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Insights in healthcare professions education: 2022

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At the limits of digital education. The importance of practical education for clinical competencies learning in the field of emergency medicine: A controlled non-randomized interventional study

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Introduction: A high-quality education of future physicians is essential. Modern approaches interlock the acquisition of theoretical knowledge and practical skills in a spiral curriculum, leading to a mutual learning benefit for knowledge and application. This model was challenged by the elimination of hands-on trainings during the pandemic, which were often replaced by purely digital teaching models. Given the holistic nature of the spiral curriculum, we assumed that a purely digital model would have an impact on knowledge acquisition due to missing hands-on learning opportunities. The aim of the study was to investigate, using an emergency seminar as an example, whether purely digital training leads to a difference in theoretical knowledge compared to the traditional model.

Materials and methods: Study design: We used a two-groups design comparing a sample of medical students taught in 2020 with a purely digital teaching format (DF; $n = 152$) with a historical control group taught with a traditional format (TF; $n = 1060$). Subject of investigation was a seminar on emergency medicine, taking place in the 4th year. Outcome parameters: The primary outcome parameter was the students' acquired knowledge, measured by the score achieved in the final exams. Students' evaluation of the seminar was used as a secondary outcome parameter.

Results: Students in the DF group scored significantly lower than students in the TF group in the final exams. Students in the DF group rated the course significantly worse than students in the TF group.

Discussion: The study results illustrate that purely digital education leads to inferior knowledge acquisition compared to the traditional spiral curriculum. A possible explanation may lie in a deeper processing of the information (e.g., understanding the information by experience and analysis) and accordingly a

better memory recall. Moreover, the students' critical appraisal of the DF may have had an unfavorable effect on learning performance. Moderating factors may be lower learning motivation or the "zoom fatigue" effect.

Conclusion: These study results clearly illustrate the importance of hands-on teaching for knowledge acquisition. The interlocking of theoretical knowledge and practical skills, as ensured by the spiral curriculum, is essential.

KEYWORDS

medical education, emergency medicine (MeSH database), clinical competency, practical skill, competency-based medical education (CBME), digital education

Introduction

A high-quality education for future physicians is essential for each healthcare system (1–4). Modern approaches are based on the hierarchical models of Bloom's taxonomy (5) and Miller's pyramid (6) and implement them in form of a spiral curriculum (7–9). A characteristic feature of the latter is re-iterating the topics on ascending levels, while alternating theoretical lessons and practical application. This holistic approach enhances attitudes, cognitions, and skills of the students by continuously deepening the understanding of the covered topics (10). A characteristic feature of this approach is the close entanglement and temporal proximity of related theoretical and practical elements, which promotes both cognitive learning processes and skills development.

The COVID-19 pandemic with its sudden consequences for on-site teaching, however, has challenged this model (11–17). Under these conditions, medical education has changed fundamentally: large parts of the medical curricula, practical teaching modules and bedside teaching have been transferred to digital settings or virtual simulation (VS). Several previous studies have underlined the beneficial effects of simulation-based learning (SBL) and show that SBL is helpful in integrating theoretical knowledge and practice, with experience leading to better internalization of knowledge (18). Furthermore, medical SBL is effective for the acquisition of clinical skills (19, 20). Related to the field of emergency medicine SBL has long been considered as a cornerstone of training (21). Several recently published studies showed that the embedding of virtual reality (VR) in emergency medicine trainings provided auspicious zero-risk training for students (18, 21–23).

During the pandemic, digital skills education is comprehensible—and perhaps the only feasible way to acquire the respective competencies. However, the difference to hands-on training is fundamental, and the question arises whether a purely digital education can successfully maintain the spiral curriculum—or whether it leads to inferior learning outcomes.

The aim of the present study was to investigate whether a purely digital education had an influence on theoretical knowledge in the field of emergency medicine as compared to the traditional approach. Although we had reason to believe that a possible influence may be a negative one, we decided for two undirected hypotheses and postulated a difference (in any direction) between the approaches. We addressed this question on the example of an emergency medicine seminar with theoretical and practical elements. Specifically, we were interested whether a purely digital seminar led to inferior outcomes in terms of achieved points in the corresponding written exam compared to the traditional format with hands-on practical teaching. Moreover, we were interested in the subjective evaluation of the digital teaching format by the students.

Materials and methods

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. The study protocol was approved by the Ethical Committee of the Faculty of Medicine of RWTH Aachen University (Chairperson Prof. Dr. med. G. Schmalzing) (EK 215-20) on June 6th, 2020. Furthermore, the study was planned, conducted, and reported according to the SQUIRE EDU Guidelines (24).

Study design

The present study used a two-groups design comparing a novel digital teaching format (DF) with a historical control group taught by a traditional face-to-face on-site format (traditional format, TF) The study compared two teaching-learning formats in the field of emergency medicine.

During the internship in the 4th year of medical school, students learn the contents of emergency medicine, such as the organization of emergency medical services. Additional content ranges from basic life support and advanced life support to ABCDE algorithms, pediatric emergencies, and case scenarios. Furthermore, the leading symptoms of chest pain, dyspnea and loss of consciousness are subject. The covered topics, the

learning content, and the learning goals were identical in both formats; they only differed with respect to the teaching modality (please see description below).

Data for DF was collected in the summer term of 2020. Since TF was not possible at the time of data collection due to COVID-19 related restrictions, we decided for a historical control. For TF, we therefore used previously acquired data sets from summer term 2015 to summer term 2019. The large data base (9 cohorts) for the historical control was chosen for two reasons. First, including data from several cohorts minimized any possible influence of unsystematic data fluctuations in the results between cohorts; second, a large control sample increases statistical power.

Teaching formats

In both teaching formats, the emergency medicine contents were taught on 8 days within 2 weeks. Likewise, they were identical with respect to teaching content and learning objectives.

Digital format

The theoretical seminars comprised a total duration of 17.75 h. These were supplemented by practical courses and sessions on self-directed learning with a total duration of 19.25 h. All group lessons were realized with the video conferencing software Zoom (Zoom Video Communications Inc., San Jose, California, USA). Practical courses used the browser-based version of the BodyInteract^{TM} software to take a medical history, carry out the initial assessment and initiate the necessary diagnostics and therapy. The cases were managed by small teams of usually three students, with one student taking over the operation of the software and the others contributing their knowledge as in a real team.

Traditional format

The theoretical seminars comprised a total duration of 20.25 h in the traditional format. These were supplemented by practical courses with a total duration of 22.75 h. The seminars were implemented in groups of up to 12 students in the form of an interactive, media-supported lecture. The theoretical processing of case studies was a frequently used tool. Practical exercises took place in groups of maximum 6 students. In addition to learning how to handle rescue service materials, emergency medical scenarios from the domains of resuscitation, internal medicine and traumatology were performed.

The difference in the total duration by the theoretical units was due to the omission of room switching times, breakout rooms, and the shorter time required for a single session because of the digital format.

The two formats had identical learning content and learning objectives and differed only with respect to their teaching method.

Outcome parameters

Primary

The study's primary outcome parameter was the students' acquired knowledge. This was measured by the score achieved in the final examination at the end of the course in emergency medicine. The examination questions of both formats (DF and TF) were randomly selected from the same item pool; the number of examination questions as well as the maximum achievable score (20 points) were identical. For all included data sets, the examination consisted of single-choice questions with predefined correct answers; thus, there was no bias with respect to the assessment of expertise. Our analyses refer only to the emergency medicine section.

Secondary

Following the course, the participants rated it with a school grade according to the German system (1 = very good to 6 = insufficient). This grading was used as a secondary outcome parameter. All evaluation data in all semesters were collected with the software *Evaluna* (https://medicampus.uni-muenster.de/evaluna0.html) in digital form. The evaluation "school grade" was the final item of a questionnaire for course evaluation. Precisely, the item was "Your overall school grade for the entire course; Scale: 1 (very good) - 6 (unsatisfactory) (German: Ihre Gesamtnote für die Gesamtveranstaltung; Skala: 1 (sehr gut) - 6 (ungenügend)).

Research hypotheses

We defined the following research hypotheses (RH) for the present study:

RH1 (Primary)

DF leads to a different degree of expertise than TF, as expressed in significantly different scores achieved in the final examination in the field of emergency medicine.

RH2 (Secondary)

DF leads to different student ratings than TF, as expressed in a significantly different school grade.

Sample size planning

Sample size was based on the primary outcome parameter and calculated with *G*Power 3.1.9.7* (25). Since we assumed a violation of normal distribution based on the final examination score data from previous semesters [e.g., for summer term

2019: W(128) = 0.87, $p < 0.001$, Shapiro-Wilk test], we decided to plan for a non-parametric test (Mann-Whitney U for two independent samples). Assuming a medium effect size of Cohen's $d = 0.5$, an α error probability of 0.05, a power of 0.95, and an anticipated allocation ratio of 1/9 (1 semester in the intervention group and 9 semesters in the historical control), we required a total sample size of $N = 484$, with $n = 48$ in the intervention group and $n = 436$ in the control group.

Statistical analysis

Data were analyzed using *IBM SPSS Statistics* version 28 (IBM Corp., Armonk, NY, USA). As expected, we observed a significant deviation from normal distribution for the primary outcome in both groups [Shapiro-Wilk test, W (152) = 0.95, $p < 0.001$ for DF, W(1060) = 0.91, $p < 0.001$ for TF]. This was also true for the secondary outcome [Shapiro-Wilk test, W (46) = 0.92, $p < 0.01$ for DF, W(647) = 0.56, $p < 0.001$ for TF]. Thus, group differences for the primary and secondary outcomes were investigated with Mann-Whitney U tests for two independent samples, applying a significance level of $p < 0.05$.

Results

Participants

In the intervention group (DF), a total of $n = 152$ participants were included, all 4th year medical students. Data collection took place during the curricular course "Emergency Medicine Internship."

The control group (TF) encompassed a total of $n = 1{,}060$ participants, corresponding to an average of 118 participants per semester (range: 110–130 participants). The final allocation ratio DF/TF was thus 1/7.

The present study used regularly assessed data from the Medical Faculty. Since this data is usually not related to other demographical information, gender and age of the participants were not assessed at the time of data acquisition. As a representative estimate for both groups, we selected the basic demography of the student cohort encompassing our intervention group (DF) at the first day of their studies, which was October 1st,2016. As of this date, the cohort consisted of 303 students (64.4% female, 35.6% male), with a median age of 19 years (range 17–34 years). The time between the first day of studies and data collection was rather consistent in each of the cohorts (~3 years and 8 months), resulting in an estimated median age of 22–23 years in both the intervention and the control group at the time of data collection.

RH1

For DF, the median score was 16.5 [standard deviation (SD) = 2.30]; for TF, the median score was 18.0 (SD=1.75). Students in the DF group scored significantly lower than students in the TF group (Mann-Whitney U = 50186.0; standardized test statistic = −7.65, $p < 0.001$).

RH2

A total number of $n = 693$ participants rated the course (DF: $n = 46$; TF: $n = 647$). For DF, the median score was 3.0 (SD = 1.45); for TF, the median score was 1.0 (SD = 0.66). Students in the DF group rated the course significantly worse than students in the TF group (Mann-Whitney $U = 5{,}352.5$; standardized test statistic = −9.04, $p < 0.001$).

Figures 1, 2 compare the digital format (DF) and traditional format (TF) with respect to the exam score and school grade.

Moreover, we calculated effect sizes for RH1 and RH2. Following the methods described by Fritz et al. (26), we decided to use Pearson's r for both hypotheses, which is defined as $r = \frac{z}{\sqrt{N}}$. Effect size for the score in the final examination was $r = 0.22$; effect size of the school grade was $r = 0.34$. According to Cohen (27), these were small and medium sized effects, respectively.

To test for between-cohort variation in the historical control group, a one-factorial Kruskal-Wallis ANOVA of ranks was calculated for the 9 cohorts of TF. The result was significant [H(8)=207.98, $p < 0.001$], indicating a substantial variability in scores across semesters. For a visualization of the cohorts, please see Supplementary Figure 1.

Similarly, to the score variable, a one-factorial Kruskal-Wallis ANOVA of ranks was calculated for the 9 cohorts of TF for the school grade. The result was significant [H(8) = 16.67, $p < 0.05$], indicating again a substantial variability in scores across cohorts. For a visualization of the cohorts, please see Supplementary Figure 2.

The results illustrate that the findings within the historical control vary substantially, both for the score and for the school grade. We consider this a strong argument for including all available data sets in the control group of the present study. Thus, including all 9 cohorts improves not only statistical power, but also ecological validity of the study results.

The findings showed significant differences between the groups for both outcome variables. To rule out that these differences were caused by effects of novelty resp. non-familiarity of the teachers with DF, we incorporated data for the two subsequent semesters (winter term 2020/2021 and summer term 2021), which took place in a similarly newly developed hybrid format (HF) combining online and on-site elements. In HF, the hands-on training was resumed under strict hygienic measures (e.g., close monitoring of the participant's vaccinated, recovered or tested status, wearing face masks etc.), whereas theoretical lessons were still kept online. We compared HF

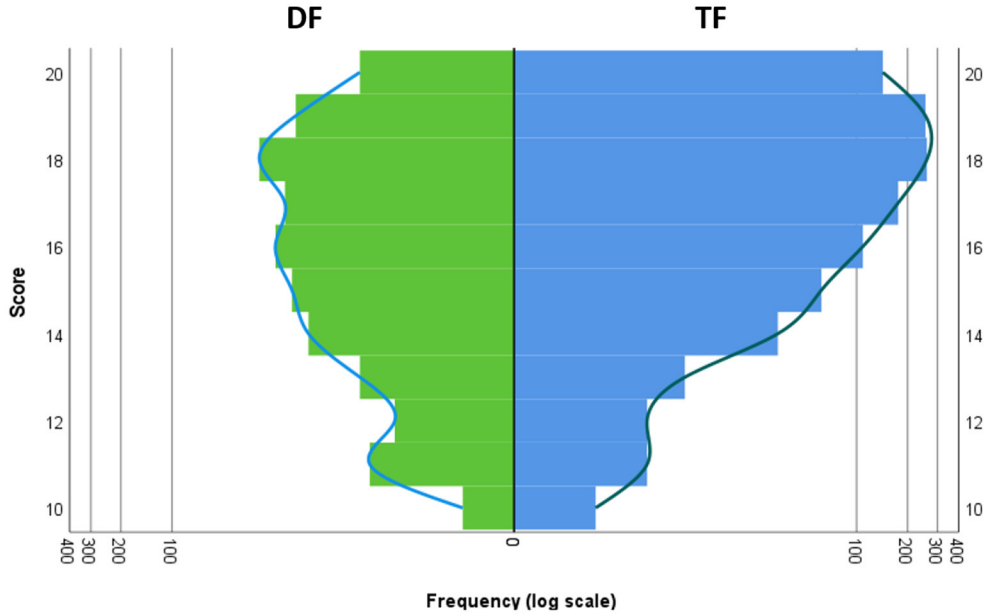

FIGURE 1
Comparison of DF and TF with respect to the frequency of the exam scores. Left/green: DF, right/blue: TF. The x axis shows the frequency of each score displayed on the y axis. To account for the different sample sizes of DF and TF, a logarithmic scale was used for the x axis.

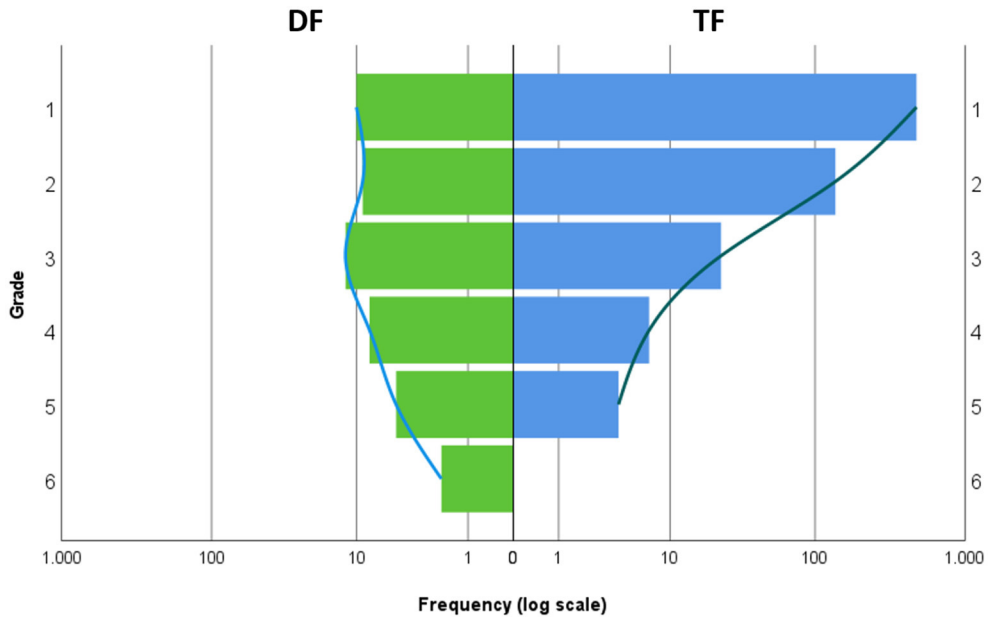

FIGURE 2
Comparison of DF and TF with respect to the frequency of school grades. Left/green: DF, right/blue: TF. The x axis shows the frequency of each grade displayed on the y axis. To account for the different sample sizes of DF and TF, a logarithmic scale was used for the x axis.

with both TF and DF with respect to score and school grade. Remarkably, HF led to an intermediate performance: Scores were still lower than in the TF group (median of HF = 17.0, SD = 2.19; Mann-Whitney U = 1,014,047.5; standardized test statistic = −6.37, $p < 0.001$), but higher than in the DF group (Mann-Whitney U = 22,097.5; standardized test statistic = −2.39, $p < 0.05$). Concerning the school grade, HF was significantly better than DF (median of HF = 1.0, SD = 0.75; Mann-Whitney U = 1012.0; standardized test statistic = 6.67, $p < 0.001$) and on a comparable level to TF (Mann-Whitney U = 38364.0; standardized test statistic = −1.08, $p = 0.28$, n.s.). Looking at the two HF semesters in detail, we found that this improvement was already present from the very beginning, i.e. the winter term of 2020/21, where the median score (18.0) was even better than in the following summer term of 2021 (17.0). Moreover, HF achieved a median school grade of 1.0 from the first semester on.

Discussion

The study results impressively illustrate that purely digital education for teaching clinical skills (5, 6) (5) (5) leads to worse performance in final exams compared to competency-based on-site learning in the field of emergency medicine. Findings from two subsequent semesters with a similarly new hybrid concept (HF) demonstrated that this effect can – at least to a substantial part - be attributed to the aspect of the teaching format.

This finding is particularly remarkable given the fact that the content and teaching form of the theoretical units were basically identical between the study arms (DF, TF). Thus, it is reasonable to assume that the essential difference between study arms was in the practical units—and still we found a substantial impact on the theory aspect. In terms of the spiral curriculum, this strongly argues for a mutual support of theory and practice in terms of learning success. In other words, theoretical knowledge benefits from practical application in simulation-based learning settings (18). Moreover, the students' subjective evaluation of the digital teaching format was significantly worse than for the on-site format. These findings point at some essential limitations in the application of digital education.

Incorporating data from the subsequent HF group demonstrates that the differences between study groups can indeed be attributed to the formats themselves and not to effects of novelty or familiarity. Novelty was also given for the hybrid format which was introduced in the winter term of 2020/21. Nonetheless, both the score and the school grade improved substantially, and this was the case from the very beginning on. Still, we cannot exclude that novelty and familiarity with the teaching formats contributed to the results; however, the present data clearly indicate an influence of the teaching format itself beyond this explanation.

A possible explanation for the higher effectiveness of the spiral curriculum with hands-on practical training may lie in Craik and Lockhart's "level of processing" model (28, 29). This model highlights the particular importance of the learning process for the later recall of the learning content (28). The ability to recall a learning content is a function of the depth of mental processing: Deeper processing of an information (e.g., understanding the information by experience and analysis) leads to a better memory recall than shallower processing (e.g., learning facts by heart). The levels of processing model has been confirmed in various studies and has become one of the most influential frameworks in cognitive psychology (30), and it has immediate implications for the findings of the present study. A high processing depth achieved, for example, trough practical experience and active application thus seems to favor encoding in long-term memory and better learning performance (28). This notion is also corroborated by recent findings on simulation-based learning (18–23).

In addition, the students' subjective evaluation of the course was significantly worse for the digital teaching format (DF) than for the traditional format (TF) or the hybrid format (HF) with hands-on teaching elements. This subjective evaluation of the digital format (lower grade) may also have an unfavorable effect on learning performance, e.g. by leading to lower learning motivation. A contributing aspect could be the "zoom fatigue" aspect: Zoom conferences are very tiring and exhausting. This is due to the following reasons, among others: excessive close-up viewing, cognitive load, increased self-assessment by staring at videos of oneself, and limited mobility (31). These factors may have led to a decline in attention and, consequently, to poorer knowledge acquisition. This finding would also be in line with the findings from the HF condition, which combined online and hands-on elements and, consequently, led to exam results that were intermediate between DF and TF. However, it should be noted that the subjective evaluation of HF was on a similar level as the one for TF; thus, it is reasonable to assume that the negative evaluation of DF cannot be attributed to digital settings per se, but instead seems to reflect certain aspects of digital teaching – in our case the practical application.

Furthermore, there are other potential reasons for the poor evaluation by the students. A recently published study shows that students are more likely to be dissatisfied with online learning and rate it significantly lower than faculty (32). One reason for this could be the lack of exchange or sharing and group learning in the digital format. Particularly in emergency medicine, group sizes of 6 are aimed for in order to train BLS (33–35). Many studies demonstrate the success of team-based learning (TBL) concepts in healthcare professions education (36–38). Another reason for the poor evaluation by the students could be the lack of communication skills in the digital setting (39). The loss of the constrained teaching of practical skills, communication skills, and team skills in digital learning formats is a very significant limitation.

An interesting observation is a difference in skewness of the distributions between the conditions. The most likely explanation for the latter is a ceiling effect in the TF group, which usually leads to a skewed distribution (cf. Figure 1), since the maximum value is fixed by definition. In other words, the skewed distribution is most likely a result of the high allover score level in TF. If the score level is lower, the distribution will be more symmetric (as in DF). The same effect appears to be true for the school grade as well.

This statistic effect may also be responsible for the more heterogeneous student evaluation of DF, which was in our case reflected by a larger SD and range compared to TF. Thus, the distribution is most likely a consequence of the generally lower ratings in DF. This is in line with findings from a recent review by Naciri et al. (40) who found that acceptance of digital teaching formats is generally only moderate among health profession students. The contributing factors are manifold and encompass usability and ease of use platforms, lecturer characteristics, system quality, the information provided, and available technical support (41).

Another noteworthy aspect is that the return rates of the evaluation were considerably different between the study groups: the mean return rate of TF was 60.90%, whereas the mean return rate of DF was only 30.26%. We can only speculate about the reasons for this difference; in our view, the most likely explanation is that the students in DF were oversaturated with digital content and thus not motivated to participate in another online activity. The essential question, however, is whether this had an influence on our study results. Differences in response rates can indeed be critical, e.g. if only those participants evaluated that were particularly unsatisfied with the course. However, looking at the statistics, we are confident that the latter was not the case in our study. For each of the three worst grades (4–6), even the absolute numbers in DF were higher than those in the entire TF group. Given the fact that DF was only one out of 10 semesters in total, it seems very unlikely that this finding was caused by a response bias. Specifically, the grades 4–6 made up for a total of 1.7% of the TF group evaluations- but for 32.6% of the DF group evaluations. Thus, we conclude that the evaluation differences reflect true dissatisfaction with DF and not a response bias.

There is theoretical content that can be taught very well digitally. However, as soon as complex clinical activities such as resuscitation are involved, practical instruction (within a learner's team) is indispensable in order to achieve the necessary depth of processing, as our results show.

These findings show the importance of further scientific review of different teaching concepts and their consequence for medical education. Specifically, if the decision is made again to discontinue hands-on practical teaching for whatever reason, we must be aware that a lack of essential knowledge may be the consequence. We need to ensure that future doctors are adequately trained and can start their careers without deficits. The results appear to be highly transferable to other educational settings where healthcare providers are prepared for their clinical work.

Limitations

The present study used a non-randomized study design. In other words, the allocation of the participants/ students to the study arms could not be randomized due to the pandemic situation. A proper randomization would have been desirable but was not feasible. Instead, we used a design with a historical control. This is clearly a limitation; to minimize any possible bias arising from this fact, we undertook all efforts to keep as many variables as possible constant between study arms, both concerning the teaching formats and the student samples.

Another limitation is the discrepancy of ∼10% in the number of hours of the two formats. This resulted not from differences in content but was due to the digital nature in the DF. Here, no room changes were needed, and no time was lost due to long pauses and scenario preparations.

A further limitation is that the present data set encompasses only one emergency medicine seminar. However, the sample size was considerable, and the results were remarkably clear; nonetheless, we need more data from other fields of medicine to establish the findings.

Conclusion

These study results show how essential and indispensable practical hands-on teaching is in medical education for knowledge acquisition. The interlocking of theoretical knowledge and practical skills as ensured by the learning spiral is indispensable. Thus, Bloom's and Miller's paradigms are transferable to today's digital world. Moreover, it can be assumed that these results provide evidence that a pandemic-induced decision back to purely digital courses may substantially impair essential knowledge of future physicians.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Anonymized original data are available from the authors upon reasonable request. Requests to access these datasets should be directed to lvogt@ukaachen.de.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the

Faculty of Medicine, RWTH Aachen University, Aachen, Germany. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

LV contributed substantially and has written the manuscript. She is first author of this manuscript and thus all other authors agreed to her first authorship. MK performed statistical analysis and data support. HS and MS collected the data and stored them carefully. SS and MK contributed substantially to the data interpretation and to the content of the manuscript. SS, MK, and RR have critically revised the manuscript for important intellectual content. All authors have made contributions to the manuscript and reviewed and revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2022.993337/full#supplementary-material

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Are we ready to collaborate? The interprofessional collaborative competencies of healthcare professionals in the Global South context

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Background: Current evidence of interprofessional collaboration suggests the importance of measuring and identifying the current state of the health professions' interprofessional competencies. Therefore, this study was aimed at measuring the interprofessional competencies of health professionals in the Global South context using the validated CICS29.

Materials and methods: This was a cross-sectional study involving 300 healthcare professionals of a newly established teaching hospital. Prior to the measurement of interprofessional competencies, the 29-items CICS29, which has been translated into Indonesian language, was revalidated using a confirmatory factor analysis (CFA). The 29 items of CICS29 were grouped into six subscales and each item was measured using a 5-point Likert scale. Data on gender, age, type of profession, and the length of working experience was also collected to identify whether discernible differences between grouping variables exists.

Results: Prior to measuring the interprofessional competencies, the validity of the instrument was established. Based on the CFA, the same six-factor model was found in the current study. The Indonesian CICS29 was reliable, with Cronbach alpha values of 0.921 for the whole instrument and that of each subscale ranged between 0.656 and 0.726. The mean total score of CICS29 was 128.53 (out of 145), ranged from 123 to 133.40 obtained by pharmacists and dentists respectively. No significant differences of CICS29 scores were found between grouping variables.

Conclusion: The current study has revealed relatively good interprofessional competencies of healthcare professionals working in a newly established

teaching hospital in the Global South healthcare context. Measuring the interprofessional competencies serves as baseline for further intervention to nurture and maintain collaborative practice. In addition, the current study has further proven the cross-cultural validity of CICS29, thus appropriate to be utilized in different setting and context.

KEYWORDS

interprofessional competency, health professions, CICS29, validity, interprofessional education

Introduction

The World Health Organization asserts the importance of interprofessional collaboration (IPC) practice to ensure safe and optimum patient care (1). IPC, as defined by Reeves et al. (2), is "the process by which different health and social care professional groups work together to positively impact care" (p. 7). Based on the systematic review published in the Cochrane Database of Systematic Reviews, Reeves et al. concluded that there are four types of IPC practice interventions: externally facilitated interprofessional activities, interprofessional rounds, interprofessional meetings, and interprofessional checklists (2). The systematic review suggested that these IPC practices could be effective in improving some clinical processes or outcomes, although the number of studies is small and there are limitations in terms of the studies' methodologies. Another recent systematic review and meta-analysis of randomized clinical trials by Pascucci et al. identified some positive outcomes of IPC in management of chronic conditions, although only a few studies had a moderate level of evidence (3). Some of the clinical outcomes are duration of hospitalization, reduction of glycated hemoglobin level, and low-density lipoprotein level. The authors concluded that the positive outcomes resulted from more coordinated and patient-centered care and improved quality of care.

Despite the impact of interprofessional education (IPE) on patient care that has started to emerge, Reeves et al. argued that understanding of the collaboration process is still lacking, including how such collaboration affects clinical outcomes and processes (2). The authors further suggested that future research should focus on how collaboration is conceptualized and measured. Irajpour and Alavi identified power differentials as factors influencing the interactions among health workers (4). Despite the extensive efforts to design and implement interprofessional education program, understanding how each profession perceive their power and other professions' power remains important (5). Mickan et al. in their case studies of IPE in several countries, both developed and developing, found common challenges in IPC which are the importance of good team functioning, a supportive system, including information management system and shared electronic health records and also clear protocols of case management (6). However, a study of IPC in a resource-limited setting showed how there are prominent professional hierarchy which inhibit collaboration, shortage of healthcare professionals and barriers of communication between healthcare professionals (7). Healthcare systems in a resource-limited setting are typically characterized by high patient load but limited resources, both human and infrastructures (8), in line with the classical characteristics of Global South context such as poverty, low health resources and limited access to medical education (9). Therefore, Nyoni et al. (7) suggested that there is a need for continued training on IPC in the healthcare setting and also to use the distributive leadership strategy to narrow the professional hierarchical gap.

Aside from understanding the nature of the collaborative practice, it is also important to learn about the interprofessional competencies of health care professionals. Measuring the interprofessional competencies of health care professionals is necessary given the role of health care professionals, especially those working in the academic health setting, as interprofessional role models for students (10). In a systematic review, Oates and Davidson identified nine instruments to measure the outcomes of IPE and collaborative practice in the health professions education setting and found a lack of evidence to support the instruments' construct validity (11). This particular systematic review only accounts for the instruments used in the pre-qualification setting. However, an instrument called the Chiba Interprofessional Competency Scale (CICS29) was developed by Sakai et al. to measure the interprofessional competencies of health professionals (12). The 29-item scale was developed in a Japanese health care context through a series of instrument development steps. Its six subscales—namely attitudes and beliefs as a professional, team-management skills, actions for accomplishing team goals, providing care that respects patients, attitudes, and behaviors that improve team cohesion, and fulfilling one's role as a profession—are considered compatible with the domains of IPC (13). The domains of IPC include roles and responsibilities, teams and teamwork, interprofessional

communication, values, and ethics for interprofessional practice. These four domains are targeted toward delivering patient/family oriented or community/population-oriented healthcare services (13).

Several studies on measuring interprofessional competencies, either in pre-qualification or post-qualification settings, have been conducted in Indonesia. Three studies from Syahrizal et al., Dewi et al., and Lestari et al. measured health professions students' readiness for and perceptions toward IPE (14–16), while Soemantri et al. translated the CICS29 into Indonesian language and provided evidence of its validity and used it in measuring the interprofessional competencies of health professions students (17). Based on a confirmatory factor analysis (CFA), they identified a good fit between the initial CICS29 model and the final one, following language adaptation. One study from Yusra et al. was conducted in the Indonesian healthcare professional setting in order to measure healthcare professionals' perceptions toward IPC (18). The authors used Collaborative Practice Assessment Tool (CPAT) to assess levels of collaboration and identify strengths and weaknesses in collaborative practice (19). The final version of the Indonesian CPAT is slightly different from the original one with three items from the original CPAT discarded; indicating further investigation of the stability of the factors in the instrument in future research. Furthermore, because the CPAT consists of 56 items, the number of respondents in Yusra et al.'s study (n = 304) was considered relatively inadequate for a factor analysis (18).

Current evidence of IPC suggests the importance of measuring and identifying the current state of health professionals' interprofessional competencies to make an informed decision about any intervention programs to improve hospital collaborative practice. Given the limited evidence available related to the healthcare professionals' interprofessional competencies from the Global South healthcare context, with its typical characteristics such as limited healthcare resources, we argue for the need to measure it. The 29-item CICS29 is assumed to be the fit-for-purpose instrument since its validity has been established through CFA. Therefore, the aim of this study is to measure the interprofessional competencies of health professionals working in a hospital setting within the Global South context using the CICS29.

Materials and methods

Study context

The study was conducted at a university hospital which was recently established. One of the hospital's missions is to conduct IPE, and the hospital also aims to provide interprofessional collaborative health care services.

Study design

This single-site study employed a cross-sectional design to measure the interprofessional competencies of health professionals working at one university hospital using the Indonesian CICS29. Prior to analyzing the interprofessional competencies of healthcare professionals in this study, the validity of the instrument was previously established through calculating the internal consistency and conducting the CFA.

Instrument

The CICS29 consists of 29 items grouped into six subscales (12). Each item is measured using a 5-point Likert scale, from five ("always") to one ("never"), with a maximum possible total score of 145. Demographic data such as gender, age, type of profession, and years of working experience was obtained. The CICS29 has previously undergone forward and backward translation into Indonesian language in the study by Soemantri et al. (17).

Data collection

Four hundred and fifty-seven healthcare professionals, including doctors, nurses, pharmacists, dentists, public health officers, and other allied health professionals, were invited to participate in the study. Three hundred health care professionals (65.6%) participated in this study. The details of the participants are provided in **Table 1**. Based on the requirement for factor analysis, which is 10 participants for each item in the instrument under study (20) and with the calculated minimum sample size of 209, the sample of health care professionals obtained in this study was deemed sufficient. The anonymous instrument was administered online using Google Forms, and the invitation was sent to potential participants through email and WhatsApp. The instrument was administered between October and December 2020. By completing the instrument, the participants provided their consent to participate in the study.

Data analysis

To ensure the validity of the instrument, the data first underwent CFA using Stata 14 software to confirm the CICS29 model as compared with the original one. Following the confirmation of the CICS29 model, the internal consistency of the instrument was calculated. Further analysis was then conducted using SPSS 22.0 to examine the distribution of CICS29 scores and to identify whether discernible differences in the measurement results existed in relation to several variables such as age, gender, types of professions, educational

TABLE 1 Demographic characteristics of the respondents (N = 300).

Characteristics	*N*	%
Age (years)		
20–29	228	76
30–39	62	20.7
40–49	6	2
50 and above	4	1.3
Gender		
Male	59	19.7
Female	241	80.3
Educational background		
Vocational study	11	3.6
Undergraduate study	236	78.7
Postgraduate study	53	17.7
Length of working experiences in the current hospital		
1–15 months	186	62
16–30 months	103	34.3
Above 30 months	11	3.7
Profession		
Medicine	36	12.0
Dentistry	5	1.7
Public health	3	1.0
Nursing	244	81.3
Pharmacy	6	2.0
Other allied health professionals	6	2.0
Working status		
Part time	266	88.7
Full time	34	11.3

background (vocational/undergraduate/postgraduate), working status (full time/part time), and length of working experience.

Results

The validity of the Indonesian CICS29

The descriptive analysis was performed first to examine the validity of each CICS29 item by identifying the item-total correlation and Cronbach's alpha of each item (**Table 2**). A CFA was then performed (**Figure 1**), which confirmed the previous models, not only the one by the original developer, Sakai et al. (12), but also that of Soemantri et al. (17) in their validation study of the Indonesian CICS29 in the medical and healthcare professions education setting. The subscales in the current Indonesian CICS29 have again proven their comparability to the original subscales in the model developed by Sakai et al.: (1) attitudes and beliefs as a professional, (2) team-management skills, (3) actions for accomplishing team goals, (4) providing care that respects patients, (5) attitudes and behaviors that improve team cohesion, and (6) fulfilling one's role as a professional (12). Based on Hu and Bentler's two-index presentation strategy (21), the combined value of the root mean square error of approximation (0.066) and standardized root mean square residual (0.057) indicated the goodness of fit of the current model.

The validity of the instrument was further established by determining the reliability of the instrument as a whole and of each subscale. The Cronbach alpha value of the whole instrument was 0.921, and the value for each of the subscales was as follows: attitudes and beliefs as a professional (ABP), 0.732; team-management skills (TMS), 0.621; actions for accomplishing team goals (ATG), 0.726; providing care that respects patients (PCRP), 0.669; attitudes and behaviors that improve team cohesion (ABTC), 0.657; and fulfilling one's role as a professional (FRP), 0.656.

