the training of medical postgraduate students.

Keywords: medical education, postgraduate training, academic medical postgraduates, multi-dimensional teaching mode, online education

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INTRODUCTION

In recent decades, the rapid development of the Internet and information technology has greatly propelled traditional classroom teaching. Online teaching is widely applied to different majors in various universities, and the use of network technology and resources to enhance teaching activities is increasingly popular among teachers (1–3). Indeed, for the time being, online education is used

only as a dispensable aid to traditional classroom teaching (4). It was hardly conceivable that from the beginning of 2020, online education could replace the face-to-face teaching approach in the classroom with such an abrupt transition as a result of the sudden outbreak of the coronavirus disease 2019 (COVID-19) pandemic. However, in response to the Chinese Ministry of Education's policy requirements of "disrupted classes, uninterrupted learning", online education, which had previously played an auxiliary and experimental role, has swept through China's basic and higher education almost overnight (3, 5–7). Teachers and students suffering through this extraordinary period have undergone changes from being caught off guard and preparing nervously to resisting and silently accepting online teaching and then to gradually groping for a normal and orderly method (8, 9). In the post-pandemic era, students and teachers in most areas have returned to the classroom, yet the impact and transformation of online education has made the classroom no longer exactly what it used to be (10–13). Public health events have made a profound impact on and changed teaching methods in the internet age.

Postgraduate online education was also among the issues of concern during the pandemic. By searching the Web of Science, Liu et al. (14) analyzed 1,243 articles published in August 2021 and found that foreign studies on online education mainly concentrated on compatibility, content requirements, the use of popularization technologies, project design for advanced ubiquitous learning (15), the learning process and randomized controlled trial design. By searching for the keyword "online education" in the China National Knowledge Infrastructure (CNKI, https://www.cnki.net), we found that there were already 7,899 articles reporting local online teaching practices and presenting a variety of trials exploring different online education platforms, modes, systems, and prospects (8, 16–18); furthermore, there have been endless commentaries on the advantages and disadvantages of online education vs. traditional classroom education as well as their relationship (19–22). Those studies have provided a very comprehensive analysis of their strengths and weaknesses. Most scholars have fully affirmed the flexibility of online education in time and space. Online education is characterized by "being able to learn anywhere and at any time"; that is, it is not limited by time, place or the frequency of teaching (23). This teaching approach breaks through the limited resource space and interactive scenes of classroom teaching, shortens the space-time distance of communication, and gives postgraduates more flexibility and independence in learning (24).

In this study, we systematically reviewed online education and offline traditional teaching practices in medical universities for the cultivation of academic medical postgraduates. Through a holistic evaluation, we identified some success factors that are necessary for effectiveness and instrumental metrics for the online teaching approach. Online teaching can benefit postgraduate education despite some of its drawbacks, can be to overcome over time and with the development of technologies. Even in the post-pandemic era, teachers and students have returned to the classroom, and online teaching is increasingly valued. For example, we can adopt hybrid teaching that integrates online and offline approaches to give full play to the strengths of online education for training academic medical postgraduates.

HOW TO TURN THE DISADVANTAGES OF ONLINE TEACHING INTO ADVANTAGES IN THE CULTIVATION OF POSTGRADUATES

1. The Strengths and Weaknesses of Online Teaching for Medical Postgraduates and the Feasibility of Realizing a "Homogenization" of Teaching Mobility and Quality

Compared to the traditional classroom, online teaching is easier to implement student-centered, personalized learning rather than an indiscriminate teaching consisting of "chalk and talk" (25). However, studies point out that online teaching is subject to student's self-discipline, uncertain learning environments, computer skills, and the network (26, 27). The lack of face-to-face interaction with teachers, the response time and the absence of traditional classroom socialization were also highlighted by higher education students. Some deemed online teaching hardly able to stimulate the enthusiasm of postgraduates to learn due to the lack of group incentives and supervision by teachers, like in the traditional classroom (24). Exploring more effective postgraduate education approaches remains a hot topic investigated both domestically and internationally from different perspectives (28–30). China's postgraduate education has reformed to adopt "dual-track" modes, "academic" and "professional," based on different cultivation objectives (31, 32). The academic mode aims to cultivate talents with strong medical research capabilities or clinicians with strong research capabilities (33, 34). However, confined by the traditional training of medical postgraduates, the cultivation of academic medical postgraduates still has some shortcomings. Generally, supervisors assign a great deal of clinical work to students. It may improve student's clinical skills and practical experience, although students lack the time to exercise their scientific research ability (35). At the other extreme, students are arranged for onerous scientific research experiments, which subjectively equate "basic experiments" with "scientific research" and lead to a disjunction of clinical practice, theory, and scientific research to some extent (36). Both approaches often take a considerable amount of precious time and therefore hardly provide a guarantee that students have enough time to study theories and carry out classroom discussions. Based on the cultivation objective, academic medical postgraduates should be able to master basic and cutting-edge theories, advanced technology, scientific research, and innovation thinking from the standpoint of their majors. However, in the current situation, academic postgraduates are first required to receive a considerable number of courses and necessary training for experimental skills at first; otherwise, in the absence of theoretical training and experience, most postgraduates do not even have the ability to independently determine their future research projects (37). In this context, with its unique flexibility and

mobility, online teaching can compensate for these shortcomings and demonstrate its irreplaceable advancement. Since online teaching is relatively free from time limitations, lectures and academic discussions can be arranged more specifically and better guarantee the students will receive a theoretical and scientific research education. Moreover, the recording and playback function allows students to watch repeatedly based on their own needs after class and meet the individual requirements of students based on their basis and learning abilities. The flexibility of online teaching at any time is thus of particular significance to medical postgraduates.