Interprofessional competency of health care professionals

Using the validated CICS29, we examined the interprofessional competencies of the participants. The mean total CICS29 score was 128.53 (out of 145, 88.6%), ranging from 123 (mean CICS29 score of pharmacist profession) to 133.40 (mean CICS29 score of dentist profession). Based on a one-way ANOVA, we found that there were no significant differences between the total mean score of each profession group, $F_{(5,294)} = 0.644$, $p = 0.666$. The scores of each subscale also did not significantly differ between profession groups, ABP, $F_{(5,294)} = 1.470$, $p = 0.200$; TMS, $F_{(5,294)} = 1.147$, $p = 0.336$; ATG, $F_{(5,294)} = 0.239$, $p = 0.945$; PCRP, $F_{(5,294)} = 1.751$, $p = 0.123$; ABTC, $F_{(5,294)} = 1.624$, $p = 0.154$; and FRP, $F_{(5,294)} = 1.048$, $p = 0.389$. Complete results of the mean scores of the total CICS29 and its subscales are presented in **Table 3**. We acknowledged that our results must be interpreted with caution given the large differences in sample size in certain groups; however, most of the homogeneity of variance (Levene's) tests showed non-significant results, which inferred that equal variances can be assumed. Significant Levene's test results only occurred in the first subscale (ABP).

The analysis also included the differences in the mean total CICS29 scores based on the grouping variables using the appropriate statistical analysis. The independent t-test analysis demonstrated no significant correlations on gender, $t_{(298)} = 1.881$, $p = 0.061$, and working status, $t_{(298)} = 0.582$, $p = 0.561$. Similar results were found using the one-way ANOVA on the variable of participants' educational background, $F_{(3,296)} = 0.908$, $p = 0.437$. A significant regression equation was not found between mean total CICS29 scores with age and length of working experiences, $F_{(3,296)} = 0.534$, $p = 0.660$, with an R^2 of 0.005. The predicted mean CICS29 total score is equal to 127.506–0.040 (length of working experiences) + 0.146 (age).

TABLE 2 The Indonesian version of CICS29 items.

Subscales	Item numbers	Item-total correlation (r)	Cronbach's alpha if item deleted	Items
Attitudes and beliefs as a professional (ABP)	27	0.533	0.918	*Saya selalu berusaha memperbaiki keterampilan saya* (I constantly strive to improve my performance)
	5	0.444	0.919	*Saya selalu melakukan refleksi terhadap tata laksana yang saya lakukan* (I always reflect on the care that I have provided)
	4	0.385	0.920	*Saya berusaha menjadi sosok profesional* (I strive to be a professional)
	17	0.617	0.917	*Saya dapat melakukan tata laksana pasien berdasarkan bukti terkini* (I practice evidence-based care)
	16	0.640	0.916	*Saya dapat menjelaskan dasar keilmuan tata laksana yang saya lakukan* (I am able to explain the basis for care to anyone)
	13	0.499	0.918	*Saya melakukan pekerjaan sesuai keilmuan yang diajarkan* (I am able to apply updated expert knowledge to actual practice)
Team-management skills (TMS)	12	0.608	0.917	*Saya memahami ruang lingkup dan batasan kerja anggota tim* (I understand the scope and limits of my team members' work)
	26	0.476	0.919	*Saya mempertimbangkan kesibukan dan kecepatan kerja anggota tim lain* (I respect my team members' busy schedules and work pace)
	6	0.474	0.919	*Saat terjadi masalah, saya dapat bekerja sama dengan anggota tim lain untuk memecahkannya* (I cooperate with my team members to try to solve problems when the team is not functioning well)
	2	0.376	0.921	*Saat terjadi konflik antar anggota tim, saya berusaha menyesuaikan diri untuk menyelesaikan konflik tersebut* (I reconcile conflicts among team members)
	22	0.473	0.919	*Saya mengetahui pada kondisi apa masalah mudah terjadi* (I know when problems within the team are likely to arise)
Actions for accomplishing team goals (ATG)	24	0.549	0.918	*Saya dapat menjelaskan pencapaian tim* (I am able to explain the results of my team's initiatives)
	11	0.566	0.918	*Saya dapat menyesuaikan perilaku untuk mencapai tujuan tim* (I am able to adjust my practices to achieve the team's objectives)
	14	0.662	0.916	*Saya dapat menyesuaikan pendapat selaras dengan tujuan tim* (I am able to coordinate the opinions of myself and my team members in light of the team's objective)
	10	0.403	0.920	*Saya mendukung pengembangan kompetensi masing-masing profesi* (I provide necessary support to my team members depending on their professional competencies)
	18	0.633	0.916	*Saya dapat melakukan evaluasi kerja tim secara objektif* (I am able to objectively evaluate whether the team is operating well)
Providing care that respects patients (PCRP)	3	0.414	0.920	*Saya tidak hanya menghormati kepentingan pasien, tetapi juga memperhatikan keinginan keluarga pasien* (I respect not only the wishes of the patient but also those of the patient's family)
	1	0.395	0.920	*Tata laksana pasien dilakukan dengan memperhatikan otonomi pasien* (I keep patient independence in mind when providing care)
	8	0.513	0.918	*Saya melibatkan pasien dalam proses pengobatan* (I interact with patients to help them make their own decisions)
	25	0.569	0.917	*Dalam interaksi dengan pasien, saya menyesuaikan dengan karakteristik dan kondisi pasien* (I change my manner of interacting with patients based on their characteristics and situations)
	20	0.498	0.919	*Saya selalu berusaha memberikan tata laksana terbaik untuk pasien* (I seek the best way to care for patients)

(Continued)

TABLE 2 (Continued)

Subscales	Item numbers	Item-total correlation (r)	Cronbach's alpha if item deleted	Items
Attitudes and behaviors that improve team cohesion (ABTC)	15	0.480	0.919	*Saya berusaha berkomunikasi dengan cara terbaik dengan anggota tim dari profesi lain* (I consciously create opportunities for communication with other professionals)
	28	0.487	0.919	*Saya secara rutin membahas tata laksana pasien dengan anggota tim dari profesi lain* (I discuss ideal patient care with other professionals daily)
	29	0.569	0.917	*Dalam pertemuan, saya berusaha menciptakan suasana yang memudahkan tukar pikiran dengan anggota tim profesi lain* (I try to create a suitable atmosphere during meetings wherein it is easy for other professionals to speak)
	19	0.565	0.918	*Saya berusaha membangun hubungan baik dalam melakukan pekerjaan dalam tim interprofesi* (I strive daily to create good interpersonal relationships between professionals)
Fulfilling one's role as a professional (FRP)	7	0.520	0.918	*Saya dapat menerima masukan sesuai kepakaran profesi lain* (I am able to express opinions in front of other professionals based on my expert knowledge)
	23	0.571	0.917	*Saya dapat menjalankan peran profesi sesuai kebutuhan tim* (I fulfill my professional role as required by my team)
	21	0.626	0.917	*Saya memahami lingkup pengetahuan dan keterampilan sesuai profesi* (I understand the scope of what can be accomplished through professional expertise and skills)
	9	0.476	0.919	*Saat terjadi konflik antar profesi, saya akan memberikan pendapat sesuai keilmuan saya* (I am able to state my opinions when necessary from the viewpoint of my professional expertise, even if doing so creates friction with other professionals)

Sentences written in italics are in Indonesian (the English versions of the sentences are provided in brackets).

Discussion

The findings of the CFA have demonstrated the validity of the CICS29 as an instrument to measure health professionals' interprofessional competencies. The original CICS29 has also been validated in the Italian setting (22), where the authors confirmed the six-factor model as originally developed by Sakai et al. (12), based on the data obtained from 530 healthcare professionals. The current study in which the Indonesian version of CICS29 was administered to healthcare professionals in a single hospital demonstrated the same six-factor model (ABP, TMS, ATG, PCRP, ABTC, and FRP). Furthermore, the Cronbach alpha values are comparable to those of other studies. For example, for the ATG subscale, the Cronbach alpha value in the current study was 0.726, whereas Tonarelli et al. obtained a value of 0.77 for the same subscale (22).

Since the CICS29 has undergone several CFAs in different settings and countries and still retains its original six-factor model, we argue for the strength and quality of the instrument, which further support the suitability of its use in measuring interprofessional competencies in the current setting. Peltonen et al. (23) in their scoping review identified 29 instruments measuring IPC and found few studies which have reported the construct validity of those instruments. Moreover, the authors also revealed that most studies included in their scoping review involved only two major groups of health professions (i.e., doctors and nurses). Therefore, we argue that our study has also supported the validity of CICS29 across professions since we involved six professional groups as study participants. Other studies utilizing the CICS29 have also involved more than two professions, for example psychologists, social workers, and radiology technicians (22), as well as pharmacists, dieticians, and rehabilitation-related therapists (12).

Using the valid Indonesian version of the CICS29, the interprofessional competencies of health professionals in this study were measured. Despite the unavailability of clear guidelines on how to categorize and interpret the CICS29 scores, the interprofessional competencies of the study participants are considered satisfactory because the mean total score of the CICS29 was around 88.6% of the maximum possible score. Other studies in the healthcare professional setting measured the perceptions of health care professionals toward IPC practice. For example, Soemantri et al. (24) conducted a study in another newly established teaching hospital using the Indonesian CPAT and found a median score of 205 (out of 265, 77.4%), whereas in one of the oldest teaching hospitals in the country, with the same instrument, Yusra et al. (18) obtained a median score of 205.5 (out of 265, 77.5%). Both studies were conducted in the

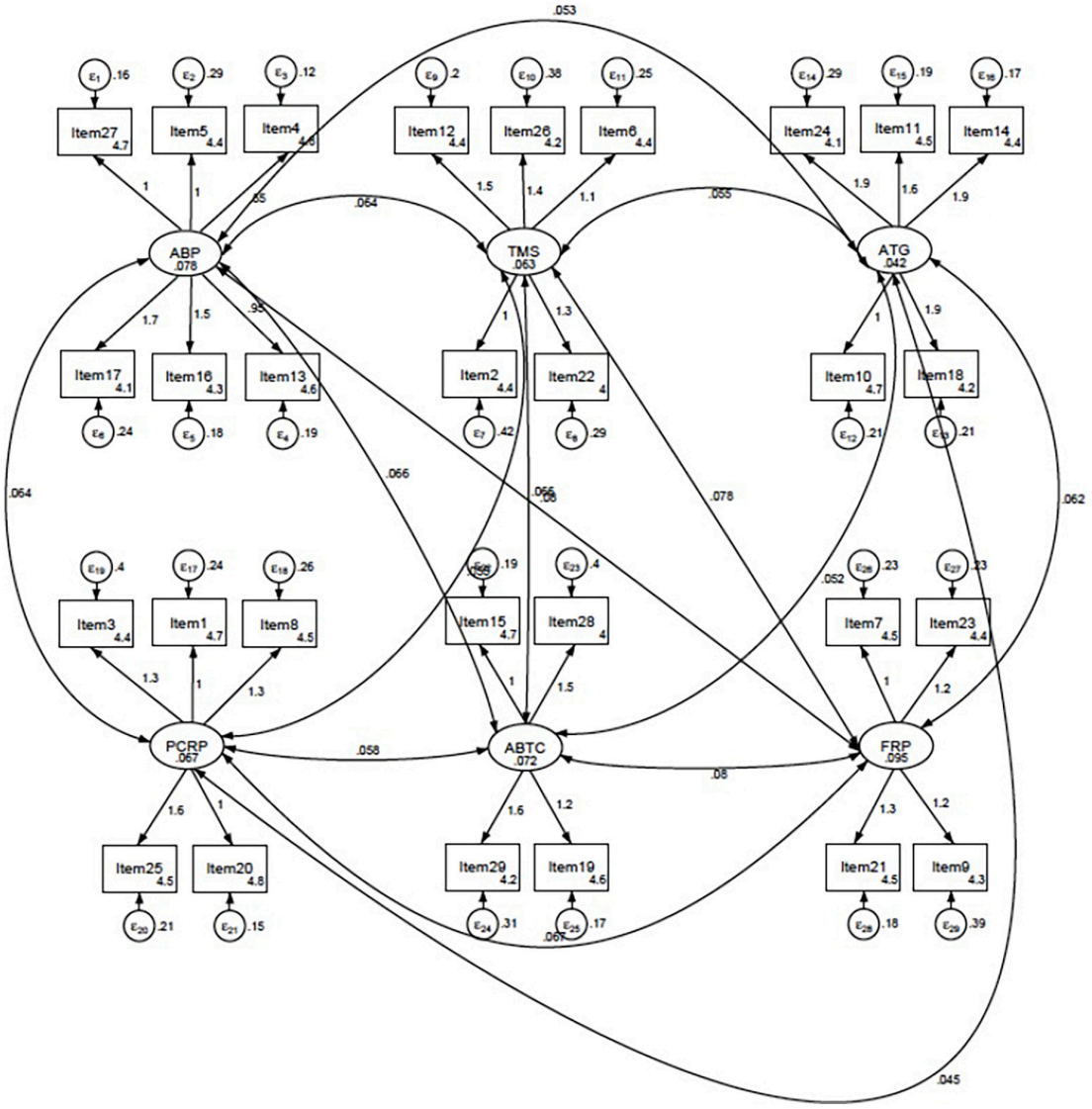

FIGURE 1
Final model of the CICS29 in the current study established through confirmatory factor analysis (CFA). ABP, attitudes and beliefs as a professional; TMS, team-management skills; ATG, actions for accomplishing team goals; PCRP, providing care that respect patients; ABTC, attitudes and behaviors that improve team cohesion; FRP, fulfilling one's role as a professional.

TABLE 3 Mean scores of total CICS29 and each of the subscales.

Profession	*N*	Mean score						
		Total CICS29	Subscale 1: ABP	Subscale 2: TMS	Subscale 3: ATG	Subscale 4: PCRP	Subscale 5: ABTC	Subscale 6: FRP
Doctors	36	128.53	27.61	20.89	21.75	23.11	17.11	18.06
Dentists	5	133.40	27.80	22.00	22.40	24.20	18.20	18.80
Nurses	244	128.55	26.99	21.48	21.93	22.92	17.64	17.59
Pharmacists	6	123.00	25.50	20.67	21.33	21	16.17	18.33
Public health officers	3	129.67	28.33	21.33	22.33	23.33	16.67	17.67
Other allied health professionals	6	129.00	27.17	22.50	22	22.50	17.17	17.67
P-value from one-way ANOVA		0.666	0.200	0.336	0.945	0.123	0.154	0.389

Indonesian healthcare service setting; therefore, although direct comparison with the results of the current study cannot be made given the different instruments used, we can conclude that the perceptions toward collaborative practice and interprofessional competencies of health care professionals in Indonesia are relatively good.

Based on the breakdown of subscales, the relatively high CICS29 subscale scores indicated that most participants in this study have what it takes to become effective interprofessional team members. Since the CICS29 subscales represent the essential abilities and attitudes for effective IPC, summarized by Reeves (25) in his editorial review of various interprofessional competency frameworks. The ABP subscale indicates values and identity as a professional. Majima et al. (26) found that nurses in their study valued their work highly and this has led to increase job satisfaction. The TMS, ATG, ABTC, and FRP subscales relate to teamwork. Reeves (25) highlighted that teamwork involves clear roles and responsibility among team members, shared goals and responsibility, shared identity as a team and interdependence between members. The last subscale is PCRP which indicates the ability of healthcare professionals to provide patient-centered care. Dahlke et al. (27) demonstrated that older people and their families appreciate the delivery of healthcare services which have taken into account the characteristics of the elderly population. The data of total CICS29 and its subscales scores can serve as baseline data which can be re-evaluated following a particular intervention to improve collaborative practice, for example a study by Shikino et al. (28) has found increases in CICS29 scores after a simulation-based training for delirium management.

The study findings also demonstrate that there are no statistically significant differences in the CICS29 scores based on professions and other discerning variables such as age, gender, working status, and length of working experiences. Older age and longer working experiences have been found to be the factors that influence IPC (15). Because the hospital in which the study was conducted is a newly established hospital, most of the hospital's health care professionals have similar characteristics, for example in terms of length of working experiences and age. These characteristics might be partly responsible for the attainment of a relatively similar level of interprofessional competencies. It is also likely that the hospital's mission to provide collaborative healthcare services has imbued each individual to conduct collaborative practice. Soemantri et al. (24) found similar results in their study involving health care professionals in a newly established hospital and argued that power distance is narrow between health care professionals in that particular setting, which results in them having relatively similar perceptions toward collaborative practice. However, a study in an older hospital also found relatively positive attitudes and perceptions toward interprofessional collaboration (18) thus other factors play important roles in affecting interprofessional competencies. Dahlke et al. (29) summarized the four factors influencing collaboration process which are relational (professional power, hierarchy and socialization process), processual (time and space for collaboration), organization (system and resources to collaborate) and contextual issues (sociocultural, political and economic). Given these complex interconnected issues, the causes of positive perceptions toward IPC and good interprofessional competencies are very much multifactorial, for example when healthcare professionals in a certain hospital are very diverse, there needs to be stronger system and resources in place to facilitate the IPC.

Based on the study findings, several implications can be outlined. First, measuring healthcare professionals' interprofessional competencies is important to serve as baseline for assessing the effectiveness of any interventions to improve collaborative practice. Second, the CICS29 is proven to be one of the instruments with cross-cultural validity, thus using the same instrument results from different countries can be directly compared to further inform IPC practice throughout the world, including within the Global South healthcare context. This is perhaps even more important for the Global South healthcare context since the hierarchical professional boundaries can be more prominent (7). Third, based on the subscales of CICS29, each component of collaborative practice, starting from the teamwork skills, professional roles to individual professional's identity can be assessed and intervened.

We acknowledge the limitation of the study in that it only involved one hospital in Indonesia. Therefore, the study might not be directly generalizable. As with other self-administered scales, there is a possibility for participants to provide socially desirable responses, which might not reflect the real situation. Despite these limitations, we believe that our study has contributed to the understanding of healthcare professionals' interprofessional competencies in a Global South healthcare context. Measuring health care professionals' interprofessional competencies could serve as the basis for intervention programs to further improve interprofessional competencies and enable more patient-centered and collaborative care. Our study has also established the construct validity of the Indonesian version of the CICS29, including cross-cultural validity. Further study is necessary to include more study sites and explore each of the factors which influence collaborative practice in more depth, which can lead to an understanding of how IPC can be further nurtured and maintained, especially in the Global South healthcare context. Moreover, a study to examine the relationships between interprofessional competencies and certain healthcare outcomes is also worthwhile.

Conclusion

Measuring the interprofessional competencies of healthcare professionals in this study, using the CICS29 which has been proven to have cross-cultural validity, has advanced our

understanding in terms of how they perceive their competencies, especially in a newly established hospital in the Global South healthcare context. The current study has identified relatively good interprofessional competencies and moreover, no differences in the competencies based on professions, age, and length of working experiences were found. Thus, an effective collaborative practice is to be expected, along with continued awareness that collaborative practice is indeed a complex construct that requires further in-depth exploration and observation.

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 Research Ethics Committee, Faculty of Medicine, Universitas Indonesia. The patients/participants provided their written informed consent to participate in this study.

Author contributions

DS led the study from the concept development, data collection, data analysis, and manuscript development and wrote the first draft of the manuscript. AF, RW, SK, and DD contributed to data collection, analysis, reviewed, edited, and finalized the manuscript. All authors have read and approved the final version of the manuscript.

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Conflict of interest

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

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Is student mentoring career-defining in surgical disciplines? A comparative survey among medical schools and medical students for mentoring programs

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Objective: Facing a shortage of young surgeons, this study aimed to examine the availability of mentoring programs and if this can counteract this lack.

Summary background data: Medical mentoring programs have proven to be decisive to influence students' later career decisions. Since their structure may depend on the medical school and the effort of single disciplines, the offers are often very heterogeneous.

Methods: Anonymous online-questionnaires were developed and distributed among medical students in Germany and the dean for teaching of the medical schools from July 2019 to January 2020 in Germany. Data of the availability of mentoring programs, their structure and the impact of surgery were collected.

Results: Forty three medical schools participated, with 65% offering mentoring programs. 18 of medical schools had no additional funding available for this. Surgical subjects participated in these programs in only 30%. Additionally, 1,516 medical students participated in the second survey. A total of 70% had already participated in a mentoring program with a significantly higher proportion of men. Of these, 94% stated that this was helpful and had an impact on their career planning, without any gender differences. 95% would participate in structured surgical mentoring programs and 95% agreed that this could have an impact on their career planning.

Conclusion: Mentoring programs may be able to influence career planning, nevertheless participation by surgical specialties has been low. Becoming

more active in providing mentoring programs with a special focus on women and offering more surgical content can be a way to counteract the lack of surgical trainees.

KEYWORDS

mentoring, medical students, gender, career, surgery

Introduction

Factors influencing medical students in their choice of later specialization are not yet well understood. Even at the very end of their studies, there are still quite a few medical students without a clear choice of specialization (1). However, the current generation of students in particular attaches importance to the compatibility of family, career, and the workload expected in the future (2). All the more, it seems that the discussion of student recruitment during clinical training in their education is coming to the fore. One way to arouse the students' interest in different fields of study could be created and intensified with mentoring programs.

Mentoring programs in medical schools exist to provide students with support and guidance. Although the definition of mentorship varies, it is typically described as a relationship between a senior (mentor) to a junior person (mentee) to reflect career development, professional growth or satisfaction (3, 4). Nevertheless, the availability and structure of mentoring programs for medical students internationally, Europe-wide and nationally in Germany remains heterogeneous and confusing. Data from Germany published by Meinel et al. 10 years ago showed 22 mentor programs in German medical universities (5). No newer data have been collected since this study. Thus, the current situation for the proposal of mentoring programs in medical education in Germany is currently unclear, while also the international data situation is relatively low. An overview of published reviews of mentoring programs among medical students is shown in **Table 1**.

Declining interest in surgical careers has been observed for more than a decade (6). In addition, the community of medical professionals is aging (7). However, US data showed that while 45% of first-year medical students were interested in a surgical career, only 7% of graduating students were matched to surgical residences (8). Next to personal skills and experiences, the work-life balance becomes more and more important for young medical students (2, 9) rather incompatible with a surgical career. In addition, the presence of the mentor is very essential to 90% of the questioned students (10). Successful mentoring programs can lead to the strengthening of interests in the area concerned which in turn help to initiate a career decision. This is especially important as, the surgical specialties are facing a shortage of junior staff in Germany (11, 12).

The first purpose of the study was to assess the current situation of mentoring programs offered at medical schools from the perspective of medical schools and medical students.

On the one hand medical schools were evaluated for their range of mentoring programs and their structure, initiators, and funding. On the other hand, medical students were asked about their experiences with mentoring programs in their studies.

The second aim was to determine the current career planning of the students and to check whether the students feel that this can be changed through surgical mentoring programs.

Materials and methods

Questionnaire design

The study questionnaires were designed concerning published guidelines on questionnaire research in a web-based design (13). The selection of questions for the questionnaires were based both on comparable work and on the quality criteria for online questionnaires (14). The surveys were created in SurveyMonkey^{TM} (SurveyMonkey, San Mateo, CA). Both questionnaires are included as additional material.

Performance of the surveys

The students' survey was distributed among all medical student councils of the 36 medical schools in Germany. The duration of the survey was from July 2019 to January 2020. Medical students at all stages of their studies were included. In Germany, the study program is divided into 3 sections, the first 2 years of pre-clinical basic studies, 3 years of clinical studies and a practical year in the clinic. With a population of 98,736 medical students, a confidence interval of 95% and an error margin of 2.5, the target case number was 1,513. Thus the online survey can be considered representative of the entire German medical student population.

The questionnaire was distributed *via* e-mail distribution lists of the student councils to all enrolled students. In an information letter, participants were informed that their data would be treated strictly confidential and anonymized. Access

TABLE 1 Review articles searched by "mentoring" and "medical students" in PubMed on 11/01/2020.

References	Year	Main statement	Number of included articles
Skjevik et al. (41)	2020	Group mentorship programs benefit from being longitudinal and mandatory. They should provide regular meetings where discussions and personal reflection occur.	20
Chua et al. (42)	2020	In mentoring programs, there was a need for balance between ensuring consistency and flexibility to meet the individual needs of stakeholders throughout the stages of the mentoring process.	71
Guraya and Abdalla (43)	2020	Peer-assisted learning can be used as a valuable learning tool in the medical field.	11
Radha Krishna et al. (44)	2019	Role modeling, teaching and tutoring, coaching and supervision lie within a mentoring spectrum of increasingly structured interactions, assisted by assessments, feedback and personalized support that culminate with a mentoring approach.	104
Farkas et al. (45)	2019	Mentoring programs for medical students can positively improve medical school satisfaction and career development.	30
Nimmons et al. (46)	2019	Outline of the challenges encountered, potential benefits, and critical future implications for mentees, mentors, and institutions.	82
Tan et al. (47)	2018	There were two vital elements of an effective mentoring framework: flexibility and structure	34
Burgess et al. (48)	2018	Mentoring had an essential influence on personal development, career guidance and career choice.	not named
Frei et al. (49)	2010	Mentoring was a career advancement tool for medical students.	25
Buddeberg-Fischer and Herta (50)	2006	Despite promising results, no publication contained statements on the effectiveness or the efficiency of the programs.	16

Of the 346 articles found, ten could be included. Inclusion criteria were review articles, where medical students were addressed with mentoring programs during medical school. The main statements of the reviews were mentioned. Nine reviews point out the importance of mentoring programs and try to evaluate important facts for the successful program. One review criticizes the lack of information on the effectiveness and efficiency of the programs.

to the study was granted with a survey link and a QR (quick response) code in the cover letter. The responsible local ethics committee was informed and had no objections to the study.

The medical school survey was distributed among all deanery of the 50 medical universities of German-speaking medical schools in Germany, Austria and Switzerland between October till December 2020 *via* email. In an information letter, participants were informed that their data would be treated strictly confidential and anonymized. Access to the study was granted with a survey link and a QR code in the cover letter.

Medical school questionnaire contents

A 12-item, self-administered online questionnaire survey was developed according to the students' questionnaire. The main sections were:

1. *Existence and claims*: Number of students enrolled, offers of mentoring programs and their use of these by students
2. *Structure of the mentoring programs*: disciplines involved, specifications for the structure, Requirements for the structures and specifications for the structure and content of the program, possible orientation toward defined standards of the German Medical Association
3. *Finances and support*: Funding of mentoring programs, desire of medical schools for support from professional societies or academic institutions
4. *Demand*: assessing the potential uptake of mentoring programs by students if they were offered.

Students questionnaire contents

A 10-item, self-administered online questionnaire survey was developed based on a comprehensive list of questions bases on the published research in mentoring among medical students. Members of the Teaching Working Group of the DGOU (German Society of Orthopaedics and Traumatology) Young Forum were invited for the validation process to provide feedback on question format, comprehensiveness, clarity, and flow (15). According to this, the questionnaire was refined. It consisted of five binominal questions and five multiple-choice questions and was entitled "mentoring programs for a surgical career." The main sections were:

1. *Epidemiological demographics*: gender and study level.
2. *Mentoring relationships:* Participation in a mentoring program in the past, benefits from the mentoring program, positive encouragement of choice of specialization

3. *Career specialization:* Desired subject choice, if surgical, which specific discipline
4. *Mentoring relationship in surgery:* Wish for participation in a structured mentoring program in surgery, assumption of the positive influence on the choice of a surgical specialty

The aim was a short duration of the survey of maximum of 3 min to keep the drop-out rate as low as possible and the motivation to answer the questions as high as possible (16). Also, open questions were avoided, as this can also have a demotivating effect on the participants.

Data analysis

Only fully completed questionnaires were included in the subsequent analysis. Analysis of results was undertaken using SurveyMonkey^{TM} and the Statistical Package for the Social Sciences, SPSS (version 17.0, SPSS Inc., Chicago, IL, USA). *P*-values were calculated using the Mann-Whitney *U*-test. A *p*-value of less than 0.05 was considered to be significant.

The responsible local ethics committee was informed and had no objections to the study (Reg.-Nr.: 2019-1456-Bef). All experimental protocols were approved by the local ethics committee of the University Jena. The informed consent was obtained from all participants.

The study was carried out in accordance with the relevant guidelines and regulations.

Results

Medical school questionnaire

Of the 50 German-speaking universities that offer medical studies, 86% (43/50) took part in the survey.

Existence and claims

The majority (51%; 22/43) of universities had 2,000–4,000 students of human medicine, 35% of the universities had less than 2,000 students and 14% had more than 4,000 students. 65% (28/43) of the universities offered a mentoring program for students, 12% (5/43) said they planned to offer one in the future and 19% (8/43) had offered a program in the past but no longer did so. Only two of the universities negated the question if they considered a mentoring program. The acceptance of such programs by the students was mixed. An average of 200–500 students per medical school was indicated to take part in a mentoring program. Overall, approximately 20% (16,400/82,050) of medical school students participated in a mentoring program.

Structure of the mentoring programs

Seventy two percent (31/41) of the universities described their planned, past or current mentoring program to be structured, with 71% (29/41) referring to defined individual criteria regarding the structure, content and organization of the mentoring program. Only 29% (12/41) of the universities adhered to the standards of the German Medical Association. A total of 37% (15/41) offered their mentoring program across clinics. Surgical subjects participated in the mentoring programs in 46% (13/28).

Finances and support

Funding is provided by 43% (18/42) without an existing budget. A total of 9% (4/42) medical schools had up to 5,000 Euros, 29% (12/42) between 5,000 and 10,000 Euros, 7% (3/42) between 10,000 and 20,000 Euros and 7% (3/42) 20,000–50,000 Euros, and 5% (2/42) over 50,000 Euros as budget for mentoring programs. Whether medical schools wanted more support from professional societies or from academic institutions, 45% (19/42) answered yes. One medical school did not answer the questions about funding.

Demand

All 14 medical schools that do not currently offer a mentoring program saw students taking part of any offered mentoring program.

Students questionnaire

Of the 98,736 medical students enrolled at German medical schools (in 2019/2020), 1,516 responses could be received. This corresponded to a percentage of 1.54%.

Epidemiological demographics

Overall, 55% participants were male (n = 653), female (n = 840) and divers (n = 23). Responses were received from medical students in early semesters (first 2 years of studying pre-clinical medicine) in 10% (n = 156), from the later semesters (3 years of studying clinical medicine) in 35% (n = 535) and from the practical year 42% (n = 634), 13% (n = 191) were not defined (pregnancy, vacation semester, PhD thesis).

In the pre-clinical semester significantly more female students (f = 89, m = 67; $p < 0.001$) answered the questionnaire and in the practical year more male students (f = 241, m = 382; $p < 0.001$). For the clinical part, an equal distribution was

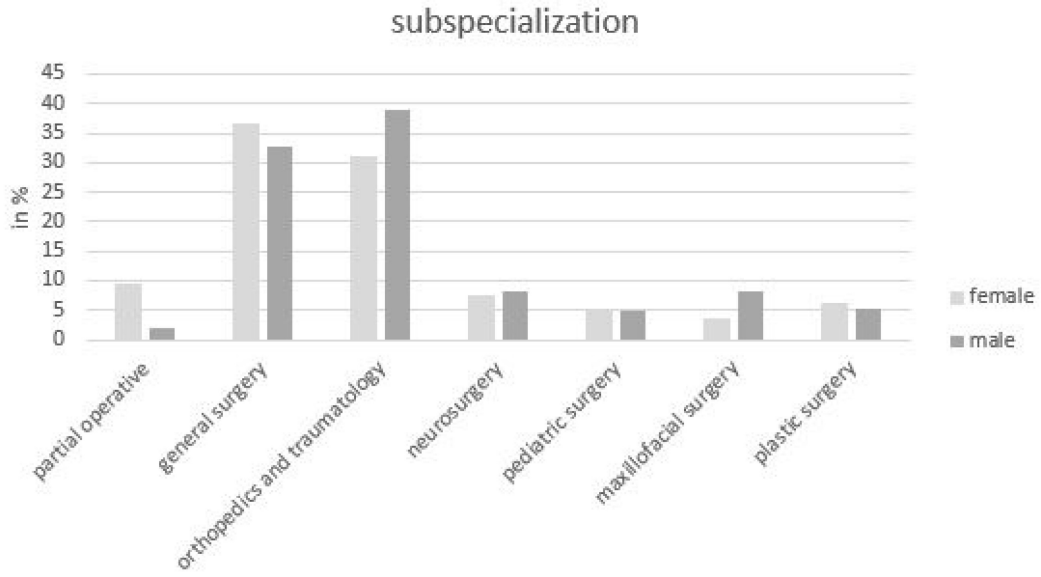

FIGURE 1
Epidemiological breakdown of the questionnaire replies. The data were given in percent, subdivided by gender and semester level (n = 1,516).

observed (f = 246, m = 280; p = 0.54). Participation increased as students reach a higher level of education (Figure 1).

For further analysis diverse gender (n = 23) was specified but not statistically evaluated due to the small numbers to keep the clarity.

Mentoring relationships

The majority (70%, 1,059/1,516) of those surveyed had a mentor-mentee relationship in their previous studies (Figure 2). Significantly more male students than female ones had taken part in a mentoring program in their studies (f = 415, m = 622; $p < 0.001$). In the higher semesters, the number of students who had attended a mentoring program was significantly higher (pre-clinical = 58, clinical = 396, practical year = 486, other = 97; $p < 0.001$). In the practical year, 70% (168/241) of the female and 83% (318/382) of the male students had participated in such a program.

Of the responses with a mentoring relationship, 94% (993/1,059) considered this as helpful with a personal benefit and 94% (1,000/1,059) confirmed an influence on the later choice of career specialization through the mentoring relationship. There was no significant difference in gender (f = 392, m = 601; p = 0.61), but in study period (pre-clinical = 53, clinical = 386, practical year = 487, other = 89; p = 0.01).

Students of pre-clinical medicine (5%; 5/58) tended to deny that the mentoring program influenced on their later careers. Only 3% (37/1,059) did not see any connection between participated mentoring programs to their career specialization. Higher semester students (98%; 488/496) saw an influence on their choice of subject area.

Career specialization

A total of 77% (1,161/1,516) of the responders were interested in a career in a surgical specialization. Interestingly, there was no difference in gender for choosing a surgical career (f = 500, m = 645; p = 0.87). Study period had no significant influence on surgical career choice, too (pre-clinical = 121, clinical = 414, practical year = 486, other = 140; p = 0.19).

Subdividing the surgical career opportunities, 96% (1,097/1,161) voted for surgery and 4% (47/1,161) for specializations with partial surgical care like gynecology, urology or otorhinolaryngology. Gender had an important influence. Female students wished to choose disciplines with partial surgical care and male rather wished to choose surgical careers (f = 34 m = 12; $p < 0.01$). In this question, the study period within the medical education program showed no significant influence (pre-clinical = 7, clinical = 19, practical year = 17, other = 4; p = 0.295).

Surgery was divided into general surgery, orthopedics and traumatology, neurosurgery, pediatric surgery, maxillofacial surgery, and plastic surgery. Most students were interested in orthopedics and traumatology (37%) and general surgery (35%). Looking at the percentage distribution of sexes of the most strongly represented surgical disciplines individually, more female students wanted to go into

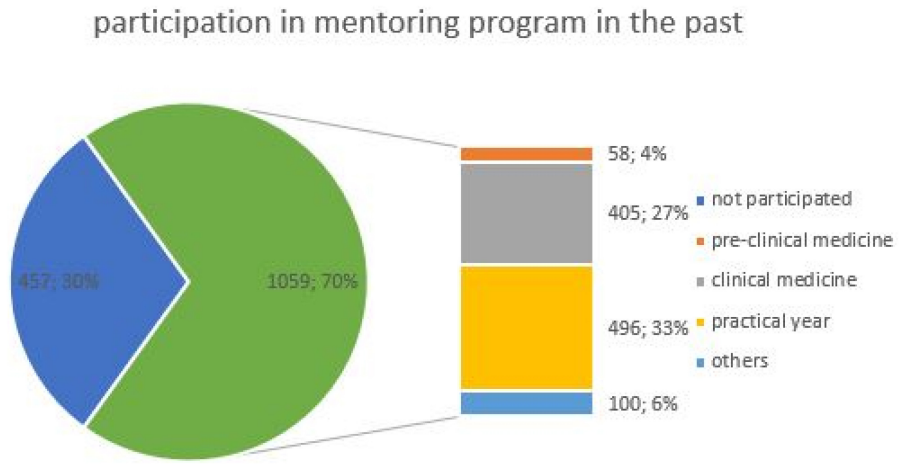

FIGURE 2
Distribution of students who had participated in the mentoring program in the past in absolute numbers (n = 1,516) and in percent. The figure is divided according to the participation mentoring program in the pie chart (blue: not participated, green: participated) and divided by study period in the bar chart.

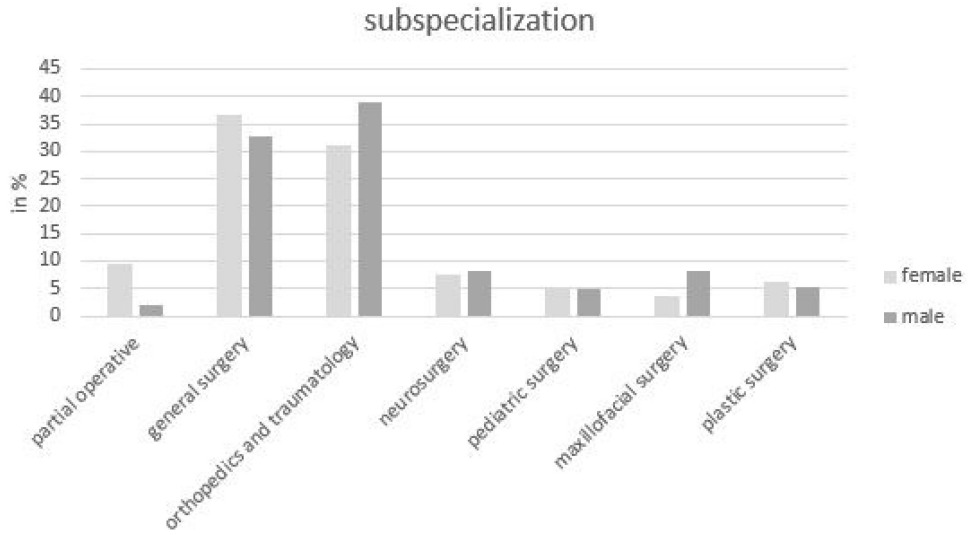

FIGURE 3
Distribution of the sexes in the surgical subjects in percent (absolute numbers) of all students, which want to choose a surgical subject area (n = 1,161).

general surgery (42%; 189/451) and more male students into orthopedics and trauma surgery (40%; 250/633) (Figure 3).

Mentoring relationship in surgery

When asked about possible participation in a surgical mentoring program, 95% (1,443/1,516) of the responders showed interest in such a program with the significant difference in gender (f = 607, m = 816; $p < 0.001$) and study period (pre-clinical = 147, clinical = 500, practical year = 619, other = 177; $p = 0.04$) (Figure 4).

The higher semester would take more frequently part in surgical mentoring programs. Male students (97%; 816/840) would be more likely to participate in a surgical mentoring program than female students (93%; 607/653). Additionally, 95% (1,438/1,516) thought, a mentoring program could influence their choice toward a surgical specialization with significant difference in gender (f = 607, m = 811; $p < 0.001$) or study period (pre-clinical = 146, clinical = 502, practical year = 615, other = 175; $p = 0.04$). Only a remarkably small

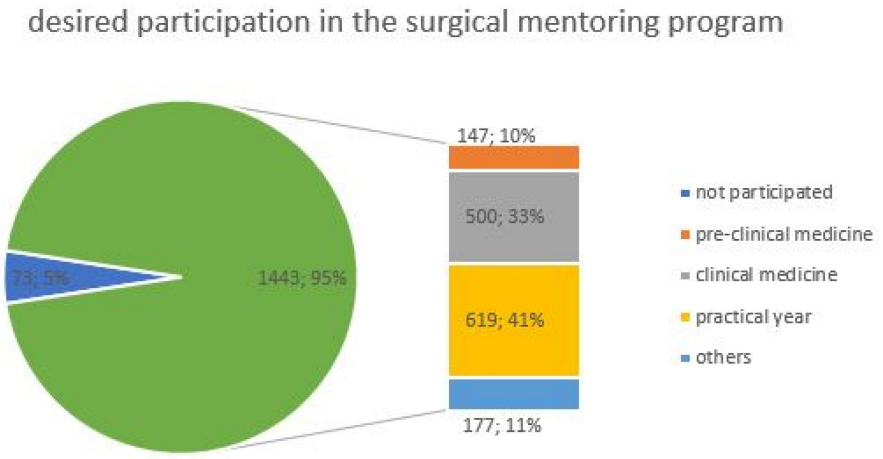

FIGURE 4
Distribution of students who wished to participate in a surgical mentoring program (n = 1,516). The figure is divided according to the participation mentoring program in the pie chart (blue: not participated, green: participated) and divided by the study period in the bar chart.

proportion of students 9 (4 female, 5 male) denied any expected effect on a surgical career choice by a mentoring program.

Discussion

As a multicenter survey this study aimed to provide an overview of presence and participation in mentoring programs. The study focused on questions from medical schools and students about the availability and use of mentoring programs.

When mentoring programs are available for students, this could influence the choice of specialization for surgical specialties (17). Knowledge about the impact of mentoring programs in medical undergraduate education could be used to guide young people also into disciplines with a shortage of young talents. To the authors' knowledge, this is the first representative study dealing with the current mentorship availability and at the same time included the choice of surgical career specialization in the consideration in Germany.

Currently, about two-thirds of German-speaking medical schools offer mentoring programs. This results in 1 in 3 students not even having the opportunity to decide if they want to participate in a mentoring program in 2020. Although the remaining one-third of medical schools estimated that this would be well received by students, eight of the medical schools terminated existing mentoring programs. The number of participating students in the offered ones was low compared to the number of students enrolled at the single institutions. On average, 20% of students participated in a mentoring program. The question of whether there were simply not more places for mentees, or no student interest in this, cannot be answered by the study. It is striking, however, that of the 15 medical schools without offering mentoring programs, nine have no budget for it. The question is whether providing more financial resources could significantly increase the opportunities for mentoring programs.

A wide gap is emerging between the answers of universities (20% participation rate of students) and medical students (70% took part in a mentoring program). While the medical school survey reflects the more objective situation, a selection bias in the student survey may exist, since especially students who were already familiar with the topic of mentoring participated. Also the different definition as an objectifiable mentoring relationship to rather loose mentorships, which are difficult to trace on the part of the medical school, could play a role. As a sign of this bias, 71% of medical schools offer structured mentoring programs, as the majority of more loose mentor-mentee relationships are not reflected here. But the supply of possible mentee places is certainly also limited, so that even in existing mentoring programs not everyone with the desire to participate can do so. Furthermore, it is noticeable that only in 30% (13/43) of the medical schools surgical subjects were involved in mentoring programs, revealing an objective lack in surgical engagement in this topic. This development is particularly deficient in light of the growing shortage of young surgeons.

In the western world, high workload and low work-life balance are described as the main reasons why medical students do not plan a surgical career (2, 9, 18, 19). In contrast to the study of Kleinert et al., who stated that 11% of female and 19% of male German medial students planned a surgical career (12), 77% of the medical students in this study wanted to pursue a surgical career. It is likely that especially students interested in surgery participated in the survey, and even insecure students were more likely to choose a surgical specialty as this could be suggested by the questionnaire.

Analyzing the online survey in terms of students' gender, under-representation of women (45%) in the study becomes apparent and additionally the percentage of women decreased during the study periods. However, since females are with up to 70% much stronger represented among medical students, an equal distribution is still an under-representation of women (20). Women in particular showed significantly lower participation in mentoring programs in the past despite high interest in surgical mentoring programs, if they could decide. The study also showed that women were as likely as men to pursue a surgical career with a significantly more frequent decision to pursue disciplines with partial surgical care.

In literature, women are still a minority in surgery, accounting for 28% of surgeons in the USA (21) and 18% in Germany (20). The reasons for this were sexual harassment and gender discrimination (22–24), perceptions about the challenges of a surgical lifestyle, a lack of parental leave or childcare (22, 23, 25) and a lack of role models or mentorship (22–24, 26–29) in literature.

Interviewed at the Ruth Jackson Orthopedic Society about reasons for choosing an orthopedic specialty, female surgeons stated that participation in mentoring programs contributed in 27% to their decision-making process (30). The low percentage influence of mentoring programs in this study results from the fact that 81% of the respondents were retired members and mentoring programs had only become available in the last few decades. But if women participated, they showed better exam results through participation in mentoring programs in the study Fallatah et al. and believe in better career planning through the mentoring program (31).

If the choice of specialization was a parameter for effective mentoring programs, women could become the focus of this consideration as they are still underrepresented in the surgical disciplines and there is a strong interest (93%; 607/653) in surgical mentoring programs.

Looking at the study period, it becomes apparent, that higher semesters, such as clinical studies and practical years, assign a high value to mentoring programs. Mentoring programs are important in all study periods but seem to become even more decisive with the higher semesters. Some studies presumed that students decide their speciality at the end of studies or after they have graduated from medical school (32) others claimed that they make decisions about their future medical careers during or even before medical school (33). Other studies showed that the majority of students in their last year have not yet decided on a subject (34, 35).

Interesting, however, was the high number of students interested in surgical specialties over all semester periods in this study. A previously reported declining interest in surgery during the course of studies (36–38) could not be observed in the gained data. The interest in surgical career remained rather constant, as other authors described, too (1, 39). Many factors influence the choice of specialization some, like family recommendations already exist before the study, but many others were recognized only by contact to a special field (40). The higher value of the mentoring programs in higher semesters could have many reasons, such as support for doctoral theses or exam preparation. Since the choice of career is also made individually in the course of medical studies, a mentoring program should also be individually accessible in each study period.

Strength of the study

It is the first national study to look at peer mentoring programs at medical schools from the perspective of students and faculty, their availability, their usefulness, and their existence. Data from Germany were compiled by Meinel et al. published more than 10 years ago. These showed 22 mentoring programs at German medical universities and only investigated the presence of mentoring programs (5). No recent data have been collected since this study. The present study thus describes for the first time the views of students and medical faculties on mentoring in Germany and may form the basis for further studies. For the first time in German literature, the students' perspective on mentoring is also examined in detail in this case issue. Comparable data have not yet been provided. Thus, despite the low response rate, the available data may have made a significant contribution to the area of mentoring.

Limitations of the study

As a limitation, in particular, highly interested students may have responded earlier than undecided or already familiar with the topic, rather than students without any connection to the topic in the past. Participation rates increased with the semester, so many of the students have a good insight into the possibilities of choosing a field of study and may have already firmly chosen their field of study. Although there were significantly more women studying medicine, there is a male majority among the respondents, which may influence the data. The mentoring relationships were not recorded in more detail and qualitative (the type of mentoring relationship, mentorship goals) or quantitative (frequency of meetings, hierarchical level of the mentor-mentee relationship) criteria of the mentoring relationship were not asked. But by simplifying the questionnaire, it was not possible to ask about the modalities of mentoring programs. Therefore, this study cannot evaluate the availability, structure and design of mentoring programs.

Conclusion

In conclusion, it can be mentioned that mentoring programs are able to influence career planning. However, only two-thirds

of medical schools offer mentoring programs and only one-third have surgical involvement in mentoring programs. Becoming more active in this direction, providing mentoring programs and offering more surgical content can be a way to counteract the lack of surgical trainees.

Women in medical school participated less in mentoring programs, thus the women represent a suitable group for mentoring offers in order to interest them in surgical postgraduate training. Students in higher semesters more frequently requested participation in surgical mentoring programs, so especially undecided medical students could be inspired by surgical subject areas through the influence of mentoring programs.

Data availability statement

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

Ethics statement

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

Author contributions

IG, ES, and SH conceived the research and designed the experiments. DB participated in the design and interpretation of the data. SH performed experiments and analysis. IG and SH wrote the manuscript and participated in the revisions of it. All authors read and approved the final manuscript.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2022.1008509/full#supplementary-material

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The worrying, current state of addictions training in medicine

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KEYWORDS

addictions, drugs, alcohol, training, dual diagnosis, competency, curriculum

Introduction

Over 10 years ago, a systematic review by Rasyidi et al. (1) highlighted grave concerns about the split between addiction medicine and addiction psychiatry in the USA. It also expressed concerns about gaps in the curriculum and competencies from undergraduate education through to residency. The review argued that the integration of addiction training should be primarily focused outside of psychiatry and made a strong argument for standardizing the assessment of the training provided using validated scores to measure progress (1). Another review by Ayu et al. (2) demonstrated that the literature only holds descriptions of the curriculum and training structure for a handful of countries (United States, Canada, Australia, United Kingdom, Germany and Netherlands), identifying significant gaps in our knowledge of how addictions are taught (2).

Since then, substance use and addiction have remained unaddressed problems in medicine. Previous large-scale public health policies, such as three decades of "war on drugs" in the USA, have drained public resources and failed to impact the prevalence of addictions significantly (3). The World Drug Report 2021 demonstrates that the potency of substances is increasing while the public perception of risk from use is decreasing. This development follows a global increase in substance use by 22% over the past decade. There are also grave concerns around unexpected global events such as a four-fold increase in access to illicit substances obtained from "the dark web" during the COVID-19 pandemic (4).

Attempts to estimate the global financial cost of drug abuse poses many challenges and often fail the capture the wider issues. However, the catastrophic impacts on individuals are well documented and include physical and mental health conditions, ranging from infectious and respiratory disease to trauma and depression. Most concerning, considering the lack of international policy developments to tackle it, is that drug use is currently the sixth most common cause of death in 15–49-year-olds (5). While there is an increasing awareness of mental health problems, it has not yet become common to address the similar stigma associated with addictions in public and medical settings.

We can't treat what we can't see

International research consistently demonstrates the high prevalence of drug and alcohol morbidity among patients presenting for health care services. A large audit of

patients presenting to Australian emergency departments found that over one-third of patients had a drug and alcohol problem that was contributing to their current presentation and requiring intervention. Unfortunately, these concerns are frequently unidentified, increasing the risk of inappropriate treatment and patient management. This also makes it difficult for hospital services to plan sufficient interventions (6).

Whilst there is a clear need for specialist care regarding addictions, it is vital to remember that drug and alcohol issues are not bespoke, and all healthcare professionals should have essential core competencies in addiction. Unfortunately, the exposure to addictions in medical school is variable, often not entering curriculums until after graduation. Ayu et al. have proposed a set of basic addiction core competencies for doctors, highlighting the appropriate knowledge, attitudes, and skills in addiction that doctors should achieve at each education level. While specific areas of knowledge are not outlined in detail, these skills are vital to the provision of holistic, evidence-based healthcare (7).

A focus on theory alone will not be sufficient. Lubman et al. demonstrated that despite acknowledgment of the need for varied health professionals to undertake training and "expand the curriculum", the limited clinical exposure and appropriate supervision regarding working with people living with primary and co-occurring substance use problems amplifies the evident issues around recognition, screening and ultimately the ability to provide effective intervention (8).

There are some recent examples of improving postgraduate exposure to addiction. The 2021 Royal Commission into Victoria's Mental Health System helped introduce mandatory psychiatry rotations for all junior medical staff and has been hailed as a positive development in increasing mental health knowledge and reducing stigma (9). While an important step, there is a clear need for a similar development for addictions. As such, early work in integrating mental health and addiction services could be introduced at the medical student level. It has been demonstrated that spending one of six weeks of a psychiatry rotation focused on addiction will increase knowledge of substance use. This should be considered an acceptable trade-off considering the study also showed that the overall gains from the mental health component were not lost (10).

Hearing the stories

A persistent theme in addiction is the lack of health professional knowledge. It is well established that this often reinforces stigma and a lower prioritization of addiction as a core issue in medicine. In the UK, nursing students completing a 3-year program demonstrated no increase in knowledge and skills of addiction between the beginning and end of their degree. While this likely represents a lack of structured training and education, it was further found that the clinical experiences they had with patients had negatively affected the "therapeutic commitment." This is an even greater concern because stigma appears to be increasing when clinical contact lacks relevant supervision, reflection and education. It remains unclear if the attitudes seen are generated from the clinical experience directly or passed on from senior staff members, which would be helpful information in targeting intervention (11).

Importantly, the current zeitgeist of addiction is shifting. The Rethink Addiction campaign in Australia is an independent campaign representing a collaborative industry effort to reinvent addiction services through evidence-based information and linkages to support. Rethink Addiction was formed to educate and advocate for the need to change Australia's attitude and approach to addiction. Key to addressing the widespread and damaging misunderstandings of addiction and the associated stigma is the encouragement of those with lived and living experiences to share their stories of hope and recovery. Sharing the real stories of addiction demonstrates that this complex issue does not only touch all humans but reinforces that help is available and change is possible.

It is postulated that exposing health professionals to these stories can function as a primer to eliciting a cultural change in medicine. This becomes increasingly important considering the effects of clinical exposure without context as outlined above. A starting point would be to better see addiction as a core competency in medicine and something that all health professionals have a duty to provide evidenced based interventions for.

Specialist pathways

There is currently no established single pathway for training an addiction physician. In the United States, addiction medicine and addiction psychiatry have been listed as medical specialities accredited by the Accreditation Council for Graduate Medical Education since 2015 and 1993 with 1- and 2-year training fellowships, respectively (12, 13). In other countries, like the United Kingdom and Australia, addiction training is primarily split between psychiatry, physician and primary care (family medicine) training colleges with varying degrees of collaboration and standardization of curriculums (14). These training colleges face important debates regarding whether addiction training should be more generalized to all psychiatrists or a specialist concern. Despite this, addiction problems and their consequences are equally seen and managed by pain specialists (particularly opioids), emergency physicians (overdoses and intoxication) and general medicine (detoxification and complications from use). This means that upskilling the current workforce needs input from all these medical stakeholders (12).

TABLE 1 Overview of key challenges facing addiction training in medicine.

Challenges in addictions training	
No agreed training pathway	Addiction training is currently split between primary care and psychiatry, (12, 13) with limited collaboration on core competencies in addiction (7, 14)
Workforce education	There are identified gaps in addiction training for nurses, (11) medical students (10) and general medicine (17) and psychiatry trainees (15) surrounding knowledge of disorders and the competency and confidence in treating them
Substance use disorders not identified	Outdated training, often due to rapid changes, means that substance use problems are not identified in clinical settings (6, 8)
Novel therapeutics	Development of new interventions such as virtual reality (19) and long-acting injective buprenorphine (18) means the treatment landscape is rapidly changing and requires a continuing medical education focus
New diagnoses on the horizon	New technology means the introduction of new addictive behavioral disorders like Internet gaming disorder (20)
Psychedelics	Re-ignited focus on the use of psychedelics in psychiatry means legislative and clinical challenges will need more research around microdosing, use with psychotherapy with need for a measured debate (21)
Common framework that defies stigma	Old anti-drug campaigns have failed and there is need for new frameworks, such as brain capital, to describe addictions with a focus on stories and lived experiences (22)

While most members of the public will look to the psychiatrist as an addiction expert, most training programs only have limited coverage of addictions. In a survey of psychiatric trainees in 30 European countries, only 59% had training in drugs and alcohol. Of these, 43% reported problems with their training. This is a particular concern due to the significant variations in training opportunities, systems and curricula across Europe, demonstrating a greater role for regional organizations (15). The situation is even worse in low- and middle-income countries, which are simultaneously seeing the most rapid growth in the prevalence of drug use and the availability of addiction specialists will be even less. The solution can, therefore, not rely on doctors alone (4, 16). Similar gaps are seen in general internal medicine residents in the USA, where the majority report being unprepared to treat substance use disorders (17).

Large and rapid changes

Outdated curriculums and limited exposure to substance use disorders do not only make the medical workforce unfit for the current landscape. On the horizon loom a wide range of new developments, challenges and treatments that require understanding and involvement in legislative developments and policies. Most recently, the treatment option of long-acting injectable buprenorphine (LAIB) is moving through countries as a game-changer in the management of opioid use disorder. It remains unclear how LAIB affects other co-occurring addictions and prescribing is still often limited to specialist treatment providers as opposed to primary care. Overall, LAIB provides a wide range of benefits from reduced cost, stigma, improved stability across multiple domains and allows more time to engage in society (18).

Following increasingly widespread use in medicine and psychiatry, Virtual Reality interventions have just started exploring treatment options for addictions, such as cue exposure therapy for substance cravings. While promising, virtual therapies have yet to fully identify all potential adverse effects, which needs increased focus. Similarly, functional neuroimaging is beginning to uncover how addictive behaviors alter brain structure and functioning (19). This development parallels the only recently recognized internet gaming disorder, which is a behavioral addiction with minimal treatment options worldwide. More concerningly, this is increasingly diagnosed even before new gaming technologies with enhanced immersion, like mixed realities, have reached full maturity (20).

On the horizon is the use of psychedelic drugs through microdosing alone or in combination with psychotherapy, where several studies are currently providing the relevant evidence base to consider efficacy (21). The next step for psychedelic treatments will be the consideration of legislative changes if clinical use is to occur. If this process is left to politicians and people with vested interests alone, there is a substantial risk of laws and policies being made without sufficient evidence underlining them. It is, therefore, essential that research is carried out by independent academic institutions that can facilitate measured, impartial discussion in weighing up benefits and harm to counter the reduced perceived harm by the general public (4).

Mental health and neuroscience are increasingly utilizing the concept of Brain Capital as a common framework that can explain the consequences of inaction on matters that affect the brain health of the wider population. This concept helps reduce stigma, explain the impact of disorders, target investment and capacity building from businesses and organizations and promotes an evidence-based approach to public policy development. Using such frameworks can potentially help the

general public understand that addiction is not only a problem for the individual patient but rather a societal issue to be addressed. Addiction medicine would benefit greatly from the lessons learned from Brain Capital in framing how illicit substance use and addictions impact the cognitive reserve, workforce availability and overall well-being of the population. It could also help communicate the financial consequences of not acting now as a driver for addressing the rapid changes outlined above (22). An overview of the challenges faced is outlined in Table 1.

Discussion

In this article, we have outlined how the two fields of addiction medicine and addiction psychiatry lack not only an internationally recognized structure but also that substance use disorders are not satisfactorily taught in undergraduate and postgraduate medicine and nursing. While over 10 years have passed since the last systematic review of addiction training, the issues identified remain unaddressed, while the prevalence of substance use has worsened with new challenges and an outdated curriculum. We urgently need a full review of international developments since then. It will also be equally important to develop a greater understanding of the structure of addiction training outside the Western countries mentioned in order to observe international trends and guide development.

Coordinated work between medical specialities, training organizations and universities is needed to establish a training framework to implement already identified core competencies while allowing for the incorporation of rapidly changing developments like new treatments, technologies and legislation. Though some core competencies have already been suggested, further work should detail the specific knowledge needed. New technology, like machine learning, might help identify and flag substance use problems in key clinical settings to guide intervention and outline key learning targets.

Purposeful and well-coordinated educational and clinical opportunities, combined with thoughtful exposure to stories of recovery, will be powerful tools to lead to sustained change and evidence-based care. The concept of Brain Capital provides one possible framework for shifting public opinion on addictions. These changes need to translate into clear, evidence-based public health policies that address the stigma associated with substance use disorders and addictions.

Author contributions

HH conceptualized article. RL wrote first draft and. Both authors edited and approved final manuscript.

Conflict of interest

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

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Development and implementation of a comprehensive ultrasound curriculum for medical students: The Bonn internship point-of-care-ultrasound curriculum (BI-POCUS)

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Background: Point-of-care ultrasound (POCUS) is rapidly gaining ground within different areas of applications. Despite the high and increasing relevance of ultrasound, the availability of structured training programs in medical schools is still limited. Therefore, many doctors keep acquiring all their ultrasound skills throughout their postgraduate training. As a result, new residents lack theoretical and practical ultrasound abilities that are critical in everyday clinical practice. In order to improve this, we created and implemented a complete ultrasound curriculum for all medical students throughout their internship year that focuses on hands-on abilities in ultrasound imaging.

Methods: We used Kern's six-step model of curricular development comprising (1) problem identification and general needs assessment, (2) needs assessment of the targeted learners, (3) goals and objectives, (4) educational strategies, (5) implementation, and (6) evaluation and feedback by board-certified ultrasound experts. A two rounds Delphi process with multilevel, self-completed questionnaires and individual using a 9-point Likert scale and free text comments was used to identify learning objectives and reach agreement on the content of the curriculum.

Results: The curriculum developed is aimed at students with no or little experience in their internship year and will be taught as part of their weekly-based internship training courses consisting of 2 hours of theory and 3 hours of practical training. The training will be conducted within a modular framework focusing on the key requirements of POCUS with increasing levels of complexity in accordance with the recommendations of the German Society for Ultrasound in Medicine (DEGUM), the European Federation of Societies for ultrasound in Medicine and Biology (EFSUMB) and the World Federation for ultrasound in Medicine and Biology (WFUMB). A longitudinal e-learning system will be implemented in addition to the practical and theoretical teaching units to track and examine the progress of the students.

Conclusion: Early integration of ultrasound training into medical education as part of a structured and standardized broad ultrasound curriculum enables medical students to acquire basic skills and apply them practically. Fundamental scanning skills are acquired by hands-on exercises in small, supervised groups

as part of BI-POCUS. BI-POCUS therefore provides an excellent opportunity to improve the clinical skills of future physicians. More research is needed to analyze the learning outcomes for medical students and the improvement of the patient's outcome by establishing such an ultrasound curriculum.

KEYWORDS

point-of-care-ultrasound, ultrasound curriculum, curriculum, development, medical students

Background

In recent years, the importance of ultrasound in medicine has increased substantially, owing to its diverse advantages as an imaging modality. In contrast to competing imaging techniques, such as computer tomography (CT) or magnetic resonance tomography (MRI), ultrasound offers superior mobility, speed, and availability. Additionally, it is an extremely safe and non-invasive technique for real-time visualization of the human body (1), and can be effectively employed for guiding interventional procedures. As a result, ultrasound is rapidly evolving into a fundamental diagnostic tool across various medical specialties, and has, in fact, become the most commonly utilized imaging tool in clinical practice (2, 3). Widespread clinical application of ultrasound holds potential for promoting interdisciplinary integration and enabling an intensified interdisciplinary treatment approach (4).

Point-of-care ultrasound (POCUS) is gaining significant traction across a diverse range of applications. It can be performed using either a conventional ultrasound device or a portable/hand-held device. As a result of these technological advancements, ultrasound diagnostic equipment has become significantly more affordable (5, 6). Although hand-held devices currently vary in the quality of images generated, they serve a specific purpose based on the area of application. The ability to rapidly visualize and address clinical concerns at the bedside is increasingly vital. Bedside utilization of POCUS offers potentially life-saving insights regarding the cardiac status, presence of free abdominal fluid, and the occurrence of a pneumothorax with a high degree of accuracy (7). Furthermore, POCUS has the potential to enhance the quality of physical examinations, confirm the physician's preliminary clinical observations, and ultimately improve patient outcomes (8).

Compared to other imaging modalities, sonographic diagnosis partially relies on the skills of the operator. Performing an ultrasound scan requires a blend of theoretical physical knowledge, anatomical proficiency, pathology identification, and the ability to manipulate the ultrasound device to generate precise images. In addition, expertise in pathophysiology and spatial vision is critical. Fundamental skills are often acquired through supervised clinical training, followed by independent practice (9, 10). Due to advancements in technical capabilities, expanding areas of application, and deepening understanding of ultrasound imaging, a continuous learning process is imperative. Failure to maintain up-to-date knowledge and expertise may result in misinterpretations, errors, and poor reproducibility of equipment usage (11). Various organizations worldwide are working to implement standardized ultrasound education. The World Federation for Ultrasound in Medicine and Biology (WFUMB), the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB), and the German Society for Ultrasound in Medicine (DEGUM) are all dedicated to promoting and standardizing ultrasound imaging (12).

Despite the growing significance of ultrasound, structured training programs for medical students remain considerably limited. Consequently, newly-minted residents often lack the theoretical and practical ultrasound skills that are urgently required in daily clinical practice. Many physicians acquire their ultrasound skills exclusively through postgraduate training. In response, several universities have successfully offered ultrasound education for several decades, utilizing a range of different approaches, teaching methods, and curricula (8, 12–15). Recent studies have evaluated the implementation of ultrasound educational curricula in both graduate and postgraduate programs (15–22), testing practical training in small groups, online training, and case-based discussions (23). These studies have illuminated various aspects of the implementation of medical ultrasound education, ranging from strictly subspecialty-focused programs to more general ultrasound standards training. Continuous performance assessment of sonoanatomical and ultrasound-related clinical knowledge can increase learning success and ultimately enhance clinical practice outcomes (3). Integrating ultrasound education into existing coursework may also support successful implementation and bolster general knowledge of anatomy, physiology, and pathology (15).

However, various problems became evident during attempts to implement ultrasound education. Training in ultrasound necessitates practical instruction to ensure competency. Success is more likely when the group size is smaller and the tutor can engage more intensively with the trainees. However, key limiting factors include resources in terms of time, personnel, and equipment (19, 24–28). Several studies have attempted to address this issue by implementing a peer-teaching process (24). Interestingly, not only could non-inferiority be demonstrated with regard to peer-teaching versus classical teaching approaches for trainees' benefit, but even the peer-teachers themselves can benefit from this educational approach (18, 29).

This study represents the first attempt to address the numerous challenges associated with developing a comprehensive, structured, and reproducible ultrasound education curriculum (30). BiPOCUS, designed to align with international and national ultrasound guidelines, is a universally implementable, competency-based, and quality-driven curriculum tailored to undergraduate students in their internship year, rooted in internationally peer-reviewed ultrasound standards. BiPOCUS incorporates essential basic skills and recent innovations, such as hand-held ultrasound devices, in an innovative educational process. As a result, students are provided with a diversified ultrasound education that serves as an essential platform for continued skill development throughout their residency.

Methods

Our objective was to develop a highly advanced, universally implementable, and reproducible POCUS curriculum, utilizing Kern's six-step approach, for undergraduate students in their mandatory internship year within the German medical curriculum (31). During this year, students acquire practical skills and expand upon previously obtained knowledge through hands-on patient practice. Given the distinct lack of ultrasound training within the curriculum thus far, most medical students possess only rudimentary ultrasound training and may be considered beginners in this field. In order to comprehensively address this issue, we employed Kern's six-step approach to problem identification, needs assessment of targeted learners, goal and objective setting, educational strategy formulation, implementation, and evaluation and feedback.

Problem identification

To determine the necessary content for a comprehensive ultrasound education for undergraduate medical students during their internship year, we conducted a thorough review of existing literature and frameworks. The educational objectives for students in their internship year are based on the guidelines for the "Basic Course in Ultrasound of the Abdomen and Retroperitoneum," the learning objectives of the emergency ultrasound group of DEGUM and EFSUMB, as well as the student medical education guidelines of WFUMB. These guidelines were developed and adopted in collaboration with the Societies for Internal Medicine, Surgery, and Radiology, as well as the task force for emergency medicine. We also reviewed complementary published literature to identify critical ultrasound skills or algorithms for medical students and residents across various specialties, ensuring a universally implementable and reproducible curriculum for internship year students that is based on international peer-reviewed quality standards.

Needs assessment of the targeted learners

We ensured alignment with the competencies proposed by DEGUM/EFSUMB/Abdominal Ultrasound, as well as established ultrasound projects. The various aspects of ultrasound identified in our assessment, along with identified application areas, techniques, and implementations, were thoroughly discussed with members of different faculties at the University of Bonn. To ensure adequate needs assessment of targeted learners, we conducted a survey with 1,040 medical students from 31 universities in Germany within our research group (32). Although a high level of interest in ultrasound education and affiliated peer teaching was revealed, students reported insufficient time allotted for ultrasound education in the curriculum, as well as a lack of courses offered by medical schools. These results were taken into consideration during the implementation of BIPOCUS.

Goals and objectives

Each identified ultrasound technique, application area, and implementation was operationalized with consideration given to their technical, physical, and pathologic characteristics. The Delphi process involved clinical members with EFSUMB and DEGUM Level I-III certifications from various specialties and medical students. The Delphi technique is a consensus method used in research for problem-solving, concept generation, or priority definition (33). In our study, the Delphi process was employed to identify learning objectives and reach an agreement on the content of the curriculum. Initial statements were generated through open discussion within a Core Panel consisting of the author of this study, and a total of 10 members participated in two rounds of Delphi using multilevel, self-completed questionnaires and individual feedback. Participants expressed their agreement or disagreement using a 9-point Likert scale and free text comments. The statements of the questionnaires were generated based on literature, clinical experience of panel members, and previous evaluation of ultrasound curricula in Germany by a Core Group within our study group (32). Following the first Delphi process, the data was analyzed, and a new questionnaire, including selected free text responses, was created. Consensus was defined as a medium score greater than or equal to 7, as previously described (Figure 1) (33). Throughout the process of establishing the guidelines, faculty members from specialties that provided the services and medical students played vital roles.

Educational strategies

The implemented educational strategies needed to cover a range of requirements to address all areas and aspects of the curriculum. Consequently, we combined different educational strategies to ensure the teaching of both practical skills and theoretical knowledge. Specifically, we focused on the techniques developed, used, and evaluated by DEGUM and EFSUMB for ultrasound medical student training. Theoretical knowledge was delivered through traditional educational strategies, such as lectures and manuscripts, while practical skills were developed through tutor-supervised training sessions. To categorize the level of competence required, we categorized the subsidiary components into hierarchical categories with ascending degrees of complexity. Since the learning goals comprised both theoretical knowledge and practical skills, different educational strategies were blended to cover all areas and aspects of the curriculum. For ultrasound training, we used the techniques developed, applied, and evaluated by DEGUM and EFSUMB, including scripts and lectures for theoretical knowledge and supervised hands-on training for practical application of the knowledge.

Implementation

An appropriate time slot was chosen for the implementation of the BIPOCUS curriculum in educational and clinical settings. To avoid implementation problems, the teachers, who were board-certified ultrasound experts, were involved in the development and implementation of the curriculum and had already been part of ultrasound teaching programs. Additionally, the development process was guided by award-winning didactics experts who ensured adequate preparation for the curriculum's requirements for all tutors. As a result, most of the necessary infrastructure for organizing the ultrasound curriculum was already established before the implementation stage.

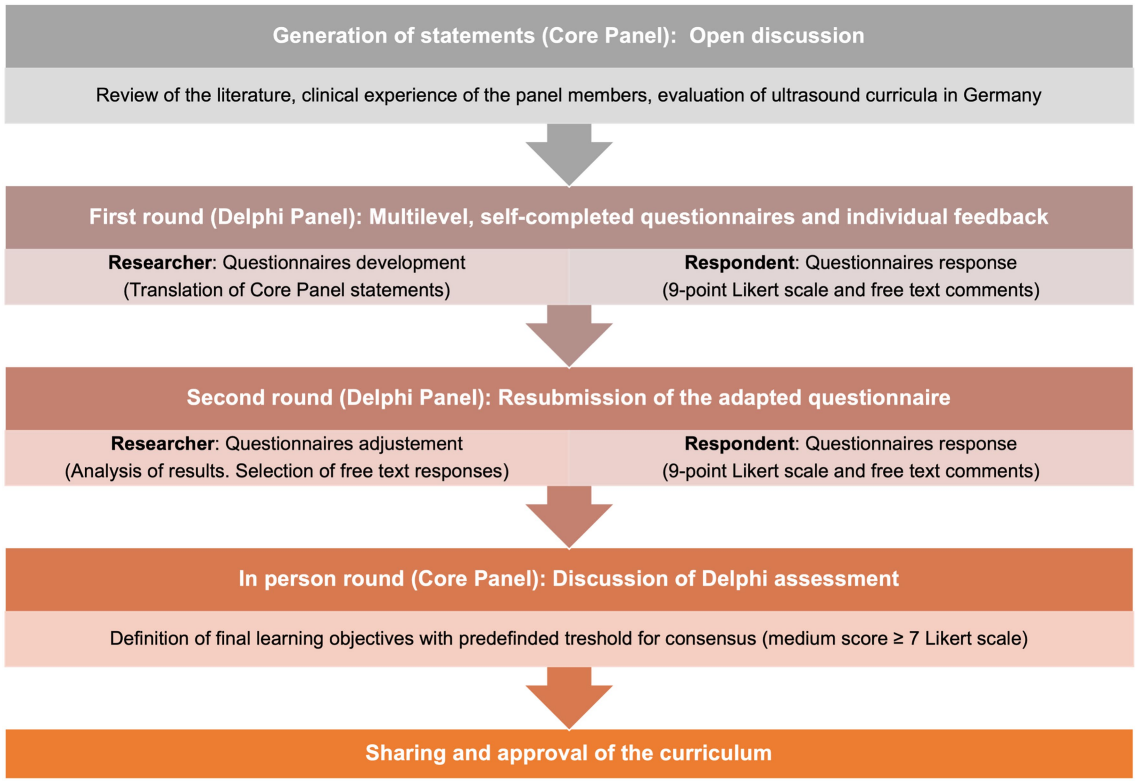

FIGURE 1
Needs assessment and Delphi process. Illustration of the steps of the Delphi process in the context of the needs assessment.