In addition, medical postgraduates face spatial limitations. For example, confined to the requirements and restrictions of joint training policies, beds, and the number of training programs, medical schools usually assign medical postgraduates to different training bases (38). As a result of such a training arrangement postgraduates, even under the same supervisor, cannot gathering together in one place for study, and traditional classroom teaching cannot be realized. Meanwhile, due to differences in teaching resources and teachers' proficiency between various practice bases, it is difficult to guarantee the "homogenization" of teaching quality (30, 39). To address this issue, the advantage of online education is embodied once again by being free from geographical restrictions and being able to ensure that students in different places receive uniform learning and mentoring. Students can also keep abreast of the progress and level of their classmates, the requirements of supervisors, and the trend of the subject so that they can make adjustments accordingly (40, 41).

From the above analysis, the main strengths of online teaching allow for the flexibility of teaching without time limitations as well as feasibility without spatial limitations. The weaknesses of online teaching mainly lie in the lack of network coverage, computer skills, and measurements for maintaining teaching disciplines. All these facts have also been observed in teaching practice in other countries; however, the mainstream views tend to believe that online teaching will become an integral part of teaching approaches for improving teaching quality, motivating student's interest in learning and reducing learning costs (42, 43).

2. Online Teaching Does Not Decrease but Increases the Classroom Participation

Traditional classroom teaching is generally believed to be very convenient for teachers and students to engage in face-to-face communications. Especially in small-class teaching, teachers can easily judge postgraduate's understanding of the lecture content through eye contact, tone of voice, and question-and-answer interaction, and accordingly adjust the teaching progress in real time (44, 45). In contrast, with online teaching, it is harder to maintain such immediate feedback and adjustment. However, our teaching practice and other studies have indicated that postgraduates become even more active in online teaching than in offline traditional teaching. Although there is a lack of real-time eye contact and feedback in offline classrooms, students can leave messages and comments in the teaching moment through auxiliary teaching software such as DingTalk or Tencent (46, 47). Studies further reveal that online teaching can allow for a relaxed atmosphere for on-the-spot comments and discussion. First, in the traditional classroom layout, teachers often stand at the front and face students, leading to an opposing and top-down power-suppressing relationship with students and a nervous atmosphere (48). In contrast, in the online teaching environment, teachers just appear as icons or are projected on a screen, which greatly relieves this tension. Second, in face-to-face teaching, students need to spend more time on psychological preparation to overcome their shyness and stage fright in speaking in front of the class and, at the same time, ensure the integrity of their content and language and accept the teacher's judgment (49). However, leaving a text message is more casual since the message can be long or short, and many students will even use emojis to express their psychological reaction. Although there is a lack of eye contact and oral expression, like in the traditional classroom, students generally think that the use of text messages and emojis is an equally good way of emotional communication in the classroom, particularly those who have the intention to talk but are hesitant to do so. Not only does this method of communication give students a greater sense of security, but it also brings a relaxed atmosphere to the class. In an article aiming to promote the construction of postgraduate courses in the online teaching mode, Mo et al. pointed out that online teaching could increase the interaction between teachers and students. In the process of teaching supervision, we also found that more postgraduates were enthusiastic about speaking in WeChat groups or on conferencing platforms in online teaching than in previous offline classrooms. The reason is that when speaking in front of the class, students are required to organize their language and make eye contact with everyone, which therefore makes students feel intimidated. However, all these factors disappear in online communication. Students become more active in speaking, and teachers can better receive teaching feedback as well (50). The ability of online teaching to enhance teacher-student interaction also appears in scenarios other than postgraduate teaching. For example, in interviews with teachers in elementary and middle schools, teachers generally believe that online interaction is more frequent than in offline interaction. Online communication does not require face-to-face communication, which breaks down the psychological defenses line of some students with poor communication. They can choose to communicate with teachers in private messages online; students do not have to worry about losing face to ask questions that may be laughed at by others (23).

Another noteworthy phenomenon is that when teachers deliver online lectures and postgraduates present academic reports, speakers usually receive more feedback than they would offline. Although feedback is not realized through eye contact and the exchange of expressions, students give immediate feedback by receiving messages and comments in the teaching process. This kind of feedback is more specific and constructive and almost impossible to realize in the traditional classroom. Students can also record their doubts and evaluations in a timely manner by leaving a message without worrying about disturbing lecturing and reporting. The lecturer can not only see the feedback in real time but also choose a suitable time to adjust the lecture content and answer questions more easily. Therefore, online

teaching is conducive to creating a relaxed class environment that is able to enhance student's enthusiasm for learning and desire to express themselves, increase student's classroom participation and improve teaching quality.