Evaluation and feedback

Finding the time and resources for ultrasound training programs within an already overloaded curriculum can be a challenge. Early research has shown that medical students can acquire the psychomotor and interpretive abilities necessary for effective focused ultrasound in small groups. For example, first-year medical students were able to effectively use portable ultrasound following six 90 min courses on abdominal, cardiovascular, genitourinary, and musculoskeletal applications. The WFUMB and EFSUMB have recently devised strategies to achieve this objective within European medical institutions (12). The BI-POCUS curriculum incorporates a multi-formative assessment and corresponding feedback, including the concepts of adaptive testing in the ultrasound teaching process. The corresponding feedback occurs through a global practical assessment, as well as learning objective-specific assessments, which utilize repetitive, adaptive testing strategies. Additionally, general feedback is obtained from students *via* questionnaires. The presented concept is constantly evolving at the level of evaluation and feedback and is accompanied by the Centre for Evaluation and Methodology at the University of Bonn.

Results

We have developed BiPOCUS, an ultrasound curriculum that meets the needs of undergraduate students with regard to the growing demand for ultrasound imaging. The reproducible, competency-based, and quality-oriented nature of BiPOCUS is ensured through its alignment with international and national guidelines, involvement of board-certified ultrasound experts, and collaboration with award-winning didactic specialists. As such, BiPOCUS is not intended as a location-specific enhancement of education, but rather as a universally implementable curriculum for internship year students that adheres to international peer-reviewed quality standards.

Problem identification

There are several studies published dealing with the requirements to achieve basic quality standards in ultrasound imaging (8, 12, 15, 34). It is expected that all medical students receive at least basic theoretical and technical training in ultrasound during their internship year. This is especially important as ultrasound imaging, and POCUS in particular, is gaining popularity for various applications. The dynamic and real-time capabilities of ultrasound are well-suited for clinical examination and interpretation by physicians, enabling rapid and appropriate treatment decisions. The early implementation of POCUS into the curriculum can have a significant impact on the quality of future examinations by young physicians. However, there is currently no standardized ultrasound curriculum integrated into the medical school curriculum in Germany. As a result, there is a strong demand for systematic teaching of basic ultrasound skills (32). Additionally, students face structural problems, such as a lack of ultrasound equipment and rooms, a shortage of qualified training staff, and limited time within the curriculum due to the lack of standardized implementation.

Needs assessment of the targeted learners

To assess the practical ultrasound skills of students, a five-step approach was developed with increasing levels of complexity. The fifth level aims to provide competencies required for independent operation during 24 h shifts in the emergency room or intensive care unit, and in residency. The practical ultrasound skills were categorized into the following levels (see Figure 2).

As prior theoretical knowledge is usually required for performing hands-on skills, these were also defined. The levels of competency taught to students substantially equal Level I/ II, with a maximum of Level III in certain sub competencies. Therefore, only levels I-IIl were described in more detail (Supplementary Table S1).

Goals and objectives

The needs assessment resulted in the implementation of the subsequent modular framework, focusing on essential requirements of POCUS (Figures 3–5). Students are able to further develop their theoretical and practical skills in weekly courses. The following goals and objectives for medical students could be identified (Table 1).

Module 1: the general part of the curriculum I

Students complete a basic educational program throughout their internship. The latter focuses on the basic knowledge of general emergency protocols, which every undergraduate student should acquire by the end of the internship year. We hereby focused on the essentials of the global valid standard protocols of the respective professional societies.

Module 2: the general part of the curriculum II

The second general element of the course emphasizes more specific areas. However, these areas are important aspects of general ultrasound education. They should be well understood by all graduates. More attention is given to clinical integration. Therefore module 1, it's educational content and skills, are obligatory. The second general topic complex also includes issues addressed in the advanced courses of the DEGUM and EFSUMB. These are integrated complementarily into the education of the medical students.

Module 3: the subject specific part of the curriculum

After successful completion of the two general parts of the curriculum, the next module is focused on the subject specific areas. These specific areas can be chosen by the students. However, if interested, all subject specific subjects can be covered, allowing the graduate to choose a clinical track into each subject and to experience and learn about the subject specific integration of sonography. The individual subject specific areas of BI-POCUS were designed as shown below. These may also be supplemented by further specific subjects in the future.

Educational strategies

Learning ultrasound is very different from many other clinical jobs that may be performed in the real world with a simple method and predictable results. But operating an ultrasound probe and setting up the device requires both technical know-how and the ability to think critically and hunt for fresh information in the ultrasound image. Because it is a diagnostic procedure, it cannot yield a result that can be predicted (35). A popular and effective approach of teaching ultrasound is through brief didactic modules followed by hands-on activities during small group sessions (12, 35, 36). However, many publishers are considering and utilizing alternative tactics. Cartier et al. used a learning theory approach to design an ultrasound course for medical students that includes cognitive, behavioral, and constructivist learning components (35). The EFSUMB recommends a constructivist approach to teaching during pre-clinical training, where knowledge is taught through organ- and topic-specific modules that also incorporate clinical aspects.

To focus on the practical skill of ultrasound, we deliberately excluded the treatment of certain illnesses to a significant extent. Only a few disorders are taught to provide a better understanding of unique situations and ultrasound findings, but these are not the main areas of interest for BI-POCUS. The main objective was to set a standard for uniform basic ultrasound training within the BI-POCUS curriculum.

For this purpose, the BI-POCUS curriculum is structured as a three-level program based on abdominal ultrasound protocols. By the end of the program, students are expected to achieve levels I and II in all areas, with level III being covered in some areas. However, level III is designed as a transition to additional medical education and cannot be fully attained within the BI-POCUS program. Nevertheless, this degree of ability is also demonstrated, ensuring that students gain some of the necessary skills in this area as part of their BI-POCUS training. A detailed breakdown of the individual competence levels is provided in the following table (Supplementary Table S1). Ultrasound training is carried out in an interdisciplinary manner across both study sections to ensure good integration and implementation in the curriculum of medical degrees.

Implementation

The BI-POCUS Curriculum was introduced by the Medical Faculty of Bonn in 2022, with the optimal implementation time slot identified during weekly-based internship training courses. The

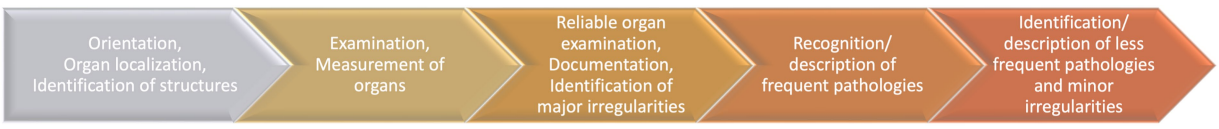

FIGURE 2
Degrees of complexity. Five-step approach for the acquisition of ultrasound skills with ascending degrees of complexity.

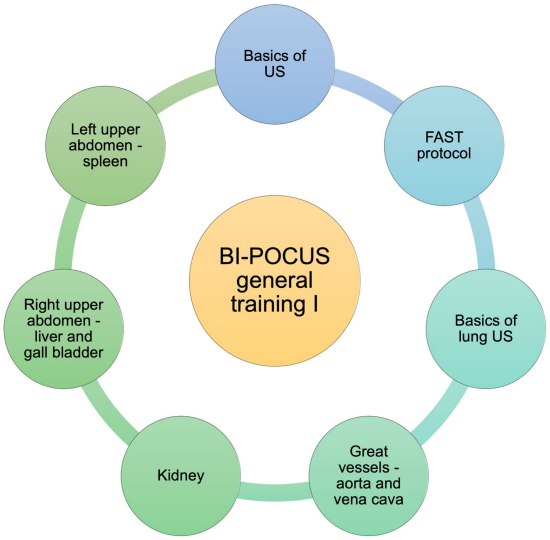

FIGURE 3
BI-POCUS – general training, educational content (Module 1). Modular framework with subdivision of the learning objectives included in the first module of the BI-POCUS curriculum; abbrev.: Ultrasound (US), focused assessment with sonography for trauma (FAST).

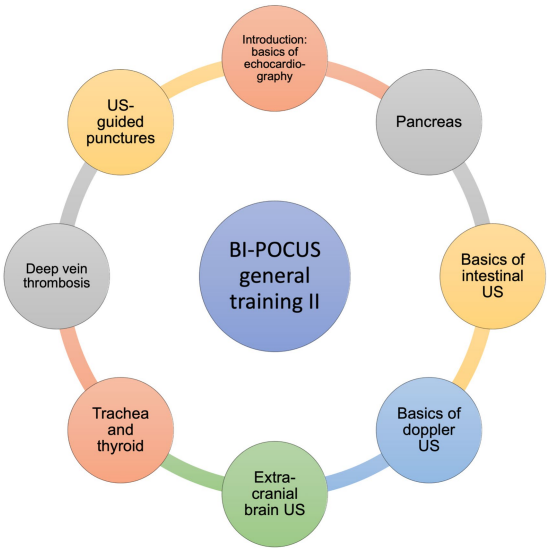

FIGURE 4
BI-POCUS – general training II, educational content (Module 2). Modular framework with subdivision of the learning objectives included in the second module of the BI-POCUS curriculum; abbrev.: Ultrasound (US).

relevant faculty members and key stakeholders were involved from the project's inception and supported the curriculum. A corresponding expert group was established, consisting of various individual members of the sonography departments, and the necessary infrastructure to support the curriculum was subsequently developed. Additionally, a dedicated working group has been formed to provide long-term assistance for this tutor-based longitudinal initiative. Over

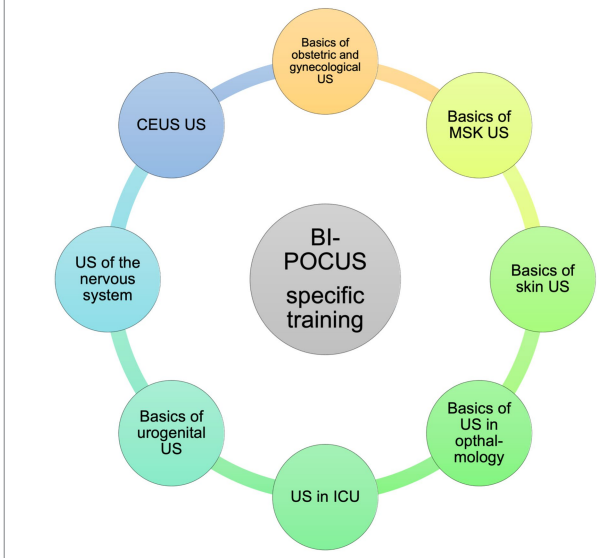

FIGURE 5
BI-POCUS – specific training, educational content (Module 3). Modular framework with subdivision of the learning objectives included in the third module of the BI-POCUS curriculum, abbrev.: Ultrasound (US), musculoskeletal (MSK), intensive care unit (ICU), contrast enhanced ultrasound (CEUS).

70% of the entire course is composed of practical content offered in different course forms, with appropriate DEGUM-certified tutors. Throughout the course, teachers provide practical training in small groups of three to four students, with each participant directly discussing the images and section planes they created during the session. Transducer guidance is altered if necessary, and the participants practice the sectional planes in line with the guidance of DEGUM, EFSUMB, and WFUMB. The practical components of each session last five to six hours, allowing each participant ample time to practice practical ultrasonography skills once a week. All participants are college students in their internship year, the majority of whom have had little to no previous ultrasound experience.

Evaluation and feedback

Within the BI-POCUS curriculum, a longitudinal e-learning system was implemented alongside the practical and theoretical teaching units to monitor and evaluate the students' progress. The ButterflyAcademy® was integrated into the curriculum, which provides individual learning units or topic modules that are accessible to students. The learning progress is also evaluated through individual tests at the end of each module, consisting of theoretical parts (multiple-choice exams) and practical parts (OSCE and DOPS), complemented by general learning surveys and participant feedback surveys. The corresponding examination formats and their integration within the constructive alignment of the curriculum are presented in Table 1. The individual formats, including multiple-choice, OSCE, and DOPS, illustrate the different examination taxonomies, which are further supported by the adaptive e-learning system (see Figure 6).

In addition, BI-POCUS includes individually adaptive computer-based training for image recognition and interpretation to improve the accuracy of diagnosis in POCUS.

TABLE 1 BI-POCUS competence levels.

Topic	Lesson (method)	Level 1 objectives	Level 2 objectives	Level 3 objectives	Assessement of competency
Technical basics	Theory (CES)	1) Explain basic principles for image generation and frequency range of ultrasound. 2) Identify different transducers and their areas of application 3) Apply basic ultrasound-specific terminology 4) Identify artifacts (sound shadows, dorsal sound amplification)	1) Explain A, B, M-mode; artifacts part II	1) Explain and apply tissue Harmonic Imaging	Multiple-choice exams
	Practise (TSTS)	1) Select transducers problem based 2) Apply ultrasound machine setting (gain, penetration depth, image and loop saving)	1) Apply device functions: Focus, Frequency, Time-Gain Compensation, Penetration Depth		OSCE/ DOPS
Patient Management	Theory (CES)	1) Assess patient sobriety 2) Assess medical history		1) Explain specifics of the examination of unconscious patients, children, infants	Multiple-choice exams
	Practise (TSTS)	1) Demonstrate a respiratory maneuver 2) Demonstrate positioning of patient 3) Demonstrate communication throughout examination	1) Handle unusual patient positioning	1) Handle of communication with anxious patients	OSCE/ DOPS
Transducer handling	Theory (CES)	1) Explain abdominal sectioning	1) Vary conventional diagonal imaging		Multiple-choice exams
	Practise (TSTS)	1) Apply transducer positioning 2) Orientate 3) Vary pressure application			OSCE/ DOPS
Preparation	Theory (CES)	1) Explain indications and limitations of abdominal ultrasound examination			Multiple-choice exams
	Practise (TSTS)	1) Apply optimal ultrasound conditions 2) Demonstrate positioning of the ultrasound device			OSCE/ DOPS
Abdominal vessels	Theory (CES)			1) Explain variations of the arterial vascular supply	Multiple-choice exams
	Practise (TSTS)	1) Identify and localize the following structures: abdominal aorta, coeliac trunc, superior mesenteric artery, caval vein, portal vein, lienal vein, renal artery and vein, iliacal artery and vein 2) Display in longitudinal and cross-sectional images	1) Identify and localize the following vessels: Inferior mesenteric artery, common hepatic artery, lienal artery; 2) Perform the vena cava collapse test 3) Display in longitudinal and cross-sectional image	1) Apply Doppler sonography of the portal vein and renal artery	OSCE/ DOPS
Pancreas	Practise (TSTS)	1) Explain pancreatic parts 2) Identify and demonstrate lead structures	1) Identify and localize: the common hepatic duct (DHC) 2) Optimize image in difficult examination conditions 3) Apply translienal pancreatic imaging	1) Identify pancreatic duct and variants (uncinate process)	OSCE/ DOPS
Liver	Practise (TSTS)	1) Localize and demonstrate the right and left liver sections 2) Compare of echogenic differences (liver and kidney) 3) Localize the portal vein in the hepatic hilum 4) Visualize the inferior caval vein junction 5) Identify and localize the caudate lobe	1) Visualize and demonstrate hepatic vein – portal vein	1) Screen the liver segments 2) Assess liver transcostal	OSCE/ DOPS

(Continued)

TABLE 1 (Continued)

Topic	Lesson (method)	Level 1 objectives	Level 2 objectives	Level 3 objectives	Assessement of competency
Biliary ducts/ vessels	Practise (TSTS)	1) Localize and demonstrate the gallbladder subcostally 2) Assess gall bladder filling status	1) Assess the gallbladder wall 2) Visualize and demonstrate of hepatic propria artery and DHC 3) Identificate fissura interlobularis	1) Detect postprandial gallbladder 2) Track intrahepatic bile duct 3) Demonstrate stone criteria	OSCE/ DOPS
Kidney, adrenal gland	Practise (TSTS)	1) Localize the kidneys bilaterally 2) Identify renal parenchyma and renal medulla	1) Visualize renal hilus 2) Visualize and measure of organ in its largest diameter	1) Demonstrate variants 2) Demonstrate sonomorphology of renal cysts and renal stones 3) Identify adrenal lobe	OSCE/ DOPS
Spleen	Practise (TSTS)	1) Localize the organ	1) Visualize Hilar 2) Measure of length and depth	1) Identify secondary spleen	OSCE/ DOPS
Small pelvis	Practise (TSTS)	1) Localize and demonstrate urinary bladder, prostate/ uterus	1) Asssess urinary bladder volume	1) Demonstrate jet phenomenon	OSCE/ DOPS
Thyroid gland	Practise (TSTS)	1) Localize and demonstrate the right and left lobes and isthmus.	1) Assess volume		OSCE/ DOPS
Lymph nodes	Practise (TSTS)	1) Explain the physiological sonomorphology of lymph nodes	1) Explain major abdominal lymph nodes, neck lymph nodes, malignancy criteria.	1) Demonstrate the level assignment of the cervical lymph nodes	OSCE/ DOPS
Focused assessment with sonography for trauma (FAST)	Practise (TSTS)	1) Assess of fluid in the following areas: pericardial, right and left pleural cavity, Morison's pouch, Koller's pouch, rectovesical excavation / Douglas space			OSCE/ DOPS
Duplex sonography	Practise (TSTS)	1) Explain basics of the Doppler effect and its applications 2) Localize and demonstrate direction of flow	1) Explain pulse repititon frequency	1) Assess resistance index/ Flow profile	OSCE/ DOPS
Vessels	Practise (TSTS)	1) Localize and demonstrate carotid artery with internal and external branches		1) Demonstrate deep leg veins	OSCE/ DOPS

Topics and competence levels of the individual organ-related teaching units in the BI-POCUS curriculum. TSTS, tutor-supervised training sessions; CES, classical educational strategies (lectures and manuscripts); OSCE, Objective Structured Clinical Examination; DOPS, Direct Observation of Procedural Skills.

Therefore, the image recognition and interpretation training, which aims to deepen theoretical knowledge, plays an important role. An individualized BIT, which is focused on the user's skills and abilities, represents a new and innovative approach to practicing these critical skills in a more targeted and focused manner, thereby improving diagnostics in terms of reliability and efficiency. Additionally, scientific projects in the field of automated image assessment have been initiated in collaboration with the Department of Artificial Intelligence in Sectional Imaging, leading to the implementation of a completely new assessment tool in BI-POCUS.

In evaluating BI-POCUS, it is necessary to consider two aspects: assessing the diagnostic competence of the trainees upon completion of the curriculum and evaluating the effectiveness of the curriculum by monitoring the development of the competence levels throughout BI-POCUS. To achieve this, a reliable and valid test is used that is based on both global and direct objective checklist ratings. The assessment procedure is directly based on the trainees' competency and is supplemented by general and topic-specific questionnaires that are completed by the respective students.

The students who participate in BI-POCUS receive a customized e-learning concept that is tailored to their individual needs. In the future, tele-didactic elements will also be integrated into the practical hands-on course to enhance the overall learning experience.

Discussion

The objective of this study was to develop a highly adaptive Point-of-Care Ultrasound (POCUS) curriculum that meets the requirements of medical schools and prepares their students for future residency. Currently, ultrasound is only offered to a limited extent at Bonn University Hospital as a voluntary course (32). It has not been systematically integrated into basic medical training for all students. To address this gap, we have designed a comprehensive curriculum

that equips all medical students in their internship year with practical knowledge and basic skills focused on point-of-care applications. Our program, BI-POCUS, introduces POCUS into clinical routines for final year medical students, facilitating the acquisition of fundamental skills that are essential for their future practice.

When implementing an ultrasound curriculum, it is important to consider several factors. One of the initial challenges is deciding which competencies should be included in the curriculum and which should not. In this case, the proposed competencies for DEGUM/EFSUMB/abdominal ultrasound were used as a basis, as they cover a range of methods and fundamental understanding of these techniques. The educational content was derived from this source, along with lessons learned from previous ultrasound projects. Unlike DEGUM ultrasound courses that include key pathologies in the foundational course, BI-POCUS focuses on practical sonography skills and fundamental information. The curriculum provides instruction on the physical fundamentals of ultrasound as well as optimizing image generation.

The most important aspect of ultrasound is the ability to perform scans, which is a fundamental requirement for producing adequate images. Therefore, the development of visual–spatial and visual-motor skills needed to operate a transducer and acquire images is crucial. These practical skills are best acquired through hands-on practice in small, supervised groups (19). It is important to introduce practical exercises as early as possible to familiarize students with different equipment and settings. Including basic ultrasound skills in medical school curricula ensures that students can perform ultrasound examinations in the early stages of their education (37). In a supervised educational environment, exercises can be practiced successfully to gain appropriate and effective experience without putting patients at risk.

Despite BI-POCUS' focus on hands-on skills in ultrasound imaging, sufficient knowledge of the medical setting is still important. Therefore, the curriculum includes teaching of basic physical skills, anatomical knowledge, basic understanding of the pathophysiology of different pathologies, and the ability to perform professional documentation. In addition, using common and simple medical scenarios, the diagnostic value of ultrasound and its potential are highlighted, and students are taught that ultrasound enables the clinical translation of basic principles and elements of medicine. Thus, it is pivotal for educational success to combine clinical data and anatomy/pathophysiology in real time with the ultrasound image. By integrating new ultrasound skills into the examination, medical students can connect skills learned in basic science and anatomy courses with those acquired in routine clinical practice during their internship year. The advantages of POCUS are thus presented to the students in a problem-centered approach, and BI-POCUS is accompanied by subject-specific content from the individual clinics and departments. As a result, students also receive subject-specific training in their respective electives.

There are multiple factors that contribute to the quality of education. A growing consensus exists to standardize ultrasound education, establish structured clinical courses, and assess expertise according to well-defined and reproducible criteria. In this context, the equipment, the expertise of the faculty, and the stringency of the implemented structure are to be noted.

Educational techniques must be clearly defined and taught from simple to complex and then to more targeted aspects. We carefully addressed these aspects throughout the development of BI-POCUS. In the light of constantly increasing amount of knowledge a focus regarding educational goals is necessary, too (12, 22). The acquired skills are supposed to meet the requirements of daily routine, including situations in which independent work is necessary. This may include, for example, night shifts in the emergency department or on ward. Especially in the latter situation, there is often a lack of sufficient training and support from more experienced colleagues and thus a lack of feedback to allow them to learn from their own mistakes.

As part of our curriculum, students are expected to acquire the proficiency to generate precise and accurate reports of findings using the correct terminology. To achieve this, students will receive repeated structured training in the appropriate terminology under supervision, as well as independently. The implementation of standardized reporting, documentation, and interpretation of clinical consequences can contribute to a higher level of ultrasound imaging quality and comparability. A successful ultrasound curriculum should also include the circumstances in which ultrasound may or may not be the appropriate imaging modality, as well as the ability to generate sufficient images with different types of ultrasound machines.

It is essential to avoid teaching multiple skills simultaneously to avoid overburdening the learning process. Instead, it is more effective to reduce complex structures to smaller and individually taught aspects. Ultimately, the aspects taught consecutively should be connected to cement previously learned knowledge. The BI-POCUS curriculum structure ensures this by providing different levels of competence that build on each other. To consolidate the knowledge acquired, ultrasound skills should be practiced routinely throughout medical school. In addition to in-class sessions, self-training for skill development should be encouraged.

In order to optimize the hands-on experience for individual students, we made the decision to recruit instructors with varying levels of qualifications. This led to the inclusion of tutors from all three qualification levels of DEGUM, as well as peer group tutors, with the aim of minimizing group size. Our choice was based on the established effectiveness of peer teaching, which can be attributed to the lower hierarchical, social, and intellectual difference between trainees and tutors (23). However, the optimal tutor-to-student ratio for hands-on ultrasound training remains unclear, and will be evaluated within the framework of our curriculum in further studies.

Hands-on teaching is associated with higher expenses than traditional lectures and self-study, but the proper implementation of ultrasound teaching throughout medical education requires planning and resources, including capital and manpower. Considering the potential benefits of our curriculum, the additional resources required appear reasonable. Inadequate examinations by young residents can be reduced by previously acquired and consolidated ultrasound skills, leading to a reduction in patient harm. Therefore, standardized ultrasound education could potentially contribute to resolving the conflict between the quality of medical education and patient safety by guaranteeing a minimum ultrasound standard among medical students (38). Quality assurance is ensured by aligning with the standards of recognized ultrasound associations. Acquiring broad basic skills instead of immediate sub-specialization during residency allows for an interdisciplinary approach to different diseases.

Further improvement of BI-POCUS could involve video recording of ultrasound examinations to verify learning progress and the quality of the ultrasound examination. Thus, technological progress enables

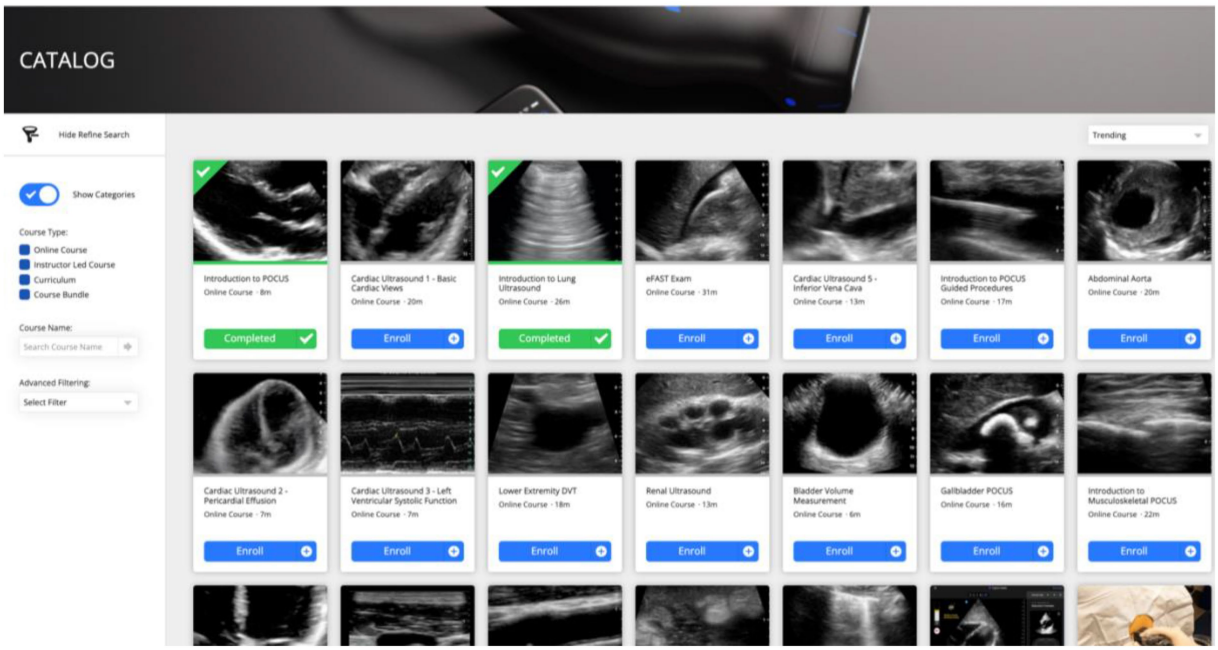

FIGURE 6
BI-POCUS – e-learning System. The integrative e-learning system with variable and topic-specific modules will be implemented in complement to the BI-POCUS curriculum, and will be adapted to the individual needs and abilities of each participant.

the processing of enormous amounts of data. This could contribute to detailed feedback with improvement proposals beyond the hectic clinical routine.

In conclusion, our study strongly emphasizes the need for ultrasound in medical education and is the first to address the various challenges of ultrasound education in a comprehensive curriculum designed to teach ultrasound imaging to students just before they begin their residency training. The BI-POCUS curriculum is not limited to a specific location, but can be universally implemented for internship year students based on international peer-reviewed quality standards. This curriculum incorporates common basic skills as well as recent innovations such as hand-held devices, providing students with a diversified ultrasound education that serves as an essential platform for further skill development during their residency. BI-POCUS offers an excellent opportunity to improve the clinical skills of young physicians.

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

FR, VS, WH, PB, and SP contributed to the study conception and design. Material preparation, data collection and analysis were performed by FR, VS, and SP. The first draft of the manuscript was written by FR and SP. FR, VS, WH, PB, and SP commented on previous versions of the manuscript. WH helped by manuscript editing and data collection. Manuscript editing was done by PB. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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Supplementary material

The supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2023.1072326/full#Supplementary-material

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Mental workload during endoscopic sinus surgery is associated with surgeons' skill levels

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Introduction: Surgeons' mental workload during endoscopic sinus surgery (ESS) has not been fully evaluated. The assessment was challenging due to the great diversity of each patient's anatomy and the consequence variety of surgical difficulties. In this study, we examined the mental workload of surgeons with various surgical skill levels during ESS under the standardized condition provided by novel-designed 3D sinus models.

Materials and methods: Forty-seven participants performed a high-fidelity ESS simulation with 3D-printed sinus models. Surgeons' mental workload was assessed with the national aeronautics and space administration-task load index (NASA-TLX). Associations between the total and subscales score of NASA-TLX and surgical skill index, including the board certification status, the number of experienced ESS cases, and the objective structured assessment of technical skills (OSATS), were analyzed. In addition, 10 registrars repeated the simulation surgery, and their NASA-TLX score was compared before and after the repetitive training.

Results: The total NASA-TLX score was significantly associated with OSATS score (p=0.0001). Primary component analysis classified the surgeons' mental burden into three different categories: (1) the skill-level-dependent factors (temporal demand, effort, and performance), (2) the skill-level-independent factors (mental and physical demand), and (3) frustration. After the repetitive training, the skill-level-dependent factors were alleviated (temporal demand; z=−2.3664, p=0.0091, effort; z=−2.1704, p=0.0346, and performance; z=−2.5992, p=0.0017), the independent factors were increased (mental demand; z=−2.5992, p=0.0023 and physical demand; z=−2.2509, p=0.0213), and frustration did not change (p=0.3625).

Conclusion: Some of the mental workload during ESS is associated with surgical skill level and alleviated with repetitive training. However, other aspects remain a burden or could worsen even when surgeons have gained surgical experience. Routine assessment of registrars' mental burdens would be necessary during surgical training to sustain their mental health.

KEYWORDS

3D printer, burnout—professional, endoscopic surgery, surgical training, surgical education, NASA-TLX

1. Introduction

Burnout among medical professionals has been recognized as "a crisis" in modern health care even before Covid-19 (1). A recent nation-wide study in the US demonstrated that 44.0% of physicians had experienced burnout at least once in their career (2). The cost of healthcare related to physician burnout is estimated at between 2.6 to 6.3 billion USD per year (3).

Identified as one of the associated risk factors of burnout in healthcare workers is a high mental workload, along with age, gender, practice setting, specialty, and hours of work per week (2). Mental workload is defined as the total cognitive work needed to accomplish a specific task (4). The National Aeronautics and Space Administration-Task Load Index (NASA-TLX) is designed to evaluate mental workload and widely accepted across many specialties including healthcare (4–7). NASA-TLX allows for evaluation not only of the overall scale of mental workload but also its subscales: mental demand, physical demand, temporal demand, perceived performance, effort, and frustration.

Among various medical procedures, surgery is particularly associated with a high mental and physical burden on surgeon (8–10). It is no wonder that endoscopic sinus surgery (ESS) burdens surgeons mentally because of the risk due to proximity to orbit and brain and requiring fine psychomotor skills (9, 11, 12). So far, however, only few studies focused on surgeons' mental workload during ESS (9, 11, 12) have been published. One of the reasons is a lack of standardized conditions to evaluate the workload. In general, surgeon's perceived mental workload is affected by the task's difficulties (13). The difficulty of ESS largely depends on the complexity of paranasal sinus anatomy, which greatly varies in every patient. Thus, precise assessment of mental workload during ESS has been challenging.

Recently, we reported a high-fidelity ESS simulation surgery using newly designed 3D printed-sinus models, with sufficient face, content, and construct validity (14). With recent advanced 3D-printing technology and the high quality of the printing materials applied, the tactile "real-life" feel of the tissues is reproduced in the models. The mass producibility of the 3D-printed sinus models allows for multiple dissections by surgeons with the exact same anatomy, which is impossible in actual clinical situations. This provides the standardization for comparison among intra- and inter-individuals on several aspects of ESS such as efficiency, efficacy, and safety of surgeries (14, 15).

In this study, we examined surgeons' mental workload during ESS using NASA-TLX under the standardized condition provided by the 3D-printed sinus models. Specifically, we focused on the possible association between the level of surgical skills and the mental workload. We also examined whether repetitive training could alleviate trainees' mental workload. This is the first study examining surgeons' mental workload during ESS under standardized conditions.

2. Materials and methods

2.1. Participants

This study was conducted concurrently with the previously published studies regarding the validation of 3D-printed sinus models for ESS training (14). Forty-seven otolaryngologists voluntarily took part in the study. Participants were explained the purpose and design of the present study in advance. The written informed consent was obtained from all participants.

2.2. Simulation surgeries

For simulation surgeries, a 4-mm rigid nasal endoscope and a monitor (Telepac, Storz, Tuttlingen, Germany), standard ESS instruments (Storz), and a powered microdebrider (Medtronic, Jacksonville, FL) and 3D-printed sinus models (Fusetec, Adelaide, South Australia) were prepared as previously reported (14). The models were 3D-printed from the axial CT scans of actual patients with chronic rhinosinusitis. Infrared reflective markers were attached to several surgical instruments for a motion capture study, although it was not the focus of the present study. The participants were allocated 45 min to complete a unilateral full house ESS (maxillary antrostomy, sphenoethmoidectomy, and frontal sinusotomy). The detail of the simulation surgeries was described in the previous study (14).

All participants performed the surgeries for the 3D-printed sinus models (Model 2 Right side). Further, 10 otolaryngology registrars among the participants repeated the exercise six times as part of repetitive training. In the 1st and the final training (2nd, and 7th surgeries in total, respectively), Model 2 Left was used for intra-individual comparison. Details of the simulation training have been previously reported (14).

2.3. Assessment of surgical skill levels

As there is no standard objective method to evaluate the ESS levels, the following index were used in this study; board certification by the Japanese Otolaryngology Society, the number of previous ESS cases performed and the objective structured assessment of technical skills (OSATS) score (16). The scoring system is designed to score surgical performance in each specific procedures during FESS on the 5-likert scale, from the scale of one (unable to perform) to five (performs easily with good flow). A score of three or more in each checklist is considered competent for the task. The OSATS score for ESS was assessed by two attending rhinologists (MS and YN). More details are provided in the previous study (14). Data on the board certification and the number of prior ESS cases were obtained from a questionnaire survey performed after the simulation surgeries. As the definition of ESS experts has not been established, in this study,

experts were defined as certified surgeons both within the top 1/3 experienced cases and with top 1/3 OSATS scores. More details of the simulation training and the assessment were described in the previous report (14).

2.4. Mental workload assessment

National aeronautics and space administration-task load index (NASA-TLX) were utilized to evaluate mental workload assessment. NASA-TLX is the most widely utilized subjective questionnaire for mental workload assessment and consists of the following six subscales: mental demand, physical demand, temporal demand, perceived performance, effort, and frustration (4–7). After the simulation surgeries, the participants answered the following questions using a 20-point visual analog scale based on the six subscales.

- How much mental activity was required for the surgery? (Mental demand, 1: not at all, 20: extremely high)
- How much physical activity was required for the surgery? (Physical demand, 1: not at all, 20: extremely high)
- How much time pressure did you feel for the surgery? (Temporal demand, 1: not at all, 20: extremely high)
- How successful do you think you were in completing the surgery? (Perceived performance, 1: perfectly completed, 20: nothing achieved at all)
- How hard did you have to work during the surgery? (Effort, 1: not at all, 20: extremely high)
- How insecure, discouraged, irritated, stressed, and annoyed did you feel during the surgery? (Frustration, 1: not at all, 20: extremely high)

2.5. Analysis and statistics

Data were shown in median (interquartile range). Shapiro–Wilk tests were applied to evaluate whether the data fitted a normal distribution curve. For analysis on experienced cases, participants were classified into three groups according to the number of experienced cases (the top 1/3, the middle 1/3, and the bottom 1/3 of the experienced cases). As well, they were also classified into three groups according to their OSATS score (the top 1/3, the middle 1/3, and the bottom 1/3 of the score). The total NASA-TLX score were calculated as sum of the 6 subscales. For comparison among three or more groups, data were assessed with the Kruskal-Wallis test followed by the Mann–Whitney U. Principal component analysis (PCA) was performed using the number of experienced cases, OSATS score, and the subscales of NASA-TLX. The paired Wilcoxon test was utilized for comparison before and after the repetitive training. p values of less than 0.05 were considered statistically significant. For comparison among three groups or six subscales, the Bonferroni correction was applied and p values of less than 0.017 for three groups (i.e., 0.05/3 = 0.017), and 0.0033 for six subscales (i.e., 0.05/15 = 0.0033) were considered statistically significant, respectively. All the analyses were performed using JMP 11 (SAS Institute Inc.).

3. Results

3.1. Characteristics and the mental workload of the participants

Table 1 shows the characteristics of the 47 participants. Among them, 28 were board-certified members of the Japanese otolaryngology society, and the other 19 were otolaryngology registrars in training. The total NASA-TLX score was 62 (49–75). In the subscales of NASA-TLX, mental demand, physical demand, temporal demand, perceived performance, effort, and frustration were 7 (5–10), 8 (5–10), 16 (10–20), 10 (6–16), 15 (10–20), and 5 (4–10), respectively (Table 1). Temporal demand and effort were significantly higher than the other four subscales (Figure 1).

3.2. The surgical skill level was associated with mental workload during ESS

The association between the mental workload during ESS and the surgical skill level was examined. First, the mental workload was compared between the registrars and the certified otolaryngologists. Registrars' response showed significantly higher total NASA-TLX score ($z = -2.8410$, $p = 0.0048$), higher temporal demand ($z = -2.7900$, $p = 0.0054$), higher performance ($z = -4.2320$, $p < 0.0001$), and higher effort ($z = -2.5390$, $p = 0.0115$) for the simulation surgeries than certified otolaryngologists, while no significant differences were found in mental demand ($z = -0.1530$, $p = 0.8867$), physical demand ($z = -0.2520$, $p = 0.8093$), and frustration ($z = -0.4460$, $p = 0.6631$, Figure 2 and Table 1).

Next, the mental workload was analyzed in association with the number of the experienced cases. The bottom 1/3 of the cases showed significantly, higher total NASA-TLX score ($z = -3.3623$, $p = 0.0008$), higher temporal demand ($z = -4.3109$, $p < 0.0001$), higher performance ($z = -4.1756$, $p = 0.0026$), and higher effort ($z = -3.7960$, $p = 0.0006$) than the top 1/3, while there was no significant difference in mental demand ($z = 3.2176$, $p = 0.7179$), physical demand ($z = 0.2799$, $p = 0.7795$), and frustration ($z = -1.7878$, $p = 0.2406$), between the top 1/3, middle 1/3, and bottom 1/3 of the surgeons who were experienced (Supplementary Figure 1) and Table 1.

For the OSATS score, the bottom 1/3 had a significantly higher total NASA-TLX score ($z = -3.835$, $p = 0.0001$), higher temporal demand ($z = -3.7034$, $p = 0.0002$), higher performance ($z = -4.4203$, $p = 0.0016$), and higher effort ($z = -3.6567$, $p = 0.0002$) than the top 1/3 (Supplementary Figure 2 and Table 2). There were no significant differences in physical demand ($z = 0.0599$, $p = 0.9895$), and frustration ($z = -1.9276$, $p = 0.0837$) among the groups. In mental demand, although the Kruskal Wallis test showed a low value of p among the groups ($p = 0.0360$), the comparison between the groups did not reach statistical significance.

The mental workload was compared between the experts and non-experts. The experts showed significantly lower score in total NASA-TLX score ($z = -4.1354$, $p < 0.0001$), temporal demand ($z = -4.48429$, $p < 0.0001$), performance ($z = -4.0808$, $p < 0.0001$), effort ($z = -3.9414$, $p < 0.0001$), and frustration ($z = -1.9941$, $p = 0.0461$), compared to non-experts (Figure 3 and Supplementary Table 3). These results suggest that surgeons' mental workload during ESS is associated with surgical skill level, similar to

TABLE 1 Characteristics of participants in the present study.

	All participants (*n*=47)	Registrars (*n*=19)	Certified surgeons (*n*=28)	*p*-value (registrar vs. certified surgeons)	*Z* score (registrar vs. certified surgeons)	Effect size (r; registrar vs. certified surgeons)
OSATS score	55 (44–69)	42 (36–51)	65 (56–75)	**<0.0001**	−4.6200	−1.4610
Work experience in years	10 (3–17)	3 (2–4)	15 (11–21)	**<0.0001**	−5.3410	−1.6890
Surgical experience in number of performed ESS cases	50 (4–100)	2 (0–20)	100 (50–400)	**<0.0001**	−5.3410	−1.6890
NASA-TLX						
Total Score	62 (49–75)	69 (56–81)	52 (39.25–65)	**0.0048**	−2.8410	−0.8984
Mental Demand	7 (5–10)	7 (5–10)	6.5 (4.25–10)	0.8867	−0.1530	−0.0484
Physical Demand	8 (5–10)	8 (5–10)	7.5 (3.5–10)	0.8093	−0.2520	−0.0797
Temporal Demand	16 (10–20)	20 (16–20)	14 (8–19.5)	**0.0054**	−2.7900	−0.8823
Performance (failure = 20)	10 (6–16)	15 (11–16)	7.5 (4.5–10)	**<0.0001**	−4.2320	−1.4610
Effort	15 (10–20)	17 (15–20)	10 (9.25–17.75)	**0.0115**	−2.5390	−0.8029
Frustration	5 (4–10)	5 (4–14)	5.5 (3.25–9.5)	0.6631	−0.4460	−0.1410

NASA-TLX, national aeronautics and space administration-task load index; OSATS, objective structured technical skills assessment.
The bold values means statistically significance.

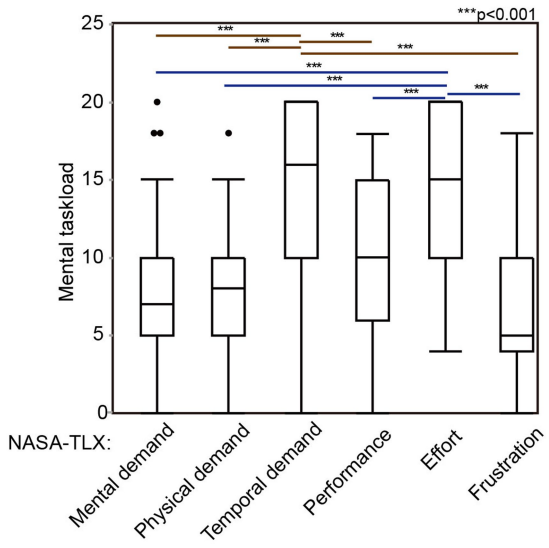

FIGURE 1
The subscales of mental task load evaluated with NASA-TLX. Forty-seven otolaryngologists performed ESS for 3D-printed sinus models and evaluated their mental workload during ESS, in a point of mental demand, physical demand, performance, effort, and frustration. ESS, endoscopic sinus surgeries; NASA-TLX, national aeronautics and space administration-task load index. ***p<0.001.

what has been previously reported in other surgical disciplines (17). This was especially true for temporal demand, performance and effort.

Next, the index related to the surgical skill level (the number of previous surgical cases and OSATS score) and the subscales in NASA-TLX were subjected to PCA test (Figure 4 and Table 2). PCA demonstrated that surgeons with low mental workload were mainly distributed to the left side of the principal component score plot and those who had a middle and high mental workload to the center and the right of the plot. The 1st, 2nd, and 3rd principal components explained 45.8, 19.2, and 10.6% of the total variance. The 1st principal component was the most strongly affected by temporal demand (loading 0.86), followed by OSATS score (−0.85), effort (0.84), performance (0.83) and the number of prior ESS cases (−0.71). The three subscales in the 1st component, temporal demand, effort, and performance, were negatively correlated to the index, prior surgical cases and OSATS score (Table 2). The 2nd principal component consisted of mental demand (loading 0.83) and physical demand (0.81). The two subscales are independent from both the number of cases and OSATS score (Table 2). The 3rd principal component was affected by frustration (loading 0.64). This implies that the mental workload that the surgeon felt during ESS consisted of a different type of burden with a part of the burden associated with the surgical skill level other parts were independent of the surgeons' experience.

3.3. Changes noted in the registrars' mental workload after repetitive ESS training

Ten registrars among the participants performed mock surgeries an additional six times as part of a repetitive training program. Their skill improvement was investigated in detail and confirmed in the previous study (14). Briefly, their OSATS score significantly increased after the program ($z = -2.8031$, $p < 0.001$). The residual bony septation within paranasal sinuses, evaluated with CT examination, was also significantly decreased ($z = -3.326$, $p = 0.013$) (14). The NASA-TLX was compared in the 2nd and final training, where the same 3D model was used. Although there were no significant differences in the total NASA-TLX, most subscales significantly changed. Mental and Physical demand significantly increased after the repetitive training, while temporal demand, performance, and effort were significantly decreased (Figure 5 and Supplementary Table 4). There was no significant change in frustration after the training.

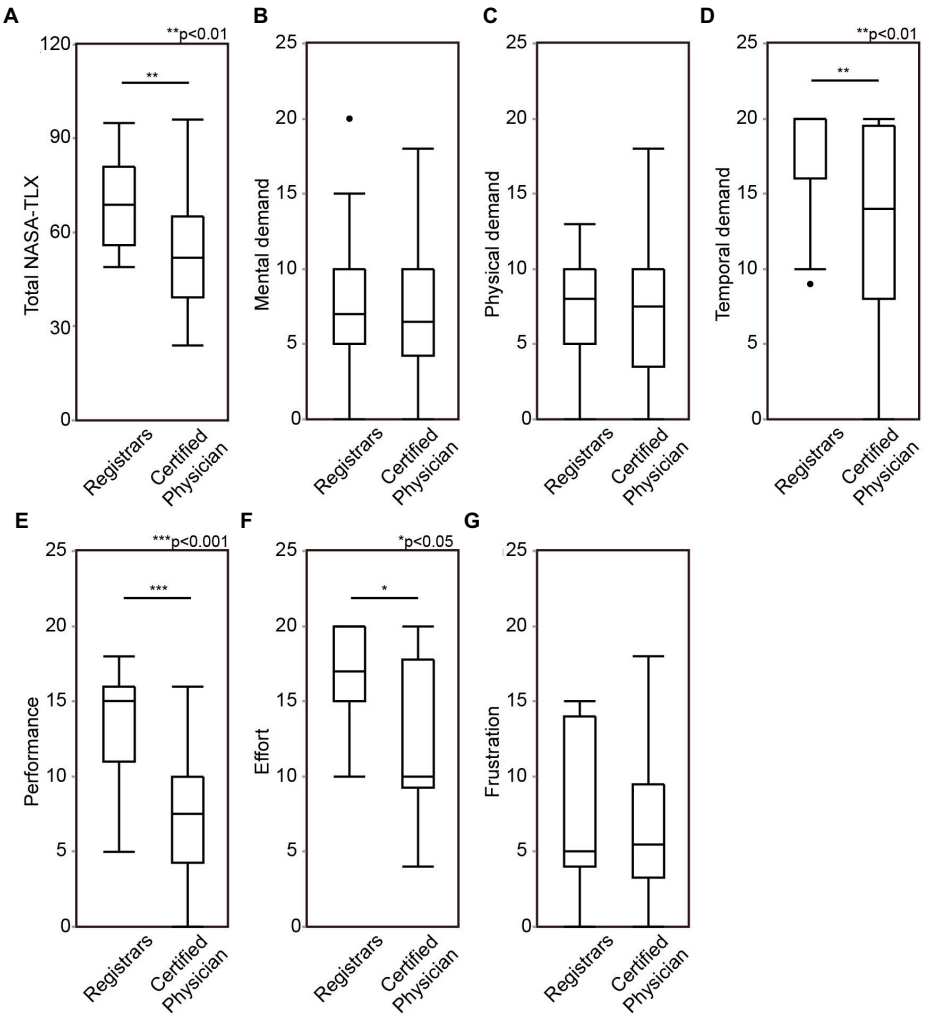

FIGURE 2
Comparison of mental workload during endoscopic sinus surgery (ESS) between otolaryngology registrars and board-certified otolaryngologists. Total score of national aeronautics and space administration-task load index (NASA-TLX) **(A)**, mental demand **(B)**, physical demand **(C)**, temporal demand **(D)**, performance **(E)**, effort **(F)**, and frustration **(G)** were compared between otolaryngology registrars and board-certified otolaryngologists. ESS, Endoscopic sinus surgeries; NASA-TLX, national aeronautics and space administration-task load index. *p<0.05, **p<0.01, ***p<0.001.

4. Discussion

So far, mental workload during ESS has not been able to be fully evaluated due to the significant variation in anatomy between patients. The first paper reported by Alobid, et al., studied 15 novice surgeons performing ESS on actual patients and evaluated their mental workload including the surgeons' anxiety score, cardiovascular index, and serum cortisol level (9). They found that the surgeons had a high anxiety score with increased blood pressure and cortisol levels during ESS (11). Stelter et al. investigated four experienced rhinologists' mental workload during transnasal endoscopic surgeries for variety of diseases including chronic rhinosinusitis, mucoceles of frontal sinuses, cerebral spinal fluid leaks, and skull-base surgeries (12). Mental workload also has been investigated as part of studies on utility of new devices, such as augmented reality (AR) image guidance (18), Virtual reality (VR) (19), and flexible endoscopes for ESS (20). In addition, the role of surgical ergonomics on the surgeons' mental workload was evaluated (21, 22). However, the major limitation common to all these studies was the limited number of participants and the unstandardized conditions due to the great diversity of paranasal sinus' anatomies in the patients or cadaveric materials on which the surgery was performed.

This study was performed with 47 participants under the standardized conditions provided by the 3D sinus model. This allows for a more detailed analysis on mental workload during ESS. We found that total mental workload was significantly associated with surgeons' skill level. As for the subscales, temporal demand, effort, and performance, these were significantly associated with surgical experience (number of prior surgeries), while the mental and physical demand had no relationship with experience. PCA demonstrated that the surgeons' mental burden during ESS could be classified into three categories: (1) the surgical experience-dependent factor (temporal demand, effort, and performance), (2) the surgical

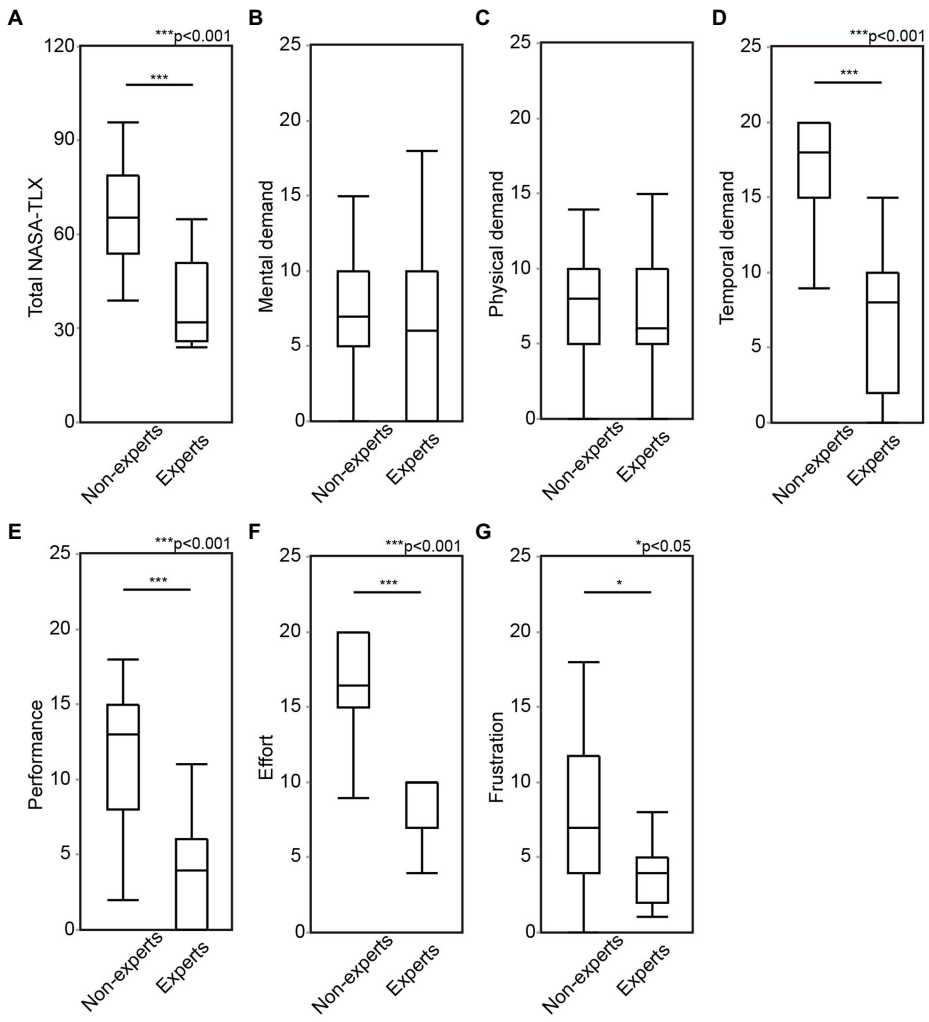

FIGURE 3
The comparison of mental workload during ESS between experts and non-experts. Total score of NASA-TLX **(A)**, mental demand **(B)**, physical demand **(C)**, temporal demand **(D)**, performance **(E)**, effort **(F)**, and frustration **(G)** were compared between experts and non-experts. ESS, endoscopic sinus surgeries; OSATS, objective structured assessment of technical skills; NASA-TLX, national aeronautics and space administration-task load index. *p<0.05, **p<0.01, ***p<0.001.

experience-independent factor (mental and physical demand), and (3) the in-between factor (frustration). Interestingly, these three categories significantly changed after repetitive training; (1) the experience dependent factors were alleviated, (2) the mental and physical factors improved, and (3) the in-between factor (frustration) did not change. As a result, the total NASA-TLX was unchanged after the training. However, training improved the most burdensome factors of temporal demand and effort. Interestingly, the mental and physical demand was increased after the repetitive training. This suggests that some mental burdens are not always alleviated after training but remain similar or even worsen even when surgeons gain surgical experience. A higher physical demand was found in surgeons with previous burnout experience ($p = 0.048$, data not shown). Evaluation of surgical skills and the routine assessment of mental burden should be part of surgical training to allow the continued well being of trainees' mental health.

Surgical residents are continuously exposed to a significant amount of mental burden (23, 24). The assessment of mental workload should be considered when residency programs are designed (23) and appropriate adjustments made. A high mental workload in surgery increases the risk of complications (25, 26). As the development of residency programs continue to evolve so the mental stress of the program should form a significant part of improving the program and consequently the health of the residents. Therefore, it is important that there is a standardized method of assessing mental health.

The significant improvement in the ability of 3D printers to generate models from actual patients for residents to perform surgery in temporal bones (27–29), paranasal sinuses (30–33), skull base (30, 34–37), kidney, renal pelvis, ureter (38, 39), spine (40, 41), mandibula (30), aorta (42) and heart (43) has been established. The 3D-printed models are not only useful for surgical training (44), but also provide a platform to assess surgeons' mental workload during surgery (39–41). With this improved technology there is now a high degree of similarity and reality for surgeons as has been shown in recent studies (39). The

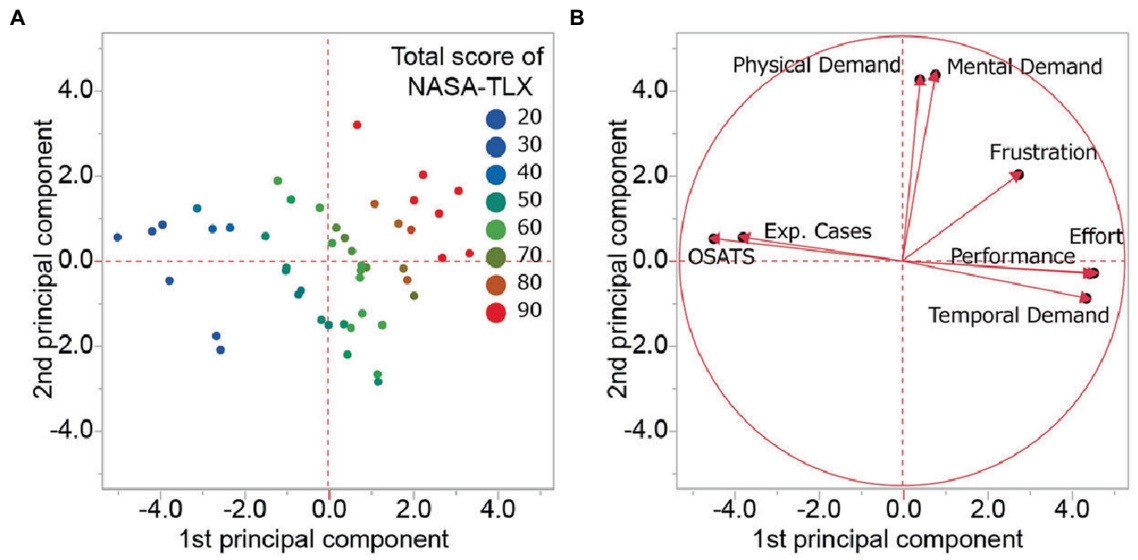

FIGURE 4
Principal component analysis regarding the surgical skill level and mental workload. **(A)** The principal component score plot on each surgeon. The color represents the total score of NASA-TLX (red; high, green; middle, and blue low). **(B)** The Loading plots of 1st and 2nd principal components. NASA-TLX, national aeronautics and space administration-task load index; Exp. Cases, experienced cases; OSATS, objective structured assessment of technical skills.

TABLE 2 Correlation coefficient among the surgical skill level of ESS and the subscales of NASA-TLX.

	Indexes for surgical skill level		NASA-TLX					
	Exp. Cases	OSATS	Mental demand	Physical demand	Temporal demand	Performance	Effort	Frustration
Exp. cases	-	**0.48**	−0.08	−0.01	**−0.67**	**−0.45**	**−0.55**	−0.15
OSATS	**0.48**	-	−0.05	−0.00	**−0.63**	**−0.76**	**−0.62**	−0.39
Mental demand	−0.08	−0.05	-	**0.44**	0.09	−0.02	0.07	0.27
Physical demand	−0.01	−0.00	**0.44**	-	0.05	−0.03	0.04	0.17
Temporal demand	**−0.67**	**−0.63**	0.09	0.05	-	**0.61**	**0.70**	0.34
Performance	**−0.45**	**−0.76**	−0.02	−0.03	**0.61**	-	**0.63**	0.36
Effort	**−0.55**	**−0.62**	0.07	0.04	**0.70**	**0.63**	-	0.37
Frustration	−0.15	−0.39	0.27	0.17	0.34	0.36	0.37	-

A correlation coefficient <−0.4 or >0.4 were shown in bold. NASA-TLX, national aeronautics and space administration-task load index; Exp. cases, Experienced ESS cases; OSATS, objective structured technical skills assessment.

3D-printed sinus models used in this study have been previously studied and have shown satisfactory face, content, and construct validity (14). There is a significantly high correlation between the assessment of the 3D-printed sinus models when compared with cadaveric materials both in terms of skill levels and surgical efficiency (skill levels; r = 0.828 and efficiency; r = 0.953) (14). The high fidelity of the 3D-printed sinus models also allows for the prediction of mental workload in ESS for actual patients in advance. The other significant advantage of the 3D-printed sinus models is that they are plastic and do not any ethical and transport restrictions, unlike cadaveric materials. This is illustrated by a recent published study for a remote surgical training course held simultaneously in Japan and Australia with combination of the 3D models and a web conferencing systems (15). This provides a standardized surgical exercise on complex anatomy that can be used to evaluate surgeons' performance, skill level and can include mental workload. There is now the ability with the number of different anatomies available for surgical boards to be able to use these standardized yet complex anatomies to evaluate actual surgical skill rather than just the theory of surgery.

This study has limitations because although simulation training using the 3D sinus model has been shown to have a high fidelity and has been previously validated (14), there are still

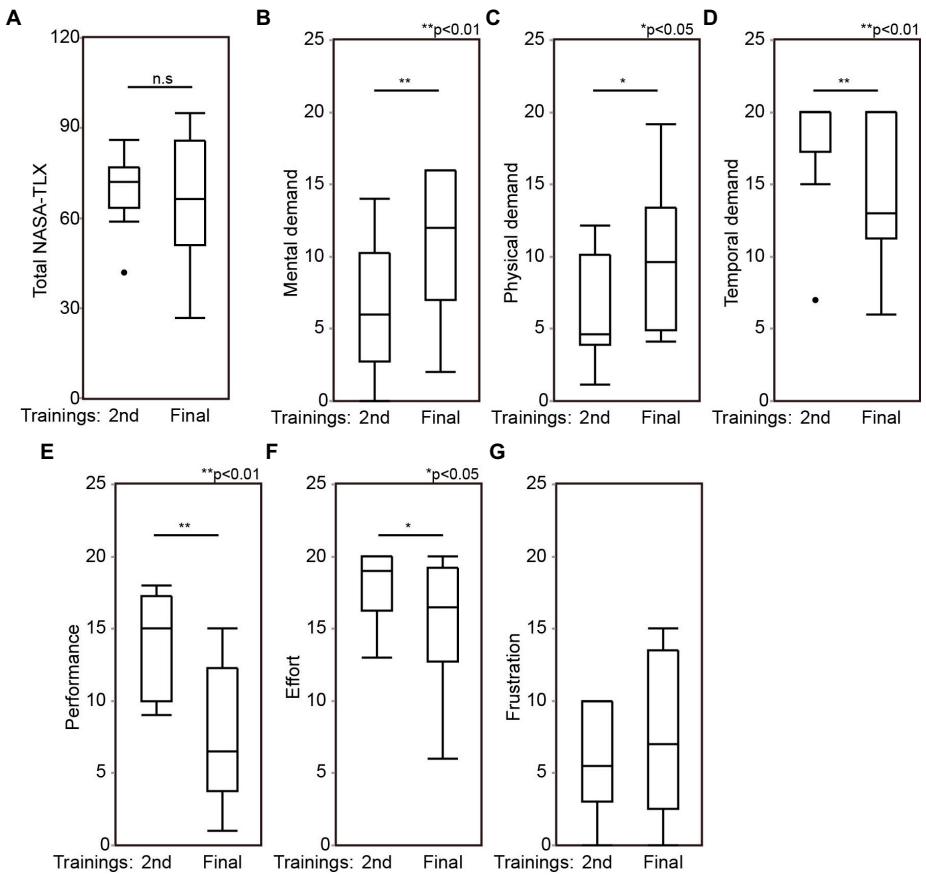

FIGURE 5
Registrars' mental workload during ESS before and after the repetitive training. After the first simulation surgeries, 10 registrars repeated surgeries more six times. Total score of NASA-TLX **(A)**, mental demand **(B)**, physical demand **(C)**, temporal demand **(D)**, performance **(E)**, effort **(F)**, and frustration **(G)** were compared between 2nd training and the final training, which the same models were used. ESS, Endoscopic sinus surgeries; NASA-TLX, national aeronautics and space administration-task load index. 2nd, the 2nd training; Final, the final training.

small differences between the models and actual ESS on patients. The models reduce the fear of intraoperative bleeding and the risk of operative complications, and this can affect the surgeon's mental workload. In addition, in this study all surgeons were asked to perform the surgery within a specified time and this may add to the temporal demand. It has been previously shown that time pressure is the biggest stressor for surgeons during ESS (12). Some differences only had small effect sizes despite their statistically significant (*cf.* a difference in frustration between experts and non-experts, Supplementary Table 3). However, most other statistically significant differences analyzed in this study also held sufficient effect sizes. The total NASA-TLX score in this study was not a weighted score but just a summation of raw figures of the subscales, although the raw total score was validated as sensitive as the weighted score (45). It is also to be investigated if the changes in the mental workload found after the short-term training are equal to the differences in the workload found among the surgeons with various skill levels produced by their long-term experience. Further, our study lacks the objective method to evaluate the workload such as heart rate, blood pressure, catecholamines or cortisol in blood and saliva (46). Despite the limitations, this study is the first step to assess the mental workload during ESS under the standardized conditions and can help with the development of surgical training curricula in the future.

5. Conclusion

The level of surgical skill significantly affected surgeons' mental workload during ESS, especially in temporal demand, performance, and effort.

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

MS, TA, AK, and AH designed the project. MS, KMi, RW, TS, AN, YN, and AH organized the simulation training and collected data. MS and YN analyzed OSATS score. KMa, and AK analyzed NASA-TLX score. MS, DH, AP, and PW wrote the draft. All authors contributed to the article and approved the submitted version.

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Conflict of interest

PW: consultant for Fusetec and receiving royalties from Fusetec. AP: consultant for Fusetec, Medtronic, ENT technologies, Tissium, and Aerin Medical, shareholder of Chitogel, and speaker's bureau for Sequiris.

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

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2023.1090743/full#supplementary-material

SUPPLEMENTARY FIGURE S1
The comparison of mental workload during ESS in association with surgeons' experienced ESS cases. Participants were classified into three groups according to the number of prior surgeries performed (the top 1/3, the middle 1/3, and the bottom 1/3). Total score of NASA-TLX **(A)**, mental demand **(B)**, physical demand **(C)**, temporal demand **(D)**, performance **(E)**, effort **(F)**, and frustration **(G)** were compared among the three groups. ESS, Endoscopic sinus surgeries; NASA-TLX, National Aeronautics and Space Administration-Task Load Index. $^{**}p < 0.01$, $^{***}p < 0.001$.

SUPPLEMENTARY FIGURE S2
The comparison of mental workload during ESS in association with OSATS score. Participants were classified into three groups according to their OSATS score (the top 1/3, the middle 1/3, and the bottom 1/3). Total score of NASA-TLX **(A)**, mental demand **(B)**, physical demand **(C)**, temporal demand **(D)**, performance **(E)**, effort **(F)**, and frustration **(G)** were compared amongst these three groups. ESS, Endoscopic sinus surgeries; OSATS, Objective Structured Assessment of Technical Skills; NASA-TLX, National Aeronautics and Space Administration-Task Load Index. $^{**}p < 0.01$, $^{***}p < 0.001$.

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Assessment of the competence in electrocardiographic interpretation among Arabic resident doctors at the emergency medicine and internal medicine departments: A multi-center online cross-sectional study

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Background: This study aims to assess the electrocardiographic interpretation abilities of resident doctors at internal medicine and emergency medicine departments in eight Arabic countries.

Methods: An online cross-sectional study was conducted between October 7, 2022 and October 21, 2022 in eight Arabic countries. The questionnaire consisted of two main sections: the first section included sociodemographic information, while the second section contained 12 clinical case questions of the most severe cardiac abnormalities with their electrocardiography (ECG) recordings.

Results: Out of 2,509 responses, 630 were eligible for the data analysis. More than half of the participants were males (52.4%). Internal medicine residents were (n=530, 84.1%), whereas emergency medicine residents were (n=100, 15.9%). Almost participants were in their first or second years of residency (79.8%). Only 36.2% of the inquired resident doctors had attended an ECG course. Most participants, 85.6%, recognized the ECG wave order correctly, and 50.5% of the participants scored above 7.5/10 on the ECG interpretation scale. The proportions of participants who were properly diagnosed with atrial fibrillation, third-degree heart block, and atrial tachycardia were 71.1, 76.7, and 56.6%, respectively. No statistically significant difference was defined between the internal and emergency medicine residents regarding their knowledge of ECG interpretation (p value=0.42). However, there was a significant correlation between ECG interpretation and medical residency year (p value<0.001); the fourth-year resident

doctors had the highest scores (mean=9.24, SD=1.6). As well, participants in the third and second years of postgraduate medical residency have a probability of adequate knowledge of ECG interpretation more than participants in the first year of residency (OR=2.1, *p* value=0.001) and (OR=1.88, *p* value=0.002), respectively.

Conclusion: According to our research findings, resident doctors in departments of internal medicine and emergency medicine in Arabic nations have adequate ECG interpretation abilities; nevertheless, additional development is required to avoid misconceptions about critical cardiac conditions.

KEYWORDS

electrocardiographic, emergency medicine, internal medicine, multi-center cross sectional, Middle East

1. Introduction

Electrocardiography (ECG) is considered a crucial diagnostic tool in detecting the cardiovascular disorders, and it is the most frequently used tool among cardiology physicians, as 200 million electrocardiograms (ECGs) are performed annually. The ECG graph evaluates the heart rate and rhythm by recording the myocardial electrical activity *via* 12 external electrodes placed on the limbs and chest. Each electrode views the heart from one specific window to form the common ECG graph (1, 2). Early detection of severe cardiac abnormalities by academic interpretation of ECGs by health-care providers is essential, since cardiac conditions are very common and could be fatal (3).

Although an ECG is simple, cheap, portable, and easy to access, (2) interpreting the ECG is a challenging and complicated mission, and any mistake in the ECG interpretation could lead to undesirable outcomes, due to almost all cardiac disorders being considered as urgent consequences, as well as being the leading cause of death worldwide for both genders (4).

Electrocardiograms help the physicians, health-care providers, or clinicians to detect a wide range of life-threatening conditions, such as myocardial infarction, arrhythmias (atrial fibrillation/flutter, ventricular tachycardia/fibrillation), electrolyte imbalance, and some drugs' toxicity. Accordingly, it is necessary for every doctor at emergency departments or intensive-care units to be able to define the risk signals on the ECG or detect the primary diagnosis as soon depending on the viewed graph on the ECG, which is classified as the most important diagnostic procedures when facing dangerous cases (4).

An accurate ECG interpretation is fundamental to providing high-quality patient care in several medical specialties, such as internal medicine and emergency medicine. Despite this, many studies have demonstrated that many resident doctors do not receive adequate training to develop their ECG interpretation skills (5). In spite of the global use of electrocardiograms (ECGs) as a diagnostic tool, ECG interpretation is linked to large mistake rates, particularly among physicians, general practitioners, and resident doctors (6). Studies showed that in developing and low-income countries, a prehospital ECG is considered a cost-efficient and worthwhile strategy for patients presenting with acute chest pains (7). Fortunately, many low-cost ECG machines are available within easy reach in low-income countries (8).

When dealing with urgent instances, such as myocardial infarction, finding a person who is competent to properly read the patient's ECGs may be time-consuming and delay treatment. Since internal medicine and emergency medicine residents are the first health-care professionals inside hospitals to deal with such urgent cases, training to enhance their ECG interpretation abilities is crucial and might reduce mistake rates (9, 10). After checking the literature to define the studies that analyze the level of knowledge of Arabic resident doctors of ECG reading academically, we did not find any multinational study for this aim, so we conducted this study to assess the competency in electrocardiographic interpretation among emergency medicine and Internal medicine residents across Arab countries by emphasizing the most important abnormalities for the purpose of quality improvement and mitigating harm in emergency situations.

2. Methods

2.1. Study design and setting

An online cross-sectional study was conducted between October 7, 2022 and October 21, 2022 in eight Arabic countries (Syria, Jordan, Iraq, Qatar, Yemen, Egypt, Sudan, and Algeria). The study's inclusion criteria were Arab resident doctors who underwent postgraduate training in internal medicine or emergency medicine departments from their first to fifth year. Resident doctors from other specialties and uncompleted surveys were excluded from the study. All participants were recruited into the study voluntarily without any pressure or coercion and were informed about the research group's identity, their right to leave the study whenever they liked, their right to privacy and confidentiality, and the fact that only completed submissions would be analyzed.

This survey was adapted from a previously published study that involved a validated scale (11). We collected data from participants using convenience and snowball tactics. First, we translated the questionnaire from English into Arabic, and we guaranteed that all medical terminologies were translated based on the *Unified Medical Dictionary*. Second, we designed a google form questionnaire and sent it to participants through social media platforms by data collectors who informed the participants about the purpose of the

study and indicated that it was not obligatory to participate in the study.