3. Online Teaching Promotes the Realization of "Student-Centered" Learning

Educators have been continuously pursuing effective teaching modes, including the postgraduate education paradigm (7, 13, 34, 51). The traditional classroom has been in existence for hundreds of years. It is a typical class-based teaching paradigm and a stably organized teaching activity. However, it has difficulties in meeting the individualized learning needs of students, and it is not conducive to cultivating student's independent learning ability (52). The flipped classroom has been vigorously promoted in recent years, with the purpose of defending students' learning autonomy with the support of information technology, adjusting the teaching relationship, and providing a basic guarantee for student's independent learning and individualized learning (53). By flipping the teaching process, the flipped classroom turns the golden rule of teaching in traditional classrooms from "pre-class preparation → in class → after-class reviewing" to "preparation → video-watching → application" (54) to realize the flip from "teacher-centered" to "student-centered" teaching modalities. In the post-pandemic era, online education has gradually become popular, and a new mode of blended online and offline teaching has also appeared in postgraduate education. Such blended teaching combines the online and offline modes, fully leveraging the features of the flipped classroom to mobilize student's initiative and autonomy in learning (25). The blended teaching mode of "combining teacher-led practice and student's self-independent learning" not only raises the initiative of learning subjects but also imposes more requirements on teachers. Teachers must not only play the role of traditional supervisors but also fully mobilize the initiative and enthusiasm of students in the learning process. Teachers are required to know not only "how to teach" but also "how to promote learning" (55). This transformation in teaching is particularly important in postgraduate education. Postgraduate education has higher standards for teaching, which should be professional, cutting-edge, and cross-disciplinary. It also requires students to have speculative and innovative thinking. All these requirements become the focus of postgraduate education and a difficulty in postgraduate education, and they result in higher standards for cultivation. High-quality postgraduate education should not be confined to traditional classes for the teaching of basic knowledge or a unilateral requirement for the proficiency of teachers. Postgraduates should be able to acquire the latest progress and skills related to their majors from various channels and obtain learning motivation and inspiration from the feedback of teachers and mutual discussions with their peer classmates. The democratization of online education will help students and teachers fulfill these demands more effectively. With the full development of online teaching, teachers and students can build QQ and WeChat groups to study and discuss the materials issued by teachers and work together on assigned tasks. In addition, they can share the scientific research papers they read and report their progress in their own research fields. Teachers and students can communicate easily in real time, and all learning processes can receive feedback and evaluation. It is through this multifaceted learning and discussion that online teaching promotes the realization of individualized learning, and with a timely feedback mechanism, online teaching further enhances student's self-learning and the transformation of the student-centered teaching mode.

This teaching mode can rule out the questions that students can solve by themselves and screen out those that deserve to be discussed more through in-depth face-to-face communication and in which hypotheses can be proposed to be tested in practice. Through the blended online and offline teaching mode, postgraduate education has changed from the "pre-class preparation, video-watching, and application" adopted in the flipped classroom to a multidimensional mode of "pre-class preparation, class, discussion, feedback, and application." As a result, teaching interaction has entered an alternating online and offline cycle, creating a rich learning experience. The autonomy of discovering, discussing, and solving problems and a more relaxed learning atmosphere have enabled many students to acquire a deep learning ability. Students can not only learn actively and critically but also have a deeper understanding and improved ability to transform the knowledge they have learned (56). Students enjoy the whole learning process in this mode, which can improve the mutual benefits between teachers and students and update the cutting-edge knowledge and scientific progress among classmates. Additionally, this mode may be beneficial for supervisors to monitor their own teaching effectiveness and the progress of students' projects (12).

CONCLUSION

In recent decades, with the development of teaching technology, people have been tirelessly exploring the organizational form of the classroom. These attempts have greatly enriched the forms of teaching and initiated a revolution in teaching. Currently, online education is aggressively entering into the daily teaching and training of postgraduates, which poses not only a challenge for postgraduate education, especially for academic medical students, but also provides a rare opportunity for great change. Offline teaching has hundreds of years of theoretical and practical history, while online education just started its journey only a few decades ago and needs to be fully exploited. If teachers could appropriately integrate online teaching with offline teaching, it would amplify the effectiveness of the construction of the medical postgraduate training paradigm and exercise postgraduates' ability to think, discuss and solve problems. Online education has already developed to overcome many of the shortcomings of offline teaching and forms the basis for the creation of an environment for sharing and discussion. That is especially effective in digitally advanced areas. Online education helps to form an active virtuous circle in the cultivation of academic medical postgraduates in the small-class teaching mode. This

gives full play to motivating enthusiasm for and participation in student-centered learning and to integrating teaching resources, exerting the effect of "one plus one is greater than two" and thus paving the way for a promising future for the further reform of medical education. However, we have to point out the limitations here, as the conclusions of this study are mainly based on local teaching practices in well-established network infrastructures. Less developed areas with difficulty accessing the latest digital technologies might produce more critical results.

AUTHOR CONTRIBUTIONS

BS conceptualized the study, searched and analyzed the literature, and wrote the draft of the manuscript.

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