Data collectors visited hospitals to distribute the survey among potential respondents, and they were under daily supervision by the supervisors and the team leader. The minimal sample size was found by applying a single proportion of the population formula [$n = [(Za/2)2P(1-P)]/d2$]. With a 95% confidence level (Z a/2 = 1.96), a 5% margin of error, P = the proportion of emergency department internal medicine and emergency medicine residents who were competent in electrocardiogram interpretation (50%) and adding 5% for a non-response rate, 385 resident doctors were required to establish this study. The final size of the sample was 660 residents.

2.2. Measures

The questionnaire used to conduct this study has two sections. The first section involved the sociodemographic data, and the second section contained 12 clinical case questions with ECG records of the most significant ECG anomalies. The researchers formulated the survey from textbooks (11–13), published papers (14, 15), and clinical experience.

Section 2 of the survey primarily has two theoretical and 14 clinical questions. The final version was reduced to a total of 12 questions, and each question has four possible answers, of which only one is correct. To exclude the possibility of choosing the right answer by chance and to reduce the bias, one of the four answers was "I do not know." Each respondent got one point for every correct answer, with a maximum score of 12 points.

After completing the questions, we changed the maximum score from 12 points to 10 points to make it easier to interpret the results. Respondents who scored 7.5/10.0 or more were considered competent in ECG interpretation; therefore, any respondent with a score less than 7.5 points assumed they had not reached the minimum level of theoretical proficiency in ECG interpretation.

2.2.1. Sociodemographic variables

This section of the survey contained eight questions about the sociodemographic features of the study population. They ranged from questions about age, gender, hospital name, and years worked in the emergency department, whether the nurse had taken an ECG course, to three questions related to the course (type, duration of the course, and years since taking the course).

2.2.2. Assessing ECG interpretation skills

In this section of the survey, we asked residents 12 questions, two theoretical questions, and 10 clinical case-related questions. The first two questions assess the participant's knowledge of the order of ECG waves and intervals and their understanding of P wave. Then there were 10 questions covering diverse clinical scenarios with ECG records to determine the participant's judgment and skills in interpreting various forms of ECGs. These records include atrial flutter, ventricular fibrillation, atrial fibrillation, pathological Q wave, atrioventricular third-degree bundle branch block, ventricular tachycardia, acute myocardial infarction, normal ECG, extra-ventricular systole, and atrial tachycardia.

2.3. Study validity and reliability

After evaluating the clarity of the questions by sending an online survey to 25 resident doctors and fixing the mistakes based on the comments we got, the reliability of the utilized scale (12 questions) was assessed using Interclass Correlation Coefficient on a small sample of 26 randomly chosen internal medicine and emergency residents. We calculated Cronbach's alpha, which was 0.68, and the value of Cronbach's alpha above 0.7 was defined to indicate adequate reliability (16). As a result, we indicated a somewhat satisfactory internal consistency.

2.4. Ethical consideration

This study was undertaken after the approval of the Syrian Ethical Society for Scientific Research (AS:2819B). Moreover, at least one ethical approval was taken from each country in our study. Respondents received a URL to access Google's online survey and were asked on the first page of the survey if they consented to complete the survey. They were assured that the collected information would be used only for research purposes. Confidentiality and anonymity were respected in all steps of the study, and all answers were saved in an online protected database.

2.5. Statistical analysis

The statistical data analysis was performed using the STATA and Excel Microsoft programs. Categorical variables on sociodemographic characteristics were expressed using descriptive statistics and frequencies. We also categorized the knowledge levels into adequate and inadequate based on two modified cutoff points: above 75% and under 75% of the total score, respectively. A Test de Kruskal-Wallis was performed to determine the statistical difference in knowledge toward ECG interruption between the subgroups.

We conducted binary logistic regression to predict the possibility of the participants having adequate levels of ECG reading, depending on the other variables, including age, gender, specialty, training year, attending a previous ECG course, years since taking the course, type of course, and duration of the course. A value of p less than 0.05 was considered for statistical significance.

3. Results

3.1. Sociodemographic description of the study population

A total of 660 residents participated in the research. More than half (52.4%) were males, and the majority were internal medicine resident physicians. Only 36.2% of the participants have taken an ECG course. Most of these courses were less than 10 h long (22.7%), and 20.8% were held within the last 2 years. Participants were mostly urban (88.1%), and (88.1%) were employed in urban hospitals (Table 1).

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TABLE 1 Socio-demographic features of the study participant.

Sociodemographic description of the study population (n =660)		
	Frequency	Percentage
Age (years) [mean (SD)]	26.85	1.74
Gender		
Female	300	47.6%
Male	330	52.4%
Country		
Syria	222	35.2%
Yemen	86	13.7%
Egypt	109	17.3%
Jordan	94	14.9
Sudan	51	8.1%
Iraq	47	7.5%
Algeria	3	0.5%
Qatar	18	2.9%
Specialty		
Emergency medicine	100	15.9%
Internal medicine	530	84.1%
Training Year		
First	334	53.0%
Second	169	26.8%
Third	59	9.4%
Fourth	37	5.9%
Fifth	31	4.9%
Type of course		
Online	77	12.2%
Face-to-face	131	20.8%
Hybrid	20	3.2%
Has attended an ECG course		
Yes	228	36.2%
No	402	63.8%
Years since taking the course		
< 2 years	131	20.8%
2–5 years	63	10%
> 5 years	34	5.4%
Duration of course		
10–20 h	59	9.4%
> 20 h	26	4.1%
< 10 h	143	22.7%
Social status		
Single	462	73.3%
Married	168	26.7%
Origin		
Urban	506	76.6%
Rural	124	23.3%
Chronic disease		
Yes	79	12.5%
No	581	87.5%
Hospital site		
Urban	560	88.9%
Rural	70	11.1%

3.2. ECG interpretation

Table 2 provides the correct and incorrect answers for the ECG interpretation scale. The ECG test waves have been properly arranged by 85.6% of the participants. Regarding atrial flutter, 84.9% of the participants provided correct responses, whereas 14.8% reported wrong answers for ventricular fibrillation. Less than three-quarters of the participants correctly identified the atrial fibrillation cases (71.1%), while approximately half of the participants failed to recognize the pathological Q wave (49.8%). As for ventricular tachycardia, 78.3% of the participants correctly identified the ventricular tachycardia case, while only 39.2% of the participants correctly diagnosed the acute myocardial infarction case. More than half of the participants (65.1%) correctly recognized a normal ECG, whereas 72.4% properly diagnosed ventricular extra-systole. The atrial tachycardia condition was misdiagnosed by 34.4% of the subjects (Table 2) and (Figure 1).

3.3. Sample description of hospital, years of work experience, and ECG training

Only three variables have a significant difference in the score, including gender, social status, and duration of the training course. Male participants scored higher (8.79 ± 2.32) than females, while participants who attended courses with more than 20 training hours scored higher than courses with fewer training hours duration (8.65 ± 2.58), see Table 3.

3.4. Prediction of the ECG interpretation

Logistic regression was used in Table 4 to determine the appropriate level of knowledge regarding ECG interpretation. Training year was the only variable significantly associated with ECG interpretation, in which participants in their third year of residency have a higher probability of correct ECG interpretation than participants in their first year of residency (OR = 2.15, p value < 0.05), see Table 4.

4. Discussion

The ability of clinicians to interpret ECGs accurately determines the results for their patients. This study was carried out with the intention of evaluating the level of competency in ECG interpretation made by emergency medicine and internal medicine residents across the Arab countries.

Particular attention was paid to the most significant abnormalities for the purposes of enhancing the level of care provided and reducing the risk of injury in the event of an emergency. The internal medicine and emergency medicine house residents who participated in this study only managed to attain a limited overall competency score. According to the findings of other research, physicians in training have a 36–80% accuracy rate when it comes to identifying ECG diagnoses (17–24).

We discovered that there was not a significant difference between emergency medicine residents' and internal medicine residents' perceptions of how adequately competent they were with

TABLE 2 ECG interpretation results.

ECG interpretation results	Frequency	Percentage
1. What is the correct order of ECG waves and intervals?		
A. T wave, P wave, QRS complex, PR interval, ST interval, U wave.		
B. P wave, QRS complex, T wave, PR interval, ST interval, U wave.		
C. QRS complex, P wave, PR interval, T wave, ST interval, U wave.		
D. I do not know.		
Correct	539	85.6%
False	91	14.4%
2. If in an ECG the P wave does not appear, what is your first thought?		
A. There is a conduction problem between the ventricles.		
B. There is a conduction problem between the atriums.		
C. It is normal; it does not have to appear in an ECG.		
D. I do not know.		
Correct	542	86%
False	88	14%
3. You perform an ECG and observe this register. What do you think it might be?		
A. A third-degree heart block		
B. An atrial flutter		
C. A supraventricular tachycardia		
D. I do not know.		
Correct	535	84.9%
False	95	15.1%
4. You perform an ECG and observe this register. How would you act?		
A. Ask for help without leaving the patient alone because it is a ventricular fibrillation.		
B. Ask for help without leaving the patient alone because it is an atrial fibrillation.		
C. Perform another ECG because it looks like there may be interference.		
D. You do not know how to act but you know it must be a serious problem.		
Correct	537	85.2%
False	93	14.8%
5. A patient comes to the emergency department because of respiratory distress. He has 140 beats per minute. You perform an ECG and observe the following:		
A. It is an atrial tachycardia.		
B. It is an atrial fibrillation.		
C. It is an atrial extra systole.		
D. I do not know.		
Correct	448	71.1%
False	182	28.9%
6. A patient comes to the emergency department with precordial pain for more than 8 h. You perform a 12-branch ECG. After observing the ECG, what catches your attention?		
A. You can see pathological pauses.		
B. You can see pathological Q waves.		
C. The patient has a low cardiac rhythm.		
D. I do not know.		
Correct	316	50.2%
False	314	49.8%

(Continued)

TABLE 2 (Continued)

ECG interpretation results	Frequency	Percentage
7. What pathology do you think the patient has as demonstrated on this ECG?		
A. A first-degree heart block		
B. He does not have any pathology		
C. A third-degree heart block		
D. I do not know.		
Correct	483	76.7%
False	147	23.3%
8. A hospitalized patient who had had surgery because of an AMI is transferred to the emergency department to be monitored because his vital signs are unstable. You perform an ECG and observe the following:		
A. The patient presents with a ventricular tachycardia.		
B. The patient presents with a supraventricular tachycardia.		
C. The patient presents with an atrial tachycardia		
D. I do not know		
Correct	493	78.3%
False	137	21.7%
9. You are in triage and call a patient who reports medium-intensity precordial pain. He tells you that the pain appeared after leaving an important meeting 2 h ago. He is 52 years of age and hypertensive; a few months ago he was diagnosed with type 2 diabetes mellitus. You perform a 12-branch ECG and observe the following:		
A. It is a supraventricular tachycardia.		
B. It is an acute myocardial infarction		
C. It is an acute myocardial infarction with a pathological Q wave.		
D. I do not know.		
Correct	247	39.2%
False	383	60.8%
10. A 24-year-old athletic, slim man comes to the emergency department. He reports feeling a pricking sensation in the left area of his chest since he finished exercise 3 h earlier. You perform an ECG and observe the following:		
A. It is an atrial bradycardia.		
B. He has conduction problems.		
C. It is a normal ECG.		
D. I do not know.		
Correct	410	65.1%
False	220	34.9%
11. A patient with digitalis intoxication comes from a hospitalization ward. Before monitoring him, you perform an ECG and observe the following:		
A. You observe an atrial extra systole		
B. You observe a ventricular extra systole		
C. You observe that he has a pacemaker.		
D. I do not know.		
Correct	456	72.4%
False	174	27.6%
12. A 30-year-old woman comes to the emergency department reporting palpitations, chest tightness, and dyspnea. You perform an ECG and observe the following:		
A. It is a ventricular tachycardia.		
B. It is an atrial extra systole.		
C. It is an atrial tachycardia		

(Continued)

TABLE 2 (Continued)

ECG interpretation results	Frequency	Percentage
D. I do not know.		
Correct	413	65.6%
False	217	34.4%

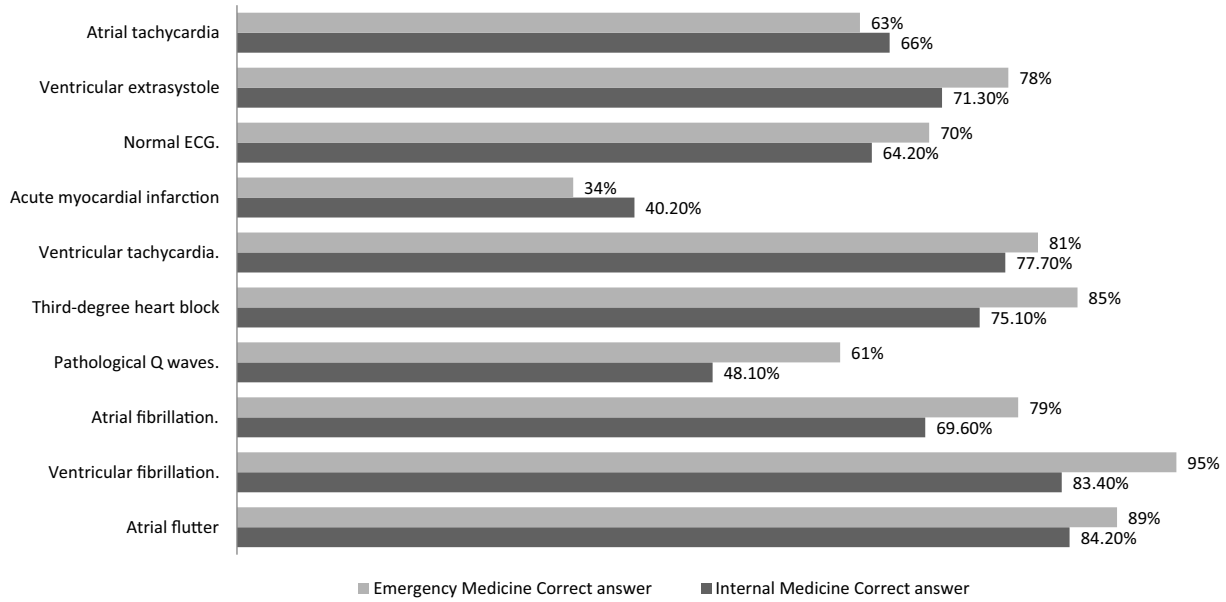

FIGURE 1
Electrocardiography (ECG) interpretation results.

ECG. Although the overall performance was low for both fields of study (rates of incorrect diagnosis were 58% for complete heart block and 8% for myocardial infarction), emergency medicine residents have similar skill levels in ECG interpretation compared to medicine residents. This could be due to the equal amount of expertise within both emergency medicine and internal medicine residents. This was found in a study conducted in New York (25). On the ECG of ventricular tachycardia, we discovered that emergency medicine residents had better scores. In fact, ventricular tachycardia is an emergency condition, where more likely emergency medicine residents will be exposed to this condition indicating more accurate interpretation of ventricular tacycardia on an ECG. In contrast, the research conducted in New York revealed that internal medicine residents had much higher scores on the ECG of ventricular tachycardia. In addition, findings from similar studies indicate that cardiologists may do better than other physicians. This could be particularly accurate when there is a lack of precise clinical data of the patients with severe conditions (26).

Compared to participants in their first year of residency, individuals in their third year of residency have a higher likelihood of making the correct ECG interpretation. Senior residents were more likely than junior residents to report ECGs on their own, according to a Nigerian study (27), which compared the two groups. As a result of their exposure to and expertise with interpreting ECGs during their residency, higher level residents are more likely to interpret ECGs accurately. In addition, our findings revealed that female participants performed worse than their male colleagues, which it might be claimed that men doctors are better able to handle severe cardiovascular diseases than women doctors since the ECG is a critical diagnostic tool that requires precision and care when investigating these cases like heart failure and ventricular fibrillation. Nevertheless, another study revealed that fatality rates for both women and men were lower in emergency departments when the treating physician was a woman because female doctors tend to listen more to their patients (28).

There have been a few studies in the past that have demonstrated how training may increase one's ability to read ECGs. Of a total of eight ECGs, Hatala et al. examined the responses of 30 fourth-year medical students, 15 residents in internal medicine, and 15 cardiologists. They showed significant improvement at each level of training (22). There are some patterns on an ECG that signify problems that a resident may be required to treat urgently. Acute myocardial infarction, complete heart block, ventricular fibrillation, and ventricular tachycardia are some of the conditions that fall under this category.

In our research, we looked at three different types of electrocardiographic emergencies: acute myocardial infarction, ventricular tachycardia, and complete heart block. Of these, 60.8% of patients had the wrong diagnosis for acute myocardial infarction, 21.7% of patients were misdiagnosed with ventricular tachycardia, and

TABLE 3 Sample description of hospital, years of work experience, and ECG training.

Sample description of hospital, years of work experience, and ECG training		
Variables	Mean/SD	*p* value
Gender		0.03
Male	8.79/2.32	
Female	8.39/2.41	
Social status		0.048
Single	8.49/2.41	
Married	8.91/2.37	
Has received training?		0.97
Yes	8.60/2.28	
No	8.60/2.42	
Time since receiving training		0.38
2–5 years	8.71/2.50	
> 5 years	7.94/2.50	
< 1 year	8.71/2.42	
Specialty		0.2
Emergency medicine	8.88/2.10	
Internal medicine	8.55/2.41	
Type of training		0.99
Online	8.65/2.06	
Hybrid	8.45/3.20	
Face-to-face	8.89/2.26	
Hospital site		0.91
Urban hospital	8.61/2.37	
Rural hospital	8.57/2.4	
Duration of the training		0.02
< 10 h	8.57/2.28	
10–20 h	8.64/2.20	
> 20 h	8.65/2.58	

23.3% had misdiagnosed complete heart block. In contrast, the New York research found that ST segment elevation myocardial infarction was incorrectly diagnosed in 8% of patients, ventricular tachycardia was incorrectly identified in 11% of patients, and complete heart block was incorrectly diagnosed in 58% of patients. In many cases, these diagnoses call for immediate medical intervention, and getting them wrong might have huge consequences. As a result, steps should be taken to empower residents in terms of ECG interpretation, such as holding standard ECG interpretation courses and techniques to strengthen ECG interpretation training and learning, such as ECG display training packages. Participants' lack of proficiency in interpreting ECGs can be improved further by utilizing computer-aided diagnosis and a focus on medical imaging.

There are a variety of measures that might be taken in order to improve ECG expertise. It has been demonstrated that even brief training in ECG interpretation may considerably improve a person's ability to read electrocardiograms (17). The majority of the time, these diagnoses require prompt medical care, and getting them incorrect might have extremely serious implications. Improving one's knowledge of ECG may be accomplished through a range of different approaches that can be pursued. It has been established that even a cursory instruction in the interpretation of electrocardiograms may significantly increase a person's ability to read electrocardiograms (20, 29).

The American Boards of Internal Medicine and Emergency Medicine have mandated that all staff members must undergo ECG training, undergo an initial evaluation of their level of proficiency, and continue to demonstrate that they can maintain their level of competency over time. It was suggested by Salerne et al. that the determination of initial competency in ECG interpretation at the end of residency training should be based on periodic objective assessment and documentation of resident interpretation skills in a clinical context rather than the completion of a minimum number of interpretations. This was in contrast to the traditional method of determining initial competency in ECG interpretation, which was based on the completion of a minimum number of interpretations. In contrast to the conventional approach, which consisted of basing initial competency on the successful completion of a certain number of interpretations (26).

4.1. Strengths and limitations

When attempting to make sense of the findings of our research, there are a few limitations that need to be noted. To begin, there were a far lower number of emergency medicine residents than there were internal medicine residents. It is possible that this is the reason why there is not a substantial association between the postgraduate year and competency. Second, for the purposes of the study, an ECG sample that was both small and somewhat arbitrary was selected. Even while we assume that these ECGs accurately reflected the majority of patients' conditions, it is likely that the residents' findings might have been different if they had been given other ECGs.

This study used both an online format with an accompanying online questionnaire as well as an in-person interview. Due to the fact that the test is administered online, locals have the ability to look the answers up, which can result in inaccurate scoring. When conducting the survey, using a questionnaire based on an in-person interview helped to lessen the probability that respondents relied on information obtained from other sources when answering the survey questions. This is a strength of the approach. One of the other strengths of this study is that it provides a clinical scenario alongside each ECG, which has a positive impact on the interpretation. Participants in our study were under no obligation to take part, and they were not threatened or coerced in any way by potential outcomes should they choose not to take part.

5. Conclusion

We have uncovered inherent drawbacks in the interpretation of ECGs, which may have major consequences for the medical treatment provided to residents and patients. As heart conditions are quite frequent and potentially result in death, it is crucial for medical professionals to notice and evaluate any abnormalities on an ECG as

TABLE 4 Binary logistic regression to determine the appropriate level of knowledge regarding ECG interpretation.

Variable	Adjusted				Un-adjusted			
	p value	OR	95% C.I		*p* value	OR	95% C.I	
			Lower	Upper			Lower	Upper
Age	0.254	1.068	0.954	1.195	0.002	1.153	1.052	1.264
Gender (Male: Ref)	1							
Female	0.298	0.840	0.606	1.166	0.236	0.828	0.605	1.132
Specialty (Emergency medicine: Ref)	1							
Internal medicine	0.726	0.920	0.578	1.464	0.229	0.768	0.500	1.181
Training year (first year: Ref)	1							
Second year	0.002	1.881	1.267	2.793	0.000	1.984	1.362	2.889
Third year	0.016	2.154	1.157	4.008	0.002	2.477	1.393	4.404
Fourth year	0.106	1.921	0.870	4.240	0.048	2.008	1.006	4.008
Fifth year	0.508	1.315	0.585	2.960	0.178	1.662	0.793	3.483
Attending a previous ECG course (Yes: Ref)	1							
No	0.777	0.831	0.231	2.991	0.751	1.054	0.762	1.459
Years since taking the course (< 2 years: Ref)	1				0.940	1.015	0.684	1.506
2–5 years	0.161	1.800	0.791	4.096	0.293	1.333	0.780	2.279
>5 years	0.087	2.170	0.892	5.278	0.511	0.789	0.390	1.597
Type of course (Online: Ref)	1				0.917	0.974	0.598	1.587
Face-to-face	0.620	0.763	0.262	2.222	0.820	1.047	0.706	1.553
Hybrid	0.700	0.820	0.299	2.248	0.385	1.500	0.600	3.748
Duration of course (10–20 h: Ref)	1				0.943	0.986	0.673	1.444
>20 h	0.546	0.756	0.305	1.874	0.715	1.107	0.641	1.913
<10 h	0.758	0.858	0.324	2.276	0.449	1.364	0.611	3.042

soon as possible. Extra training is required, especially in the treatment of cardiac crises. The primary focus of research to come should be on developing and evaluating effective methods for ECG interpretation expertise.

Data collection group

The data collection group has contributed equally to collect the responses by sharing the online google form survey to the doctors at the departments of internal medicine and emergency medicine.

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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 undertaken after the approval of the Syrian Ethical Society for Scientific Research (AS:2819B). Moreover, at least on ethical approval was taken from each inquired country in our study.

Author contributions

AR and SS: conceptualization, methodology, formal analysis, writing-original draft, and review and editing. SS, HA, HB, YA, KA, YK, BS, BR, MA, IA-F, WH, MR, AG, and EE-S: conceptualization and writing the original draft. WH, AR, AG, and EE-S: proofreading and reviewing and editing the final draft of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2023.1140806/full#supplementary-material

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The role of feedback in supporting trainees who underperform in clinical environments

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Introduction: Underperformance in clinical environments can be costly and emotional for all stakeholders. Feedback is an important pedagogical strategy for working with underperformance – both formal and informal strategies can make a difference. Feedback is a typical feature of remediation programs, and yet there is little consensus on how feedback should unfold in the context of underperformance.

Methods: This narrative review synthesises literature at the intersections of feedback and underperformance in clinical environments where service, learning and safety need to be considered. We do so with a critical eye towards generating insights for working with underperformance in the clinical environment.

Synthesis and discussion: There are compounding and multi-level factors that contribute to underperformance and subsequent failure. This complexity overwrites simplistic notions of 'earned' failure through individual traits and deficit. Working with such complexity requires feedback that goes beyond educator input or 'telling'. When we shift beyond feedback as input to process, we recognise that these processes are fundamentally relational, where trust and safety are necessary for trainees to share their weaknesses and doubts. Emotions are always present and they signal action. Feedback literacy might help us consider how to engage trainees with feedback so that they take an active (autonomous) role in developing their evaluative judgements. Finally, feedback cultures can be influential and take effort to shift if at all. A key mechanism running through all these considerations of feedback is enabling internal motivation, and creating conditions for trainees to feel relatedness, competence and autonomy. Broadening our perceptions of feedback, beyond telling, might help create environments for learning to flourish.

KEYWORDS

feedback, failure, underperformance of learners, health settings, learning culture, motivation

1. Introduction

1.1. The problem of underperformance in health professions education

Underperformance and subsequent failure are critical experiences that can have many damaging effects. For trainees, failure can be financially costly, involving reputational loss, and emotional stress, shame and stigma (1, 2); for teachers, it is a time drain, leading to ambivalence, anger, stress and guilt (3, 4); and for the clinical environments, there is potential for compromise of patient safety, financial loss, litigation and lost productivity (5, 6). While remediation models are diverse (7) feedback features in all attempts to work with underperformance (8–12) and is the focal point for this narrative review.

Remediation is the common course of action for an episode of underperformance, or a series of events that suggest a pattern of underperformance – facilitating a 'correction' for trainees who have moved off course (13). This aligns to the notion that there is a single linear course to be followed for 'able' trainees. Ellaway et al. (5) differentiate between remedial action and remediation. They define remedial action as "largely supportive, informal, and short-term events … in which a preceptor facilitates a learner's progression toward professional mastery and independent practice" (p. 394). Remediation on the other hand, "is a formal response to sustained underperformance, with a different schema (its collected rules, roles, responsibilities, and thresholds) than the ones for the mainstream curriculum" (p. 394). The depth of the intervention is tailored to the persistence and scope of the trainees' difficulties. Clearly, feedback can play a role in both these pedagogical responses – whether through formal feedback-on-action interventions including coaching and/or more embedded and informal forms of feedback-in-action (14, 15).

For this paper, we conducted a narrative review to synthesise how feedback can be used to support students who underperform in clinical environments. Narrative reviews generally do not rely on systematised search strategies, and they enable a wide range of papers to be included to provide interpretation and critique (16). Our search included papers where feedback and/or underperformance were the primary focus in medical and higher education literature, aligning with our expertise. The paper follows in the tradition of narrative reviews where we develop themes for how feedback might be understood and employed in the context of underperformance.

We start from the perspective that underperformance and learning are inextricably intertwined. Feedback is defined as a social process where trainees have an active part to play in making sense of performance relevant information, within social, cultural, relational and material environments (17). We use the term trainee to represent learners at all stages of their journey: from pre-service students undertaking clinical placements to clinicians completing specialised training. We primarily focus here on sustained underperformance, although sometimes failure might occur at a micro-level, e.g., where trainees are allowed to fail without compromising patient safety (18), or as a self-assessment where performance was below personal expectation (2).

A common response to underperformance is that supervisors do more – observation and feedback – to help trainees. However supervisors report doing more of the same to little effect (3). So, if telling trainees what to do is not the answer, how might feedback be used to support those who are underperforming in clinical environments? Overall, we aim to challenge the perception that more telling is better. We start with examining the language of struggle, failure and underperformance critiquing the discourses of deficit, meritocracy and linear achievement. We then synthesise feedback literature relevant to working with trainee underperformance. Through critiquing a broad range of literature (health professions, higher education, organisational psychology), we discuss how dominant feedback trends might help with underperformance and consider where these might not be so helpful within complex clinical environments. The paper ends with insights for clinical educators about the role of feedback in working with underperformance.

2. The deficit discourses of feedback – what's in a name?

Struggling, *underperforming*, *failing* or even the *problem* student/trainee can be found in health professions education literature. Meritocratic discourses of education present a rigid and linear notion of potential which prescribe fixed, developmental timeframes – veiled in "an aura of objectivity" that obscures the role of privilege, hierarchy, class, and power (19). Any deviance from these developmental timeframes constructs a perception that trainees have failed to engage with education processes in an idealised manner and where individual deficit can be 'fixed' through remedial forms of support (20). Failure and underperformance are thus attributed to the individual – as resulting from a trainee's individual traits or acts that "earn them failure" (21). The deficit discourse of failure serves to position struggling trainees as other – a "not like us" position (4) which only compounds that individual's struggles (7). This 'othering' can also exclude trainees from learning opportunities and has implications for how underperforming trainees might engage with feedback.

The discourses of performance, underperformance, achievement and failure are much more complex than is often represented. For example, grades may reflect structural or institutional bias (22). Failure discourses can be gendered with the ideal successful learner constructed as male, white, middle class and able-bodied, an autonomous individual unencumbered by domestic responsibilities, poverty, or self-doubt (23). Women in certain academic disciplines may "already feel that they can never be good enough or never get it right … and this is not, we suggest, about individual failings of confidence, but a result of the systematic positioning of some groups in our society as of less worth or value than others" (23) (p. 609). This is particularly true in male dominated specialties such as surgery (24). Intersecting with gender, is class, where working-class students are less likely to seek help compared with those from a middle-class background (25), with such patterns of behaviour attributed to socialised logics of action carried over from schooling (26). The persistent differential attainment between white and ethnic minority cohorts in medical education suggests that progression has less to do with capability and more to do with context and race (22). Indeed standards themselves, against which we judge performance are sociocultural and material constructions (27).

Research in higher education shows that failure and underperformance are multifactorial due to an interplay of dispositional, situational, relational and cultural factors (1). Dispositional factors include the ways trainees approach their study,

what they prioritise, how they self- and effort-regulate. Situational factors – factors outside an individual's control – might arise that influence trainees' ability to study and curtail their efforts such as illness (their own or a loved one). Relational factors include feelings of isolation, exclusion and marginalisation where trainees are afraid of asking for help due to stigma or repercussions. Finally, cultural factors can impede progress where the pedagogical and pastoral support mechanisms available in a particular location are not suitable for the particular trainee. This is illustrated by the phenomenon where a trainee cannot seem to overcome a label of underperformance in a particular rotation and yet they flourish in another environment (6).

This complex confluence of factors for trainees who are underperforming demands a multi-faceted approach to remediation. However, with this broader conceptualisation of underperformance, the band of influence of feedback may be quite narrow, or even, counter-productive in certain situations. This counters the 'face value' of feedback as an always valuable means for working with underperformance: this response suggests that the bigger picture is important in charting ways of thinking about feedback in clinical environments.

What this focused summary shows is the complexity of how underperformance is constructed, not just through individual acts but through systems of disadvantage that go beyond the individual. Much like the challenge with the ubiquity of the language of 'giving feedback'; the language of the 'underperforming trainee' comes with its own baggage. We have tried in the language of the paper, not to link underperformance to individual attributes or traits but to acknowledge the social, cultural, historical and material constitution of (under) performances. We also draw on our previous work, to remind that feedback rules do not work in the face of such diversity and complexity (28), instead we offer educational principles derived from the literature for individuals to use to reflect on and inform their practices.

3. Feedback and underperformance

While much has been written about the power of feedback for learning (29, 30), less is known about the role of feedback in supporting trainees who are failing to meet performance expectations. We outline some of the insights from the broader education literature. A recent realist review of feedback in higher education (31) identifies that undergraduate students with differential achievement approach feedback differently. For example, negative feedback comments might spur some students to greater effort regulation but in students with pre-existing perceptions of low self-efficacy it can lead to demotivation and unhelpful feedback behaviours, such as avoiding seeking clarification from supervisors and less action on feedback comments.

The review identified Ryan and Deci's (32) self-determination theory (SDT) as providing a strong theoretical explanation for feedback interventions that work in open-ended written university assessment. SDT, with psychological roots and strong evidence, suggests that internal motivation is leveraged through conditions that foster an individual's perceptions of relatedness, competence and autonomy (32). A realist review of remediation also identified motivation as a key mechanism for effectiveness (9). It has been proposed that SDT explains why students who underperform appear so disengaged and to lack insight (10): we can conjecture that being labelled as underperforming or failing can be a threat to perceptions of competence as well as potentially rupturing perceptions of relationality and that this can interfere with feedback practices. We also know that remediation can act as a threat to autonomy – at least for physicians (7). The follow-on effect would be loss of internally driven motivation. Precisely the time when you want trainees to remain motivated and engaged!

4. Troubling the intersections of feedback and underperformance in clinical environments

Against a backdrop of SDT, we present themes for how feedback conversations might be positioned to support trainee learning in the context of underperformance. Relationships are described as the backbone of feedback (33) and form a necessary pillar of SDT. Emotions are central to feedback and relationality and so we wrangle with these next. Feedback literacy opens perspectives into perceptions of competence and autonomy. We end by discussing feedback cultures as these are where conditions for motivation, performance and engagement play out.

4.1. Relationships, trust and shadow systems

Feedback in clinical environments is strongly mediated by relationships (34). In their research, Telio et al. (35) found that the strength of the educational alliance as perceived by trainees influenced how trainees made sense of and used feedback information. By recognising the important role of relationships in feedback effectiveness, we disrupt the focus on the message with typically linear thinking of positive valence comments leading to positive reactions (and vice versa). Instead, perceptions of the strength of the educational alliance might be a better predictor of feedback effectiveness. It is hard to form a strong educational alliance if you feel victimised or othered.

Supervisors have reported that they find it challenging to have feedback conversations with trainees when the observed activity is seen to be below-par, or if a series of observed events have been viewed to be sub-standard (36). Supervisors not only report the emotional burden they feel after engaging in these discussions (37), but observational studies of feedback show that supervisor language in these conversations takes on a distinctive tenor – what some have reported as "vanishing" (38), others as "mealy mouthed" (39), and others as "hesitant and apologetic." Johnson and Molloy (40) describe how supervisors talk in circles in an attempt to diminish the negative emotional impact on learners. What is not clear is the extent to which this fear of upsetting trainees will be fulfilled. We can only imagine that such mealy-mouthed approaches do not provide trainees with great confidence that their educators believe they are capable of engaging in candid discussion about their performance. The work of Castanelli et al. (41) in the anaesthesia supervisory context suggests that performance conversations are seen to be easier and more effective if the trainee trusts in the supervisor. Talking in circles or avoidant approaches may indicate a lack of bi-directional trust.

When a trainee has low trust in the supervisor, there are several strategies they might employ when it comes to feedback. Firstly within the relationship, the trainee may attempt to reduce what they reveal to

the supervisor, both in terms of working alongside the supervisor, but also what they choose to share in feedback conversations (41). "Trainees learn to expose their authentic practice in assessments as an expression of trust" (p. 288) which has implications for the complexity of challenge they might take on in front of the supervisor, and the degree of candour they display when talking about their practice struggles in the context of feedback or assessment conversations. These findings did not suggest that 'poorly performing students' hide, or that they 'game' feedback conversations, but rather that trainees, regardless of their 'performance status' made judgements about the extent to which their supervisors were trustworthy (demonstrated through action, and occasionally by word of mouth or status). The judgements of trust were seen to influence what trainees were willing to share, how curious the trainees were within working and educational encounters (most often intertwined) and how trainees sought out opportunities for alternative feedback conversations in their environments.

Where it becomes more challenging, is when the informal networks of assessment – what Castanelli et al. (42) termed a 'shadow system' – operates to forewarn clinicians that a poorly performing trainee lurks amongst them. One supervisor described making trainee performance judgements based on "lots of interactions, phone calls, conversations … You get a bit of a vibe about it … there's far more than just individual cases and individual procedures. It is a global assessment that is far more telling" (42) (p. 140). Thus, the trainee who may try to seek alternative viewpoints and interactions (perhaps even those that only reinforce their world view); they may be working within a system that has already deemed them 'underperforming', thereby limiting access to work opportunities that may stretch them appropriately or that might create a productive network to further support their learning in the workplace.

4.2. Emotions

There is a large body of literature reporting on the intersection of feedback and emotion in higher education [e.g., (31, 43)] and health professions education [e.g., (44, 45)]. Increasingly there is an acknowledgement that emotions can spur action from feedback processes, and that emotions can be an internal source of feedback in their own right. We look at each of these ideas in turn: the hurtful nature of some feedback encounters; the relationship between trainee insight and emotion; how negative emotions can be productive; and thinking about productive and caring feedback interactions.

The dominant discourse of feedback literature is that negative emotions are 'stirred up' by the feedback process, particularly when the conversations may challenge trainee perceptions of the worth of their work, or by extension, self (45). This is useful in some ways, as it helps with understanding some of the distress trainees feel. Moreover, the emotional legacy can extend far beyond the initial encounters that created turbulence (46). If previous feedback experiences – or feedback histories – have been harmful or damaging, it is unsurprising if a trainee avoids future feedback encounters unless their perceptions of the educational alliance and feedback culture can overcome the legacy of harmful feedback. Not only is feedback emotional business, so is failing. Research shows that far from having earned their failure through laziness or ambivalence, students cared deeply about failing and reported emotions of shame, shock and embarrassment (1). Similarly the nursing literature speaks to students' surprise, distress, anger and self-disappointment (47). Bynum and colleagues (2) describe medical residents' feelings of shame at fleeting moments of underperformance. Failure involves emotional work by trainees and supervisors.

Trainee surprise or shock can be seen as a failure of feedback rather than a consequence of feedback. Unless there has been a major sentinel event trainees should not be shocked if they fail a rotation or clinical placement. With good feedback processes in place, trainees should have a clear sense of progress against declarative competencies. In this way feedback builds trainees' evaluative judgement – defined as "the capability to make judgements about the quality of work of self and others" (48) (p. 467). Developing trainees' evaluative judgement of their clinical practice is one of the purposes of feedback that develops independent practice (49). Here, feedback processes should help trainees come to know what good quality looks like through comparisons of judgements of practice that help trainees generate their own feedback information. Pedagogies such as self-assessment, observation and peer review, feedback dialogue about performance, engagement with standards can all play a role. Thus, when trainees are surprised about failing, they have not sufficiently understood or engaged with the standards and thus lack insight into the gaps in their performance relative to the standard.

Categorising emotions as positive or negative does not equate to their effect on learning. While shame, anger, frustration, embarrassment etc. may lead to disengagement (often described as silence/quiet) from feedback where trainees may want feedback but fear disconfirming information (50). These emotions may also spur action in some trainees. Alternatively, emotions such as relief might prompt a lack of striving. The valence of the feedback comments (positive or negative) also does not equate to their effect on emotions, because relationship act as a mediator. For example, a supervisor opened a feedback interaction with 'you did it all wrong' – and while this might be classified as a negative comment, the trainee reported that due to the strength of the educational alliance with his supervisor he took this on board and it resulted in improvement (35).

Confidence, care and trust are three guiding emotions for productive feedback encounters (45). Underperformance in the clinical environment may compromise these – for example a trainee who has been labelled as underperforming and exposed to increased scrutiny might lose confidence in themselves. They might feel that the learning environment is more about surveillance and gatekeeping than care; this can fracture trust and an educational alliance. These emotions implicate the supervisor and trainee in needing to act together to rectify the learning environment. Actively helping trainees to reflect on and share their emotions related to feedback processes might disrupt the negative de-motivational spiral. "Emotions give feedback meaning, weight and intensity—deepening the effects of feedback and learning. If feedback provides information that indicates individuals are not who they think they are or want to be, they feel unpleasant social emotions that, if given time and reflected on in a structured way and safe environment, can prompt productive action" (45) (p. 484).

4.3. Feedback literacy and feedback seeking

The previous two sections have dealt with trainees' perceptions of relatedness, and now we move to trends that support perceptions of competence and autonomy. With feedback being reconceptualised as

a dynamic and social process, trainees are being positioned to actively seek and use feedback information to enhance their performance and learning. Reconceptualising feedback in this way has illuminated fresh ways to enhance feedback – beyond doing more of the same – and offers the potential to address gnarly situations where feedback is not working.

Firstly, this reframe means that trainees are in the driver's seat for feedback processes. Yet, effectively driving this process requires new capabilities – referred to as feedback literacy – "understandings, capacities and dispositions needed to make sense of information and use it to enhance work or learning strategies" (51) (p. 1315). Unpacking the concept of feedback literacy, a little further, feedback literate learners: (1) appreciate feedback, (2) make judgements, (3) manage affect, and (4) take action. Initial work in purposefully developing trainees' feedback literacy offered promising results because they recognise their agentic role in feedback (52). However, participants were self-selecting and so likely high performers. But what does feedback literacy offer for trainees who are underperforming? Is it reasonable to expect these trainees to be driving feedback processes?

Further exploring feedback literacy may assist here. Firstly, appreciating feedback processes means that trainees value feedback whilst recognising they have an active role to play (51). For the trainee achieving strong results in their assessments, this might be all well and good in that their experience of feedback processes has afforded enhanced learning and performance. In the face of underperformance, the experience may be less generative and less likely to be appreciated. For instance, even if the supervisor makes conscious moves to try to create conditions promoting psychological safety (perceptions of consequences of taking interpersonal risks), hearing unwelcomed feedback information risks a shame response and disengagement from feedback processes (53). It will be hard to appreciate feedback processes with this outcome. Or what if the trainee who is underperforming finds themself in a busy clinical environment where feedback processes are not accessible or apparent? It will be a bold move for a trainee to disrupt the rhythm and flow of patient care in a clinical environment not affording opportunities for active feedback engagement (54). In clinical environments, feedback processes are not as evident nor easily accessible to newcomers (i.e., trainees) or those trainees whose sense of belonging is tenuous (55). In this instance, it will be challenging to elicit the necessary performance relevant information to enhance performance. So, here the trainee faces the challenge of not enough feedback information (46, 56).

In contrast, appreciating feedback processes and being agentic has the potential to lift engagement. Rather than experiencing feedback as something which is done to them, trainees might come to appreciate that they have an active role to play, which offers them a way forward. They can, for example, ask for clarification when the supervisor's feedback information is not guiding them on the next steps (52). While for supervisors, rather than seeking to 'give more feedback', taking the time to encourage trainees' construction of goals which guide current and future actions and conversations might 'break the cycle' of feedback as telling (57). However, this requires trust and for the trainee to overcome potential feelings of inadequacy and loss of autonomy.

Secondly, when trainees are underperforming it is often assumed that they are failing to accurately judge their performance – a failure of insight (58). Theoretically speaking feedback literate trainees can make judgments about the quality of their own work and others, in order to inform their own learning. An important feature is refining judgements over time to enhance the robustness of their judgements and to calibrate these judgements against those of their supervisor and expected standards. Again, the circumstances of clinical practice may not afford this calibration process (indeed it may even hamper judgements). For instance, if supervisors are constantly changing, as in shift-based supervision, trainees may receive disparate feedback information. This is a challenging scenario for trainees who then need to make sense of this disparate advice to determine what constitutes quality work. Others have identified a lack of longitudinal monitoring and fragmentation of clinical supervision experiences as challenges to supervisory judgement making (59). This highlights how the development of trainees' evaluative judgements is constrained by system design.

Yet, developing capabilities in making judgements, as part of being feedback literate, holds promise for trainees who are underperforming. For instance, work can be done to attune trainees to the inevitability of contrasting perspectives and varied sources of performance relevant information. Pedagogical strategies can be developed to enable them to make judgements and generate internal feedback through comparisons with peers' work (60) for example. This is unlikely to be a solo adventure for trainees. Here they would benefit from guidance from peers, near peers, and supervisors as co-pilots in driving this aspect.

4.4. Building a feedback rich culture to support underperformance

Building feedback literacy is an important consideration when thinking about how to work with underperformance but it does not paint the whole picture (11). The importance of context is suggested in multiple literatures. Firstly, several literature reviews suggest that program level approaches to managing underperformance are critical to remediation (8, 9). Such strategies included means of normalising and scaffolding underperformance and designing appropriate formal institutional processes (10). Secondly, the clinical feedback literature points to a wide variation of cultural practices with respect to feedback (61). Finally, the availability of learning cues and opportunities to gather information about performance can vary widely from context to context (11). Thus, without appropriate systems, supportive cultural practices and rich opportunities to demonstrate capability, even the most high-achieving trainee might struggle to gainfully engage with feedback, let alone trainees who may already be overwhelmed.

Culture is a notoriously slippery term (62). This presents strong challenges when thinking about how to engage with culture, but nonetheless to ignore culture is to ignore much of what constitutes underperformance in the first place. As Steinert (63) suggests, the first question when asked about working with underperformance is whose problem is it? It may not be the trainee who needs to engage with feedback, but in fact the context itself that is in deficit. This is amplified by the need for trainees to rotate through contexts, some of which may provide feedback rich opportunities and some of which may be damaging to trainee confidence and possibly capability. However, it is also worth noting that what one trainee may experience as a rich feedback culture, another may flounder or even be damaged.

We propose several conundrums around feedback cultures and raise possible responses. We do so by drawing on the ways that culture has been conceptualised in previous literature (64). In some instances, it may be that trainees, supervisors and university educators are working within clinical cultures that are, for all intents and purposes, fixed. This not a problem if the trainee is engaging with feedback in a highly supportive environment but can be very problematic, particularly if the trainee is seen as someone who does 'not belong'. Supporting trainees in this situation is about increasing their literacy as outlined above, but also in ensuring that there is an external point of contact to help navigate this 'unchanging' culture. This could be a 'co-pilot', or it could be in fact a totally external feedback process, so that an external person provides comments to trainees. This has been found to be very useful in general practice training (65).

In some instances, the culture may appear to overwhelm the trainee – for example the 'way we do things around here' can be difficult to argue with. This can indeed be damaging for all trainees but is particularly difficult if the trainee is simply positioned as being in deficit with no way to improve. In this instance, looking to standards and expectations may be the way to help bolster trainees. These types of markers of quality can help the trainee navigate an environment that threatens to be overwhelming. This again points to evaluative judgement as a means of working with underperformance: "By focusing on evaluative judgment, the learner can look beyond the particular deficit at hand, which can breed defensiveness and other unhelpful emotions, toward how the learner can assess whether a performance is good or bad" (10) (p. 12).

Another view of culture suggests that educators can agentically adapt to the feedback culture that they find themselves within. This brings in the relational means of working with feedback: by focussing on issues such as psychological safety, educators can directly ensure that the culture is adapted to work with underperformers. Key issues here, as taken from the remediation literature, include enabling appropriate sequencing of tasks for a trainee who is underperforming and building strong trusting relationships (10). These can ensure that feedback is designed into the learning experience. A particularly useful approach may be to ensure that the trainee is given the opportunity to improve on tasks they are good at: this can normalise orientation towards improving performance over a sequence of activities without feelings of deficit (10). This may mean adapting the workplace curriculum to accommodate this strengths-based feedback approach. Once the trainee is comfortable with the processes of feedback, then they may be able to work in this way in other, more challenging arenas.

A final perspective comes from the organisational literature that culture can be conceived as something that can be changed (64); this offers a means to consider how to build a supportive feedback culture for working with trainees who underperform. This is the territory of overall systems changes: approaches to normalising failure, to professional development for educators (9, 13). For example Gingerich et al. (6) notes: "There were examples where it had become clear that the trainee perceived the extra attention as 'being mistreated' (S22) , but the supervisors and programme interpreted it as necessary supervision and appropriate feedback. This difference of opinion commonly involved the perception that the trainee was being resistant to feedback" (p. 400). Moreover, as Bearman et al. (3) point out, supervisors often simply do not have any alternative aside from telling the learner what the problem is – there is no 'Plan B'. We think this is a possibility for faculty development and indeed where the coaching literature may come into play. Armson et al. (66) describe joint faculty and resident development for coaching – identifying process skills, which would build a productive feedback culture – in particular: "(i) relationship building, (ii) exploring reactions to feedback, (iii) exploring understanding of feedback content, and (iv) coaching for change including development of Learning Change Plan" (p.479). In addition to this, we suggest that normalising failure is key here. It does happen that trainees do engage with feedback but fail to meet the requirements of the task. It is important in these instances that trainees do not feel that this a personal deficit or that there are no options for them. What Bellini et al. (67) call "exit ramps" – ways to leave a particular course of training – can then be built into feedback conversations, not as shameful failures but as better investments of the trainees' time to turn their attention elsewhere.

5. Implications of the review for practice and research

In a realist review of remediation for doctors, Price and colleagues (9) found that developing insight and motivation were two fundamental mechanisms of success. This accords with our own body of work on feedback, and the current review, where working with underperformance requires creating conditions that motivate trainees to engage with feedback processes in order to build their feedback literacy and evaluative judgements of clinical practice (with a focus on explicating what good work looks like). This should be a joint responsibility with efforts to create a trusting and caring environment within which both formal and informal feedback practices might be enacted. Learning environments rich in performance relevant information will enable this. Performance relevant information can be interpreted from environments (through for example, the qualities of work itself, patient outcomes, comparisons of performance) as well as through conversations with others, thus decentralising the focus on feedback from supervisors (68). By openly talking about feedback practices and how things are done around here we might shift some of the stigma of feedback away from the individual to shared goals and activities. We might know when feedback is too much or not enough.

Our narrative review will alert clinical educators to the pressing need to maintain and nurture motivation in trainees who are underperforming. Moreover, based on our review, we offer the following insights to creating conditions that foster trainees' perceptions of relationality, competence, and autonomy:

(1) Attune to diversity and to the bigger picture of underperformances. What else might be happening here beyond the individual trainee? How is power and meritocracy at play? Razack et al. (19) urges educators to create space for dialogue and questioning of the assumptions that underly meritorious work, and what behaviours are perceived and valued.
(2) When considering relationships and emotions, avoid the simple 'bad emotions, bad outcome' and 'relationships will

conquer all' thinking. Despite efforts at building trust, trainees might be reticent to share their self-assessments in response to questions such as "How are you travelling?" or "What should I watch for today when you demonstrate this procedure? Silence in this scenario may be an expression of agency rather than a signal of disengagement or lack of insight. It takes insight to suspend any self-assessment that compromises survival" (69) (p.ii). It might be through creating opportunities for building competence and autonomy that trust and openness follow. Notice what emotions are sticking and circulating in the clinical environment and invite a conversation about this. It might be quite revealing.

(3) Seek to develop trainees' feedback literacy and evaluative judgement of clinical practice as alternatives to 'telling' that build competence and autonomy. This shifts the focus to co-construction of goals and supporting trainees to 'patch together' performance relevant information about their progress through multiple opportunities for comparisons of performance, evaluation against standards and conversations with peers and others.

(4) Consider how 'shiftable' a feedback culture really is and what is dominant within it. However, importantly for supporting trainees who are underperforming, seek to build supportive feedback cultures through system changes and faculty development.

The gaps identified by the review, also alert us to future research implications. A realist review of underperformance and feedback interventions in clinical settings might help build theory and test the utility of SDT as an explanatory theory. The current review is silent on how power is negotiated within feedback encounters especially given the vulnerable position underperforming trainees may hold in relation to their supervisors and assessors. Finally, we suggest that more research is needed to examine how minority and intersecting identities influence feedback conversations about performance and their interpretations.

6. Conclusion

Overall, we have presented a view of feedback that is more complex than a process of telling and where professional judgement is needed to work with these educational principles and values. We identified several feedback landscape features required to better support trainees who are underperforming through scaffolding relationality, competence and autonomy. These features included nurturing relationships, fostering productive emotions, enabling the development of feedback literacy (and evaluative judgement) and nurturing supportive feedback cultures. We have argued that we need to shift the dial from an individual deficit-based approach to embracing the complexity of feedback and underperformances in order to support trainees to make sense of and improve how they are progressing in the clinical environment.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

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

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Clinical Pharmacy Faculty Provision of Direct Patient Care, Challenges, and Opportunities

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Background: The quadripartite mission of clinical track faculty members involves research, teaching, services, and direct patient care. However, the extent of faculty involvement in direct patient care remains a challenge. Thus, the study's objective is to evaluate the effort spent on direct patient care by clinical faculty of pharmacy schools in Saudi Arabia (S.A.) and identify factors that hinder or facilitate providing direct patient care services.

Methods: This multi-institutional, cross-sectional questionnaire study conducted between July 2021 and March 2022 involved several pharmacy schools' clinical pharmacy faculty members in S.A. The primary outcome was the percentage of time/effort spent on patient care services and other academic responsibilities. The secondary outcomes were the factors affecting the effort spent on direct patient care and the barriers preventing the provision of clinical services.

Results: A total of 44 faculty members took the survey. The percentage of effort spent on clinical education was highest at a median (IQR) of 37.5 (30, 50), followed by that spent on patient care [19 (10, 28.75)]. The percentages of effort spent on education and the length of academic experience were negatively associated with efforts spent on direct patient care. The most commonly reported barrier affecting fulfilling patient care duties was the lack of a clear practice policy (68%).

Conclusion: Although most clinical pharmacy faculty members were involved in direct patient care, half of them devoted only 20% or less of their time to it. An effective effort allocation for clinical faculty duties will require the development of a clinical faculty workload model that sets realistic expectations about the time spent on clinical and non-clinical duties.

KEYWORDS

clinical pharmacy faculty, direct patient care, clinical services, clinical pharmacists, faculty responsibilities

Introduction

The tripartite mission of any academician involves research, teaching, and services. However, clinical-track faculty members are expected to engage in additional clinical responsibilities as part of their daily duties. In the United States (U.S.), clinical-track faculty refers to practitioner educators who typically devote 50–70% and 30–40% of their effort to clinical practice and teaching or experiential training, respectively (1). Both of these obligations should be fulfilled by any clinical faculty member; however, based on experience and training, clinical faculty members typically devote more time to patient care than any other academic responsibilities (1, 2). Role conflict between patient care services and teaching obligations is reported as one of the common demands facing pharmacy faculty (3). A prospective cross-sectional survey involving 344 clinical faculty in the U.S. has reported that their mean (SD) percent effort spent on direct patient care is 30.8% (22.9) (2).

Similar to the U.S., clinical faculty members in Saudi Arabia (S.A.) usually enter the academic field after completing their postgraduate year one (general pharmacy practice) or year two residency training (specialized pharmacy residency), depending on the qualifications for the clinical assistant professor position. Unlike in the U.S., where there are two tracks for faculty positions (tenure and non-tenure), there is only one faculty track position in S.A. that is equivalent to the tenure track faculty in the U.S. In this track, faculty members are expected to participate more in research and academic/community services to become eligible for promotion (4). Also, the current model does not differentiate between clinical and non-clinical faculties. In S.A., the promotion criteria for clinical and non-clinical track faculty members heavily rely on publications, in addition to teaching and academic or community services. However, providing clinical services is not always among the criteria for the promotion. This may cause the clinical faculty members' focus to shift from providing clinical services and training to attending duties that are more essential for promotion, such as research, teaching, and services.

Currently, most pharmacy schools in S.A. offer the Doctor of Pharmacy degree (PharmD) (5). This professional degree involves an intensive didactic scientific component paired with multi-level practical experiences. At the national level, the program learning outcomes are unified between these programs to ensure all students receive similar experiences. These programs require sufficient non-clinical and clinical faculty to produce competent professionals that will join the workforce. Clinical-track faculty members who provide direct patient care may also serve as clinical preceptors for students' introductory or advanced training. Therefore, the pharmacy schools in S.A. have adopted a hiring and promotion pathway for clinical faculty members with professional training and relevant credentials, including licenses, to deliver scientific and experiential competencies in their academic programs. However, one of the challenges in pharmacy education in the S.A. is that the number of proficient clinical faculty members remains insufficient to meet the demand for instructors in clinical courses or for facilitating clinical training (6). Moreover, not all institutions are affiliated with clinical sites providing direct patient care services. Thus, this study aims to estimate the effort spent by clinical faculty of pharmacy schools in the S.A. on direct patient care and identify factors that hinder or facilitate direct patient care services.

Abbreviations: S.A., Saudi Arabia; SCFHS, Saudi Commission for Health Specialties; U.S., United States; SD, standard deviation; IQR, interquartile range; SE, standard error; PharmD, doctor of pharmacy degree; SSCP, Saudi Society of Clinical Pharmacy; PNU, Princess Nourah bint Abdulrahman University.

Methods

This multi-institutional, cross-sectional study involved clinical faculty members from several pharmacy schools in S.A., and it was conducted between July 2021 and March 2022. We included respondents who were full-time clinical faculty with advanced clinical training. The advanced clinical training for the clinical faculty includes faculty holding a master's degree in clinical pharmacy, a general pharmacy residency, or a specialized pharmacy residency with or without a Ph.D. Non-clinical faculty members without clinical practice education or training, adjunct clinical pharmacy faculty members, or those working at pharmacy colleges outside S.A. were excluded.

This cross-sectional study was conducted in accordance with the Declaration of Helsinki. It was approved by the Institutional Review Board (IRB) of Princess Nourah bint Abdulrahman University (PNU) with IRB registration number HAP-01-R-059. Participant consent was obtained through their approval to participate in the survey.

Outcomes

The primary outcome was the percentage of time/effort spent on patient care services and other academic responsibilities. The effort weight was reported in percentage, so the total weight of efforts spent on each academic responsibility, namely, education, research and scholarship, academic services, professional services, public services, and patient care, adds up to 100%. The secondary outcomes were the factors affecting the percentage of efforts spent on direct patient care, satisfaction with fulfilling academic and clinical duties, and the commonly reported factors (facilitators and barriers) affecting providing direct patient care duties and other academic duties.

Survey design and distribution

A modified version of the validated questionnaire devised by Nutescu et al. was utilized with permission in this study (2). The modified questionnaire was validated by piloting the questionnaire to a convenient sample of 10 clinical practice faculty members from various pharmacy schools in S.A. The final survey instrument contained 67 questions, including open-ended and dropdown list questions. Some questions were branched, and follow-up questions would appear depending on the respondents' answers.

The questionnaire was designed and implemented using REDCap. The survey web link was emailed using the Saudi Commission of Health Specialties (SCFHS) and the Saudi Society of Clinical Pharmacy (SSCP) portals. The respondents were assured of the anonymity of their responses and were informed that no individual or institutional identifiers would appear in the published results.

Questionnaire sections

The modified questionnaire contains five sections covering different domains. The first section collected the respondents' demographic information. The second section focused on faculty responsibilities, namely, clinical education (including didactic teaching and clinical training); research and scholarship; contribution to academic, professional, or public services; committee involvement or administrative work, consulting, professional organizations, and community services; and direct patient care or clinical service. The third section evaluated the pharmacy schools' clinical practice infrastructure, such as an affiliation with a practice site, the existence of a collaborative agreement/policy with the practice site, academic load calculation, and clinical faculty responsibilities. The fourth section focused on the characteristics of the direct patient care practice site. In the last section, a Likert scale (i.e., strongly agree, agree, neutral, disagree, and strongly disagree) was used to evaluate the perception of the clinical faculty members regarding the availability of time to fulfill their academic duties. It also evaluated the limitations of the faculty in balancing their patient care or clinical duties with their other academic commitments. In addition, factors that motivate faculty members to provide patient care services apart from fulfilling their academic duties were assessed.

The clinical faculty responsibilities indicated in the survey were *clinical education* (i.e., didactic and clinical teaching), *research and scholarship*, and *contribution to academic, professional, or public services* (e.g., committees, administrative work, consultation, professional organization services, and volunteer services); and *patient care* (i.e., clinical pharmacy service).

Statistical analysis and ethical consideration

We extracted all relevant information using the questionnaire entered in REDCapv version 7.3.6 hosted by PNU. It is an electronic data capture web application used to collect survey and non-survey data. The results of the pilot survey were excluded from the analysis. Descriptive analysis was used to summarize the data describing the characteristics of the faculty members and their institutions. The categorical variables were presented as numbers and percentages, whereas the continuous variables were presented as a median and interquartile range (IQR). An additional analysis was conducted to evaluate the statistical difference between the faculty members' demographic characteristics, as well as the characteristics of the pharmacy schools and practice sites (independent variables) based on time/effort spent on patient care (patient care <20% vs. ≥20%). The cutoff percentage was based on the median percentage of time/effort spent by the faculty members (19%).

A Chi-square or Fisher exact test was used for categorical variables, and a Student's *t*-test and Mann–Whitney U-test were used for the normally and non-normally distributed continuous variables, respectively. The reliable indepedent variable with *P*-values <0.1 in the bivariable analysis [e.g., time spent on education, academic services, and the length of academic experience, and clinical experience (in years)] were added in the model. Linear regression coefficients (β) with standard error (SE) were computed to determine the magnitude of associations of the independent variables with the time spent on patient care (dependent variable). The significance level was set at a *p-value* < 0.05 and the results were reported with a 95% confidence interval (CI). Data analysis was performed using Stata v17.0 (StataCorp LLC, United States).

Results

Demographics of the respondents

Out of the 56 respondents, only 44 were included in this study. Seven were excluded since they did not meet the inclusion criteria, two were duplicate responders, and three did not complete the survey's major sections. Thus, the response rate was around 78.5%. The majority of the included respondents were females (61%) with a median age of 34.5 years. Most of the respondents were clinical faculty members with an academic title of assistant professors and above (74%) and were working in the central region of S.A. (59%). Most of the clinical faculty members either had completed a specialized pharmacy practice residency training or had an additional fellowship (69%), as shown in Table 1. As regards participation in academic and patient care, all (100%) of the respondents participate in clinical education or training, whereas only 88% participate in patient care or clinical practice. However, only 82% of the respondents reported participating in all four duties; clinical education, research, services, and patient care, as presented in Table 1.

Faculty responsibilities and effort allocation

The highest percentage of time/effort was spent by faculty on clinical education, with a median (IQR) of 37.5 (30, 50), followed by that spent in clinical services [19 (10, 28.75)], in research and scholarship, [13 (10, 20)], and then in lasting contribution to public or professional services, as presented in Figure 1. As regards the proportion of time spent outside working hours to fulfill one's academic and direct patient care, approximately half of the respondents (47%) reported spending 26–50% of their time doing their duties outside working hours, and 16% spent 51–75% of their time also outside working hours.

The reported median academic load per semester for assistant professors was 14 credit hours. Among the respondents, 75% provide student training, and 16% participate in residency training as part of their academic load, as shown in Table 2. Moreover, only 38% of the respondents reported that clinical services for patient care were included in their academic load.

Teaching and practice site characteristics

According to the respondents, one-third of the department personnel are clinical track faculty members with advanced clinical practice training or education. Most faculty members reported having hospital-affiliated practice sites (93%). However, 57% of the respondents mentioned there had been no clear expectations of the clinical services to be offered, 47% reported a lack of dedicated time

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TABLE 1 Demographic information of clinical faculty who participated in the survey.

Participant characteristics	*N* =44
Age in years, median (IQR)	34.5 (34.5,36.75)
Sex, *n* (%)	
Male	17 (39)
Female	27 (61)
Academic rank*, *n* (%)	
Teaching assistant/ lecturer	8 (19)
Assistant Professor	29 (67)
Associate Professor	5 (12)
Professor	1 (2)
Region, *n* (%)*	
Central	26 (59)
Eastern	4 (9)
Western	10 (22)
Northern	2 (4.5)
Southern	2 (4.5)
Pharmacy classification, *n* (%)	
Pharmacist	9 (20)
Pharmacist I	18 (41)
Consultant	15 (34)
Not classified	2 (5)
Advanced clinical training or education, *n* (%)	
General pharmacy practice (PGY-1)	6 (14)
Specialized pharmacy practice (PGY-2)	10 (23)
Master's in clinical pharmacy	4 (9)
Ph.D. in clinical pharmacy	1 (2)
PGY-1 and Ph.D. in clinical pharmacy	1 (2)
PGY-1 and master's in clinical pharmacy	1 (2)
PGY-2 and fellowship	20 (46)
PGY-2 and master's in clinical pharmacy	1 (2)
Academic years of experience, median (IQR)	5 (3, 10)
Clinical years of experience after obtaining the advanced training/education, median (IQR)	3.5 (2, 5.25)
Hold an administrative position at the college, *n* (%)	16 (36)
Dean	1 (5)
Vice dean	2 (11)
Head of the department	3 (17)
Head of a unit	6 (35)
Head of a program	2 (11)
Others	2 (11)
Hold an administrative position at the practice site, *n* (%)	13 (30)
Residency program director	9 (69)
Pharmacy director	1 (7.6)
Other	3 (23)
Participation in academic and direct patient care, *n* (%)	
Clinical education	44 (100)
Research and scholars	39 (88)
Administrative/college services	37 (84)
Direct patient care	39 (88)
Participation in academic and direct patient care, *n* (%)	
Education, research, services, and patient care	36 (82)
Education, research, and services	1 (2)
Education, research, and patient care	2 (5)
Education and patient care	1 (2)
Education	4 (9)

*Percentage out of 43, one missing answer.

for clinical practice, and 30% of the responding faculty reported the lack of a clear practice policy with the practice site (Table 2). As regards the location of the practice site, most of the respondents (68%) reported that their practice sites are in close proximity to their institution (<1–5 KM). Meanwhile, 52% of the respondents reported that no one was tasked to evaluate their clinical service performance, as shown in Table 2.

Faculty fulfillment with academic and clinical responsibilities and factors affecting one's ability to balance patient care with other academic duties

More than half of the respondents agreed or strongly agreed with having sufficient time to fulfill their educational duties (57%), whereas most of them strongly disagreed or disagreed with having sufficient time to participate in research and scholarship (75%) and direct patient care (63%), as depicted in Figure 2.

The most commonly reported barriers that affect participating patient care duties, along with their other academic duties, were the lack of a clear practice policy between the academic institutions and the practice sites (68%), followed by teaching load (66%), and then university or committee assignments (61%), as presented in Figure 3. The other reported barriers were *"lack of evaluation on patient care services, lack of impact of providing patient care services on career promotion," "limited number of full clinical pharmacists at the hospital,"* and *"lack of aligned schedule between the college and the hospital."* By contrast, the most commonly reported motivators for providing patient care, along with other academic duties, were the belief that it is important for career development (90%), followed by personal drive to provide such services (86%), and then clinical services being counted as credit hours in the academic load (41%); motivators are presented in Figure 3. The other reported facilitators were *"gaining experience and building rapport with the medical team and other hospital staff members."*

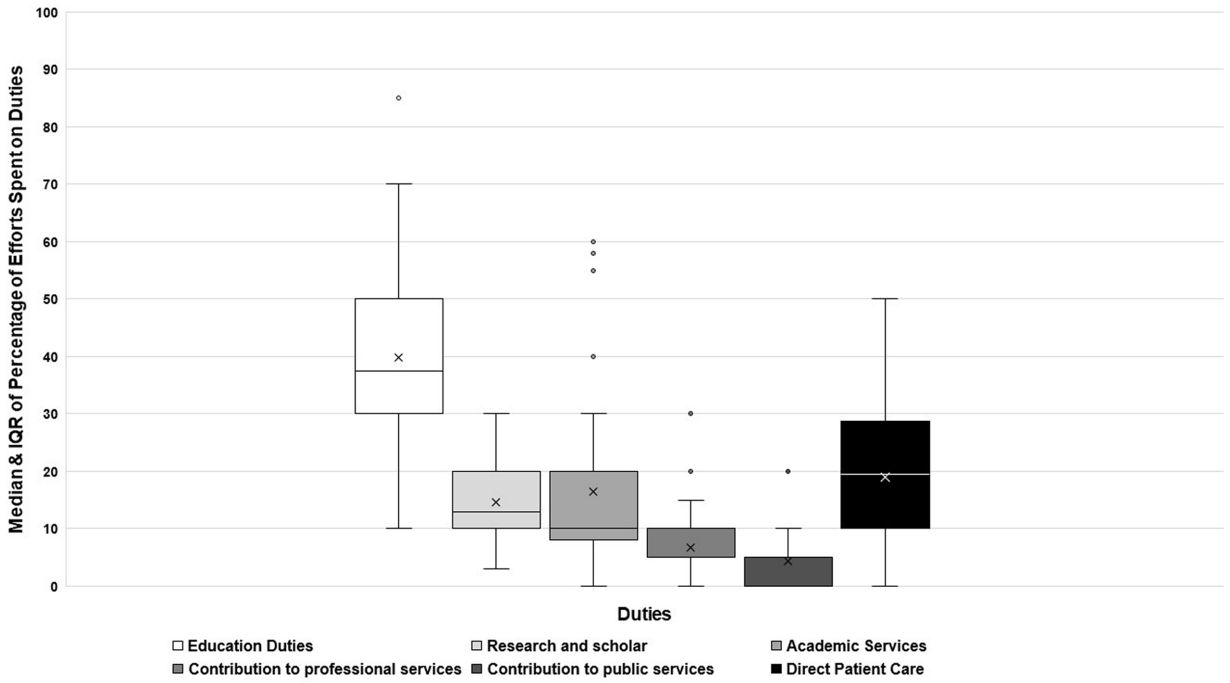

FIGURE 1
Percentage of effort spent on clinical and academic responsibilities among clinical faculty participated in the survey.

Factors affecting the effort spent on patient care

The percentage of time/effort spent on education and the length of academic experience were significantly higher among the respondents who spent <20% of their time on patient care. By contrast, those who spent ≥20% of their time/effort on patient care had institution expectations and had dedicated a greater amount of time to clinical services, as presented in the Supplementary Appendix 1. Moreover, this group had a significantly higher number of patient care load per day and number of poster presentations per year. The multivariable regression analysis showed that the higher percentage of time/effort spent on education, academic services, and the length of academic experience were negatively associated with the amount of time spent on patient care, as shown in Table 3. By contrast, a longer clinical experience (in years) was positively associated with the percentage of time spent on patient care.

Discussion

Overall, the vast majority of respondents have fulfilled the minimum qualifications for clinical practice as defined by (7). Our survey showed that not all clinical track-faculty members are engaged in patient care. The median percentage of effort spent on direct patient care, among other academic duties, was around 20%. In contrast, a recent survey involving pharmacy practice faculty in the U.S. has shown that more than half of the clinical faculty members (63.8%) spend approximately 26–50% of their efforts on providing direct patient care (8).

In the current study, we found that longer academic experience and the percentage of effort spent on education and academic services were negatively associated with the time/effort spent on the direct patients care. This result was also supported by the respondents' perception that teaching load and university assignments were the second and third most common barriers affecting balancing patient care with other academic duties. Moreover, studies have reported that academic appointments and didactic teaching workload prevent pharmacy practice faculty from engaging in direct patient care services (2, 8). Third of our respondents hold administrative positions at hospitals or academic institutions. These administrative appointments at academic institutions or practice settings could explain why clinical faculty members might spend less time on direct patient care as they gain more experience and advance in their careers.

As with any clinical pharmacist, clinical faculty members can significantly impact the community's health outcomes. Previous studies have proven that clinical pharmacists' involvement in patient care services in various settings improved patient outcomes, safety, and healthcare efficiency (9–11). However, the limited number of residency-trained clinical pharmacists involved in direct patient care in the academic settings in the S.A. negatively impacted the training and education of future pharmacists in the S.A. and, ultimately, patient outcomes (12). According to our study, the number of clinical pharmacists appointed by hospitals and the limited number of faculty members with advanced clinical training who work in academia may have an impact on how much time is spent providing direct patient care.

The lack of clear expectations in the provision of pharmacy care services is another challenge that could affect faculty members' engagement in clinical practice (2, 3, 13). In the survey, respondents declared that no clear practice policy exists in their practice setting, which was also the most common barrier affecting the fulfillment of direct patient care duties. Uncertainty regarding the required extent of active engagement in direct patient care, the number of credits

TABLE 2 Faculty involvement in academic and clinical responsibilities and the reported structure of institutions.

Clinical education responsibilities	*N* =44
Academic load per semester, median (IQR)	
Teaching assistant/lecturer	16.5 (45, 5–18)
Assistant Professor	14 (9.5, 16.5)
Associate Professor	14 (13, 17.5)
Professor	14 (14, 14)
Students' training included in the total academic load, *n* (%)	
Yes	33 (75)
No	9 (20)
I do not know	2 (5)
Average of credit hours clinical training load, median (IQR)	5 (4, 6)
Resident training included in the total academic load, *n* (%)	
Yes	7 (16)
No	35 (79)
I do not know	2 (5)
Average of residency training load from the total academic load, median (IQR)	2 (2, 10)
Number of students trained per year, median (IQR)	18 (8.5, 30)
Number of residents trained per year, median (IQR)	1 (0, 4)
Research and scholarship	
Number of publications per year, median (IQR)	2 (1, 4.75)
Number of research participation per year, median (IQR)	2 (1, 2.75)
Contribution to academic, public, and professional services	
Number of committees serves, median (IQR)	2 (2–3.75)
Clinical services responsibilities	
The academic load includes clinical services, n, (%)	
Yes	17 (38)
No	25 (57)
I do not know	2 (5)
Average of credit hours clinical service load, median (IQR)	4.5 (1.8, 6)
Number of patients caring for per day, median (IQR)	9 (2, 14.75)
University structure	
Number of faculty members in the department, median (IQR)	30 (20, 42.5)
Number of clinical-track faculty members, median (IQR)	10 (7, 20)
Percentage of clinical track faculty, median (IQR)	38 (21, 66)
The presence of hospital-affiliated hospitals, n (%)	41 (93)
The institution has a faculty pharmacy practice policy, *n* (%)	
Yes	16 (36)
No	13 (30)
I do not know	15 (34)
Provides clear expectations of clinical services, *n* (%)	
Yes	13 (29)
No	25 (57)
I do not know	6 (14)
Provides faculty members dedicated time for clinical practice, *n* (%)	
Yes	17 (39)
No	21 (47)
I do not know	6 (14)
Includes clinical services in the academic load, *n* (%)	15 (34)
Yes	15 (34)
No	24 (56)
I do not know	5 (11)
Includes clinical services in the annual evaluation, *n* (%)	3 (7)
Yes	3 (7)
No	30 (68)
I do not know	11 (25)
Provides faculty member allowance for clinical services, *n* (%)	5 (11)
Yes	5 (11)
No	33 (75)
I do not know	6 (14)
Includes clinical services in the faculty promotion, *n* (%)	
Yes	3 (7)
No	33 (75)
I do not know	8 (18)
Practice site structure	***N* = 38**
*The availability of clinical practice site, n (%)**	
Yes	33 (86)
No	5 (13)
Distance between the academic institution and clinical site, *n* (%)	
Onsite <1 km	21 (55)
2–5 km	5 (13)
6–10 km	3 (8)
11–15 km	6 (16)

TABLE 2 (Continued)

Clinical education responsibilities	*N* =44
≥16 km	3 (8)
Practice setting, *n* (%)	
Acute care*	28 (74)
Primary care	5 (13)
Both inpatient and out-patient	5 (13)
The clinical practice site fits the faculty member's specialty, *n* (%)	
Yes	36 (94)
No	2 (5)
The availability of clinical pharmacist coverage during faculty other commitments, *n* (%)	
Yes	24 (63)
No	13 (34)
I do not know	1 (3)
Who to report to about faculty member's clinical services, *n* (%)	***N* = 33**
Hospital/clinic administrator	15 (45)
School/college of pharmacy administrator	2 (6)
Both	11 (33)
None	5 (15)
Who is responsible for evaluating faculty member's performance, *n* (%)	***N* = 33**
Hospital/clinical administrator	9 (27)
Academic administrator	3 (9)
Both hospital/clinical administrators and an academic administrator	4 (12)
None	17 (52)

*Acute care settings include critical care, internal medicine, oncology, cardiology, infectious diseases, etc.

counted as academic load, and the method for evaluating patient care performance are some factors that must be considered to standardize the roles and responsibilities of clinical faculty members.

Our results showed that pharmacy faculty who are providing direct patient care services in S.A. strain to manage their clinical and non-clinical obligations. This challenge emphasizes the importance of creating clearly defined pharmacy clinical services and establishing achievable objectives in order to enhance faculty productivity and satisfaction. A multi-modal approach, for instance, was implemented by the College of Pharmacy at the University of Buffalo to assist clinical faculty members in achieving a balanced allocation of efforts (13). In that paradigm, clinical faculty members should devote roughly 30% of their time to teaching, 30% to clinical practice, 20% to research and scholarship, and 20% to service (13). Due to the significant differences in the infrastructure of clinical pharmacy practice and educational requirements in the S.A., this model may be difficult to implement.

The study also draws attention to the challenges clinical faculty members encounter in balancing their direct patient care responsibility with their other academic responsibilities. This problem was evident in our results since more than half of the respondents claimed insufficient time to handle direct patient care. Similarly, nearly 70% of the clinical faculty members in the U.S. admitted that they do not have enough time to fulfill their non-clinical and clinical responsibilities (2). Moreover, many respondents stated they had insufficient time to accomplish their research and scholarly obligations. Even though most of our study participants perceive that involvement in clinical duties could be a limitation for research enhancement, other faculty could perceive this as a great channel for research promotion that could be translated to improving health-related outcomes.

As shown in this study, the time spent on education negatively affected the time directed toward patient care. Therefore, it must be highlighted that clinical-faculty members' provision of direct patient service is not a privilege they enjoy in their spare time or on demand (8). Clinical faculty members are accountable for their patients as much as they are accountable for their students. The involvement in patient care can give back to clinical education as the faculty's clinical experience could enrich the scientific content delivered in clinical courses or laboratories. Also, there is a huge need for faculty to serve as preceptors for training students or residents. This role could help expand the availability of practice training seats when a limited number of training seats challenge most pharmacy schools in S.A. (14). Moreover, according to the Saudi Commission for Health Specialties (SCFHS), some faculty members who serve as residency program directors and/or as clinical preceptors must be full-time pharmacists at the practice site. Thus, setting realistic expectations about the time spent on direct patient care is essential to improve patient care and provide more effective didactic training and teaching strategies.

We propose several actions to help clinical faculty members fulfill patient care duties and devote more time to non-clinical academic activities. First, academic institutions must create a customized clinical faculty workload model that sets the minimum requirement for a balanced distribution of effort for clinical services, educational responsibilities, services, scholarly activities, and faculty development. Institutions can modify the model according to their specific needs (e.g., undergraduate education or postgraduate training) and faculty workload without falling below the minimum threshold for each responsibility. Integrating direct patient care within faculty workload expectations can help enhance faculty productivity and maintain research and scholarly activity, ultimately supporting their annual appraisal, promotion, and enhancing patient care through clinical research findings. Second, academic institutions must develop a collaborative practice agreement with their practice sites; this agreement governs the clinical practice of clinical faculty members and standardizes the definition of clinical pharmacy services.

To our best knowledge, this study is the first to evaluate the current status of direct patient care involvement of clinical pharmacy faculty members and balancing it among other academic duties. However, our study has several limitations. First, our sample size was relatively small. However, the available number of faculty members with advanced clinical training in some academic institutions in S.A. was quite low. Also, sample size calculation was difficult to predetermine because the total number of clinical faculty at all pharmacy schools in S.A. was not publicly unavailable. Thus, we tried to include a representative sample from different geographical regions, academic institutions, and academic ranks. In addition, there are a number of other biases, including reporting and recall bias, where many respondents might not be able to recall all the details required to answer the survey. Also, there was a potential for selection bias that may have occurred in which we have an overrepresentation of female

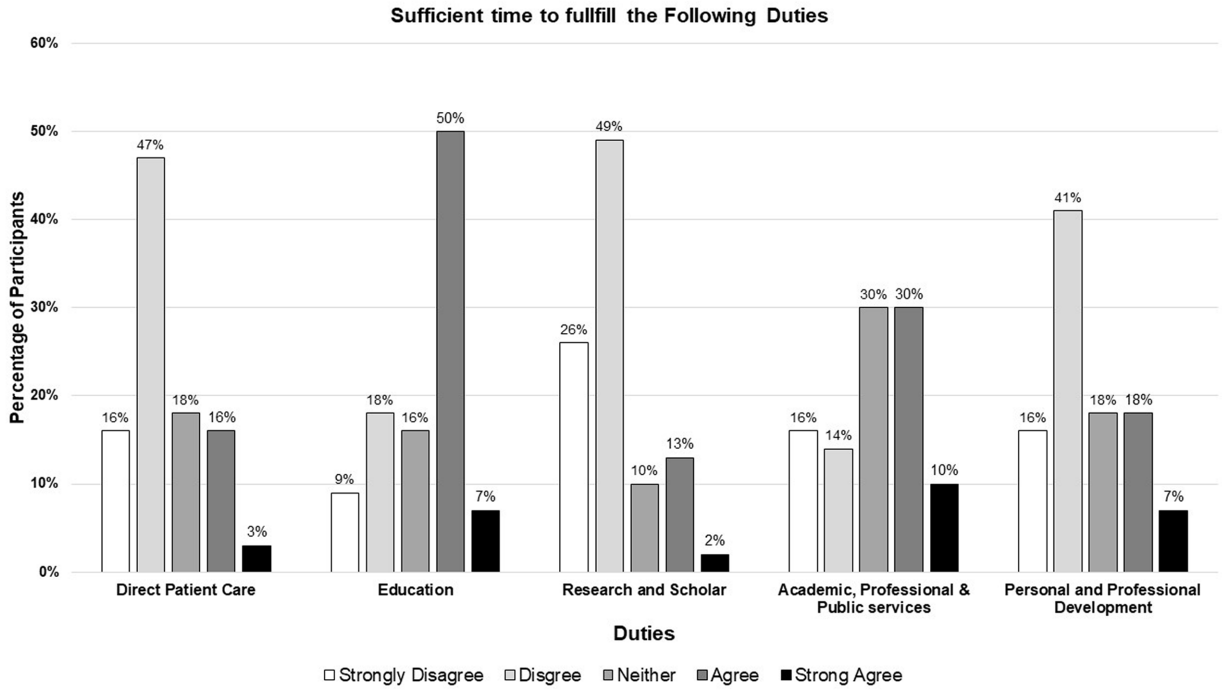

FIGURE 2
Clinical pharmacy faculty perceptions regarding the time allotted to fulfill each academic responsibility.

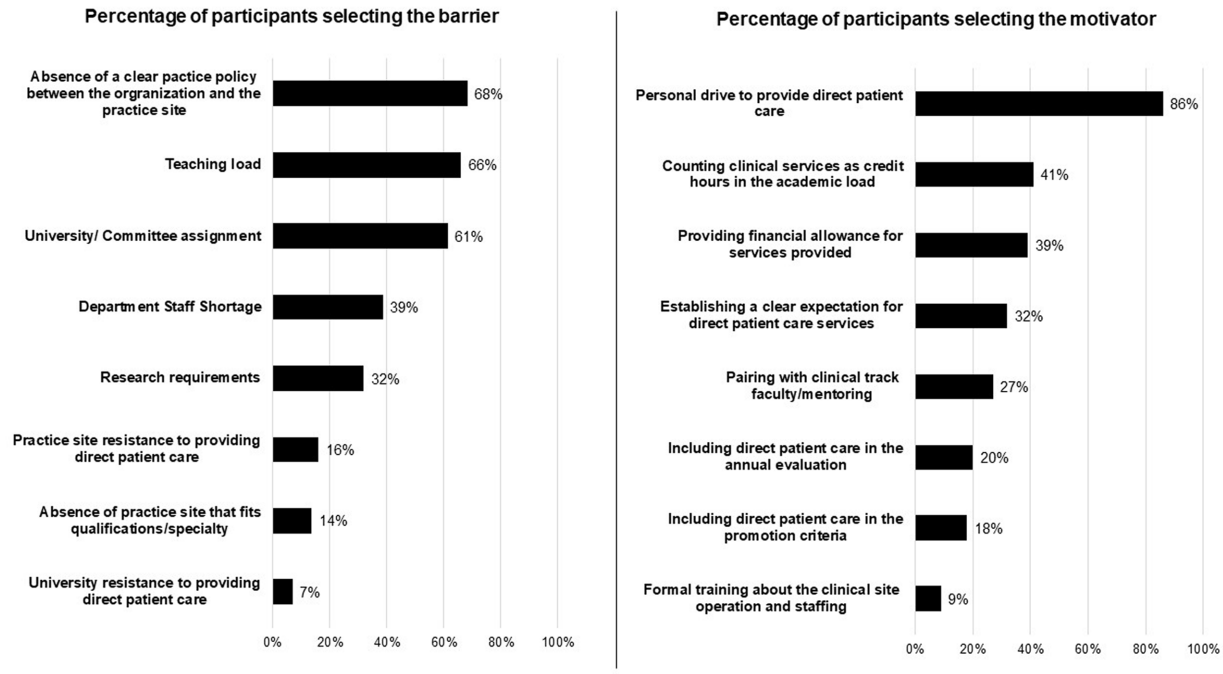

FIGURE 3
The number of Clinical pharmacy faculty perceived the following as barriers and motivators affecting providing direct patient care with other academic duties (number of responders *n* =44).

faculty members. We conducted regression analyses to eliminate some of these biases to determine whether certain confounders could affect our results. This study could help develop a national and regional framework for clinical track faculty to actively engage in direct patient care services. However, future studies should re-evaluate our outcomes using a more broadly representative sample.

TABLE 3 Factors affecting clinical-track faculty members spending <20% of their time/effort on patient care.

Factors	Coefficient (estimates) (95%CI)	*p*-value
Academic years of experience	−0.10 (−1.77, −0.26)	0.009
Clinical years of experience after obtaining the advanced training/education	0.94 (0.04,1.85)	0.04
Percentage of time/effort spent on education	−0.45 (−0.62,-0.28)	<0.01
Percentage of time/effort spent on academic services	−0.63 (−0.89, −0.37)	<0.01

Conclusion

Clinical pharmacy faculty members face challenges balancing direct patient care and academic responsibilities. The absence of a well-defined policy for clinical practice between educational institutions and practice sites often hinders direct patient care delivery. Incorporating patient care into faculty workloads can enhance productivity, promotion prospects, and overall quality of patient care. Collaborative efforts among faculty, institutions, and practice sites can create a more effective healthcare and education system.

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

This study was approved by the Institutional Review Board (IRB) of Princess Nourah bint Abdulrahman University (PNU) with IRB registration number HAP-01-R-059. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2023.1143576/full#supplementary-material

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The effect of an information intervention on the career commitment of medical students: evidence from a randomized experiment

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Introduction: The needs-based shortage of healthcare workers is severe worldwide and it would be exacerbated if many medical students switch to other careers after graduation. Maintaining and improving the career commitment of medical students, which could be a feasible, effective, and scalable way to reduce the attrition rate, is essential in medical education. We designed a randomized experiment to test whether an information intervention based on role modeling could enhance medical students' career commitment.

Methods: In the randomized experiment, the sample (N=36,482) was divided into the treatment group (N=18,070) and the control group (N=18,412). The intervention information consisted of image-text messages on Zhong Nanshan, who is an inspiring role model for he went to the frontline of COVID-19 in the most critical circumstances and received praise and affirmation from the public. A difference-in-differences model was employed to identify the effect of the information intervention. Heterogeneous treatment effects were identified using sub-sample analyses.

Results: The results showed that the information intervention statistically significantly reduced medical students' dropout intention by 2.7 percentage points (95% CI: −0.037 to −0.016, t=−4.95, p<0.001), equivalent to 14.6% of the control group mean. This estimate indicates that the information intervention could significantly increase the career commitment of medical students. Finally, male and senior students were influenced more than their female and junior counterparts, which can be explained by their relatively high dropout intention.

Conclusion: Role model-based information intervention improves the career commitment of medical students. The underlying behavioral model is that, when students use a role model as their reference point, they consider dropout as a substantial welfare loss. Role modeling is an effective way to improve the career commitment of medical students, especially for males and senior students.

KEYWORDS

career commitment, information intervention, role modeling, behavioral economics, difference-in-differences

Introduction

To fulfill the United Nations' Sustainable Development Goals and achieve universal health coverage, human resources in healthcare are the priority (1). However, there is a great demand for healthcare workers globally. A shortage of 6.4 million physicians was recorded worldwide in 2019 (2) and predictions indicate that it would even hit 14 million by 2030. Current trends in health worker supply could not cover this shortage (1). The number of medical students cultivated in higher education institutions now is barely enough for the demand of healthcare labor market, let alone some decide to switch to other careers after graduation, which worsens the situation.

Maintaining and improving the career commitment of medical students may be a feasible, effective, and scalable way to reduce the shortage (3–5). Career commitment is the commitment of an individual to a career or profession, reflecting their desire and preference for their profession, which is an attitude and determination to continue engaging in the chosen career (5, 6). It has also been operationalized regarding the reluctance to leave the professional role (5, 7). Therefore, improving career commitment is the priority of medical education since it can help accelerate progress toward universal health coverage. Previous studies on career commitment, mainly used qualitative methods, have examined questions like career commitment formation (8–10), career commitment change in clinical environments (5, 11), the role of career commitment in career choice (11), and burnout (12). The factors that affect career commitment have also been analyzed (5, 9, 13–15), one of which with high importance is the role model (10, 15, 16).

According to social learning theory, learning from role models is an effect way to improve individuals' ability to deal with a specific task or activity (17). Role models personify the ideal selves people aspire to be by manifesting clinical attributes, personal qualities and positive professional characteristics, and they can be emulated by others, especially young people (18–21). It has been proved that role modeling is a powerful, underexploited, and deliberate teaching intervention and strategy (22–24). This type of intervention originates from the prospect theory in behavioral economics. Prospect theory suggests that people have reference-dependent preferences, and the utility gained from decision-making under uncertainty depends on the perceived gain or loss relative to the reference point. The theory also proposes the principle of loss aversion, which states that the positive utility from the same amount of gain is less than the negative utility from the same loss (25, 26). A role model serves as a reference point. Individuals compare themselves with the role model, and utility loss occurs when their behavior deviates from the corresponding one of the role models. Research related to role models and commitment has focused on the function of role modeling in the formation of professional attitudes (27), professionalism (28, 29), professional identity (10, 16), and career choices (30). The effect of role modeling on career commitment was found to be heterogeneous among individuals (15). Survey data were used in some previous research (31), yet fewer studies have adopted experimental methods to identify the effects of role model-based interventions on career commitment, which provides an opportunity for this study. According to social learning theory and prospect theory, we hypothesize that role-model based information interventions can improve the career commitment of medical students.

Similar to other countries, China also has a high attrition rate among medical major graduates and physicians (32). This study aims to investigate practicable information intervention to improve the career commitment of Chinese medical students in a low-cost and predictable manner. Our results are expected to not only alleviate the shortage of human resources in China but also provide important evidence-based implications for other countries. The research questions this study addressed are as follows: (1) whether an information intervention based on a role model boosts the career commitment of medical students, and (2) whether the information intervention has heterogeneous effects on different medical students. The exploration of these questions will advance our understanding of the effect of role-model based information intervention on the career commitment of medical students.

Methods

A randomized experiment, designed in line with the CONSORT guidelines, was implemented in China between June 10 and July 10, 2021. We collected the data through the "National Center for Medical Education Development Information and Data Platform" in the form of an online survey (33). Ethical approval (IRB00001052-20069) was received from the Institutional Review Board of Peking University, Beijing, China. The electronic informed consent was obtained at the beginning of the survey from all participants included in the study. Students voluntarily participated in and were informed that their data would be kept anonymous and confidential.

Inclusion and exclusion criteria

In this experiment, we recruited participants from 93 randomly selected medical higher education institutions (out of 165 in total). Inclusion criteria included respondents who were full-time undergraduate students in those 93 institutions and majored in clinical medicine. Exclusion criteria included that the participants did not agree to provide the online consent. We also excluded foreign students, students from Hong Kong, Macao, and Taiwan (Republic of China), considering that their culture, training process, and future career choice are very different from that of clinical medical students in Chinese mainland.

Sample

The minimum sample sizes needed for the experiment were calculated according to Bloom and Dong, and Maynard (34, 35). Commonly, set α, the probability of making Type I error, equal to 0.05 and power equal to 0.8 (35). The minimum sample size was estimated to be 35,663. The number of institutions offering the undergraduate Medical Education program in China is 165, with 44.8% located in the eastern provinces, 29.7% in the center, and 25.5% in the west (36). Based on the minimum sample size and the distribution of medical institutions in China, a total of 43,174 undergraduate medical students were sampled from 93 institutions in 30 provinces, including 41 institutions (44.1%) located in the east, 27 institutions (29.0%) in the center and 25 institutions (26.9%) in

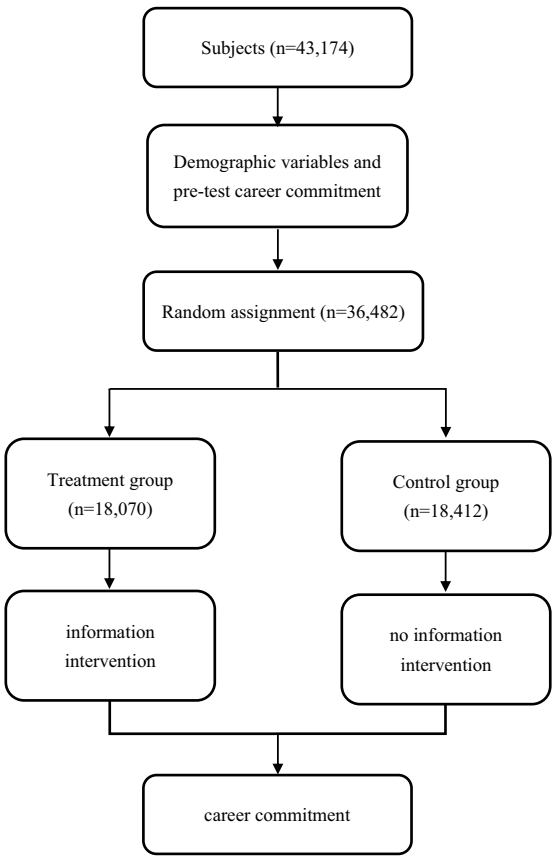

FIGURE 1
Flow chart of the experiment.

the west. The geographic distribution of the selected sample was correspondingly balanced with that of China; hence the results of the study is reasonably representative. A total of 36,482 medical students participated in the experiment, with a response rate of 84.5% (see Figure 1).

Intervention

Pre-intervention survey

In the pre-intervention stage, characteristics of the subjects were collected through an online survey, including pre-intervention career commitment, demographic information (gender, ethnicity, Communist Party of China members, and only child status), family background (having a doctor parent, father's education, mother's education, high-income families, father's International Socio-Economic Index, mother's International Socio-Economic Index), educational background (National College Entrance Examination scores, expectation, career planning). The questionnaire used is self-built. We designed the survey with references to the opinions of experts (in medical education, social science surveys, clinical medicine, and other closely related fields) and stakeholders (students). Before the formal implementation, we selected some medical students for the pre-test, so as to make the information collected by the survey accurately expressed and validated in content.

Intervention

The sample was randomly assigned into two groups by the online survey platform randomization algorithm. The treatment group received the information intervention, while the control group did not. The study personnel member who independently created the randomization process did not involve in participants recruitment or data analysis. The participants did not know the intervention content before participation and they only reached the content of their group and were unaware of what happened in the other group after randomization. The delivery method was that we inserted intervention information into the survey, containing the image and text on the role model of Zhong Nanshan, a public face of China's efforts in the fight against COVID-19. Zhong Nanshan went to the front line of the battle against COVID-19 and spread praise and affirmation of the pro-social behaviors of healthcare workers by mainstream social media. Our intervention information has been validated by Ye et al. (2022) who used the text-image to identify the effect of nudge information on students' post-pandemic dropout intention (15).

In the post-intervention stage, career commitment was measured again. In our experimental design, the intervention and the measurement of career commitment were displayed sequentially on different screens. There was a time lag between the intervention and the measurement outcome (see Figure 1).

Measurement and collected data

Career commitment was the dependent variable measured by a five-point Likert Scale question "I want to become a doctor after graduation." Those who selected options "strongly disagree" and "disagree" were coded as having a dropout intention (i.e., career dis-commitment). Medical students with a dropout intention had lower career commitment.

Treatment was used as the independent variable. We assign treatment values of 1 for individuals in the treatment group and of 0 for individuals in the control group.

The control variables included gender, ethnicity, CPC members (Communist Party of China), only child, NCEE score (National College Entrance Examination), doctor parent, father's education, mother's education, high-income family, father's ISEI (International Socio-Economic Index), mother's ISEI, expectation, and career planning. CPC members variable equaled 1 for individuals who were CPC members. The NCEE score variable was standardized. Most provinces used the national unified college entrance exam design with a total score of 750. For provinces where the total score was not 750, the original NCEE scores were converted to 750. The doctor-parent is a dummy variable that took value 1 if either parent was a healthcare worker and 0 otherwise. The high-income family variable was also a dummy variable which took value 1 when the family had an income higher than 150,000 RMB in the last year. Father's (mother's) ISEI measured whether the father's (mother's) ISEI was higher than the median of the father's (mother's) ISEI. The expectation variable corresponded to the question, "Was the college admission result lower than your expectation?." In addition, the career planning variable corresponded to the survey item "Have you participated in a career planning program in high school?," which equaled 1 if the "yes" option was chosen.

Data analysis

We first performed a balance test to validate the random assignment. Each control variable was regressed on the treatment variable to report the t-test results. Then, the treatment variable was regressed on all controls to report the joint F test results.

Next, a difference-in-differences (DID) model was employed to identify the effect of the information intervention, as follows.

$$Y_{i,t} = \beta Treat_i \times Post_t + \left(X_i \times Post_t\right)\gamma + \eta_i + \tau_t + \varepsilon_{i,t} \quad (1)$$

Eq. (1) identifies the causal effect of an information intervention on medical students' dropout intention using the DID model. Let i index the individual and t index the period; $Y_{i,t}$ denotes the intention of individual i to drop out of medicine in period t, which measures career commitment; $Treat_i$ denotes whether individual i was assigned to the treatment group; $Post_t$ denotes the period dummy variable, which equals 1 at t, and $\varepsilon_{i,t}$ is the error term; β captures the effect of the information intervention on students' career commitment, which is the main interest of this study; X_i is a series of predetermined controls, including gender, ethnicity, CPC members, only child, NCEE score, doctor parent, father's education, mother's education, high-income families, father's ISEI, mother's ISEI, expectation and career planning; η_i and τ_t are individual fixed effects and time fixed effects, respectively. According to Bertrand et al. (37), standard errors should be clustered to the individual level due to the correlation of the same individual's error terms at different times. Therefore, the standard errors were clustered to the individual level.

Finally, the heterogeneity effects of the information intervention were examined. In each subsample, Eq. (1) was used to identify the heterogeneity effects.

Results

Characteristics of the sample

A total of $N = 36{,}482$ medical students were included in the study sample. About 42% of students were male and over 13% of students were CPC members. The sample contained over 37% only-child. The average NCEE score of the sample was 547.8. A subset of $N = 18{,}412$ was assigned in the control group and N = 18,070 in the treatment group. About 10% of the student's parents were healthcare workers. The average years of schooling of the students' fathers and mothers were 11 years and 10 years, respectively. More than 30% of students' parents had a high ISEI. Nineteen percent of students were from high-income families. Thirty-five percent of students believed the college admission results were lower than their expectations. Less than 30% of students took part in career planning programs in high school (see Table 1).

TABLE 1 Descriptive statistics and balance test.

	(1)	(2)	(3)	(4)
	Full sample	Control group	Treatment group	T −C
Preintervention dropout intention	0.167	0.165	0.169	0.004
	[0.373]	[0.371]	[0.375]	(0.006)
Male	0.420	0.419	0.422	0.004
	[0.494]	[0.493]	[0.494]	(0.007)
Han ethnicity	0.871	0.871	0.870	−0.001
	[0.335]	[0.335]	[0.336]	(0.005)
CPC members	0.127	0.129	0.125	−0.003
	[0.333]	[0.335]	[0.331]	(0.005)
Only child	0.378	0.376	0.379	0.002
	[0.485]	[0.484]	[0.485]	(0.007)
NCEE score	547.772	547.282	548.273	0.991
	[60.818]	[60.746]	[60.889]	(0.901)
Doctor parent	0.115	0.115	0.116	0.001
	[0.320]	[0.319]	[0.320]	(0.005)
Father's education	10.706	10.719	10.693	−0.027
	[3.837]	[3.844]	[3.829]	(0.057)
Mother's education	9.616	9.610	9.621	0.010
	[4.279]	[4.257]	[4.302]	(0.063)
High-income family	0.135	0.131	0.138	0.007
	[0.341]	[0.338]	[0.345]	(0.005)
Father ISEI	0.343	0.343	0.343	−0.000
	[0.475]	[0.475]	[0.475]	(0.007)
Mother ISEI	0.322	0.317	0.326	0.009
	[0.467]	[0.465]	[0.469]	(0.007)
Expectation	0.346	0.341	0.350	0.009
	[0.476]	[0.474]	[0.477]	(0.007)
Career planning	0.299	0.300	0.298	−0.002
	[0.458]	[0.458]	[0.457]	(0.007)
N	36,482	18,412	18,070	

(1) CPC members means the members of Communist Party of China. (2) NCEE score means National College Entrance Examination score. (3) ISEI means International Socio-Economic Index.

Balance test

Before identifying the effect of the information intervention, a balance test was performed. No statistically significant differences were detected between the treatment group and the control group regarding dropout intention pre-intervention ($p = 0.518$), gender ($p = 0.622$), Han ethnicity ($p = 0.841$), CPC members ($p = 0.500$), only child ($p = 0.742$), NCEE score ($p = 0.271$), doctor parent ($p = 0.821$), fathers' education ($p = 0.640$), mothers' education (p = 0.821), high-income family ($p = 0.186$), fathers' ISEI ($p = 0.958$), mothers' ISEI ($p = 0.178$), expectation ($p = 0.212$) and career planning ($p = 0.772$). Regression of all variables in Table 1 using the treatment dummy variable resulted in an F value of 0.69 and a p value of 0.79, indicating that the groupings were unrelated to observable individual characteristics.

TABLE 2 Effects of information intervention on medical students' career commitment.

	(1)	(2)
	dropout intention	dropout intention
Treat*post	−0.027***	−0.027***
	(0.005)	(0.005)
Controls*post	NO	YES
Individual FE	YES	YES
Time FE	YES	YES
N	36,482	36,482
R2	0.779	0.779

(1) Control variables include gender, ethnicity, CPC members, only child, NCEE score, doctor parent, father's education, mother's education, high-income family, father's ISEI, mother's ISEI, expectation, and career planning. (2) Robust standard errors are clustered at the individual level. (3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The average effect of the information intervention

Table 2 suggested that the information intervention statistically significantly reduced medical students' dropout intention rate by 2.7 percentage points (SE = 0.005, 95% CI: −0.037 to −0.016, $t = -4.95$, $p < 0.001$), equivalent to 14.6% of the control group mean. The estimates remained consistent after controlling for the interaction of a range of observable control variables and a post dummy variable, suggesting the information intervention significantly boosted career commitment in medical students. While the measurement of outcome variable was on the next screen of the information intervention in our experiment and the treated students spent some time reading the intervention information before reporting their career commitment, this treatment effect represents an immediate behavioral response to the role model-based information.

The heterogeneity effect of the information intervention

The influence of the information intervention on different students was then analyzed, and the results are shown in Figure 2. The results of the heterogeneity analysis indicated that the treatment effect of the information intervention on male students was $\beta = -0.038$ (SE = 0.001, 95% CI: −0.055 to −0.020, $t = -4.28$, $p < 0.001$) and $\beta = -0.019$ (SE = 0.007, 95% CI: −0.033 to −0.006, $t = -2.83$, $p = 0.005$) on female students. Thus, the information intervention influenced the career commitment of male students more than that of female students. Additionally, the influence of information intervention on junior students was $\beta = -0.018$ (SE = 0.010, 95% CI: −0.039 to 0.002, $t = -1.78$, $p = 0.075$) and $\beta = -0.035$ (SE = 0.009, 95% CI: −0.052 to −0.018, $t = -4.04$, $p < 0.001$) on senior students, meaning that senior students benefited more from the intervention.

Discussion

This study designed a randomized experiment and used a DID model to estimate the effect of an information intervention on dropout intention in medical students. The information intervention, a combination of text and image, was based on a role model in the fight against the COVID-19 pandemic. The results indicated that the information intervention significantly increased the career commitment of all medical students, with the male and senior students being influenced more than their female and junior counterparts.

The results demonstrated that role modeling is an effective teaching strategy to boost career commitment, which agrees to Wang and his colleagues' research (12). Role models provide inspiration and a comparing standard for students. Role models model how to achieve tasks and transmit valuable information. The behavior of role models amplifies students' belief in reaching their goals. Students compare themselves with role models and follow their behaviors. Therefore, the role models serve as the reference point, and students revised their views by observing the role model and reflecting on their behavior (38). In this case, dropout was considered as a loss for them, which reduced their utility due to the loss aversion principle; therefore, students molded themselves to the role model's behavior. Role models encouraged students to actively participate in the medical profession. The results of the present study are consistent with previous research's, indicating that medical students are inspired when observing pro-social behaviors such as respect, compassion and empathy (16).

The information intervention was revealed to have had a greater effect on male students than female students. Studies have shown that male students are more likely to drop out of school than female students (39–43). This study showed that male students had a higher dropout intention than female students before the intervention, suggesting the presence of gender differences in initial career commitment. The informational intervention served to narrow the gender differences in career commitment.

Moreover, the results demonstrated that senior medical students would benefit more from the intervention than junior medical students. A previous study found that the career commitment of senior medical students gradually weakens (5, 14). In our sample, the dropout intention in senior medical students was higher than junior medical students. This may be explained by the fact that senior medical students are exposed to greater interpersonal pressure, complex doctor-patient relationships, and heavy academic and practice loads due to clinical medical education and clerkship rotation, which may reduce their determination and enthusiasm to continue practicing medicine. The educational student engagement in senior medical students is also lower than that in junior medical students (36). Educational student engagement is positively correlated with learning outcomes, and students who struggle academically are more likely to drop out (44). Therefore, information intervention is crucial in helping students with higher dropout intentions increase their career commitment and significantly improve their well-being, and thus make better career choices.

This study also indicates that the career commitment of medical students changed over time. Students experience a dynamic, gradual process during medical education, such as the reduction in career commitment of students in advanced degree stages receiving clinical medical education and clerkship rotation. Educational planners should adopt effective education strategies to maintain and enhance career commitment during medical education. Role modeling positively affects career commitment, especially for medical students with low career commitment.

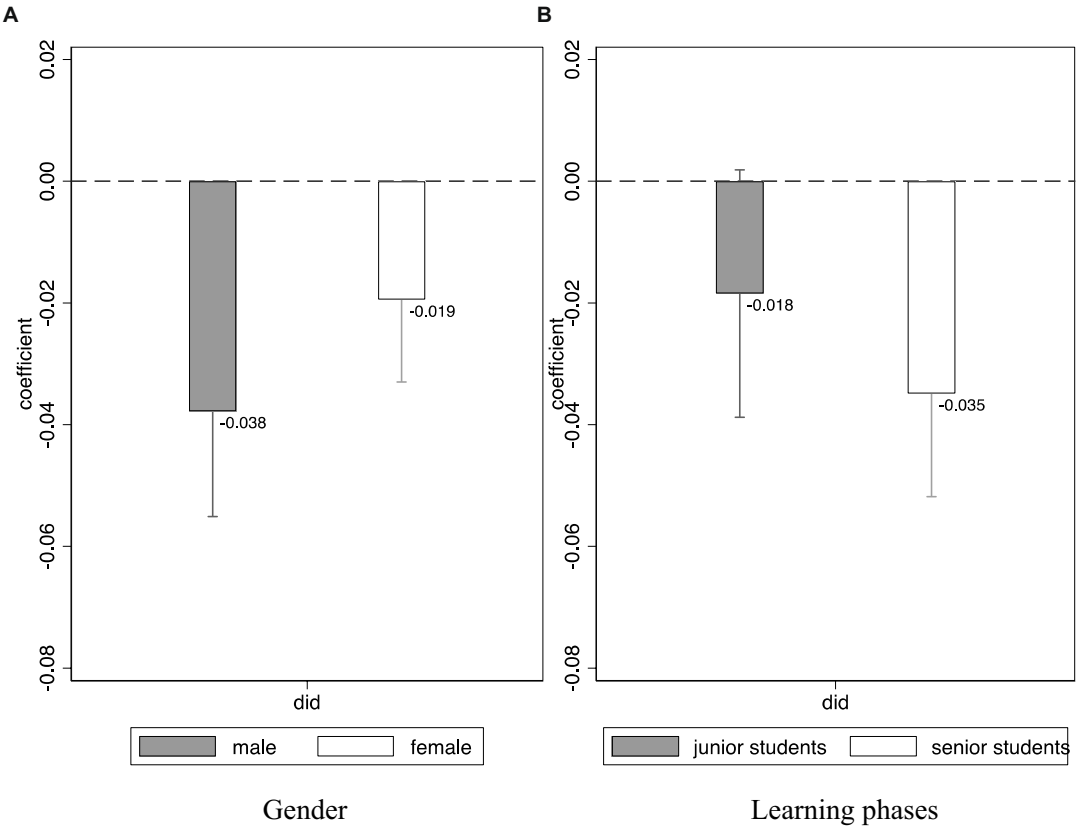

FIGURE 2
The heterogeneity effect of information intervention.

Therefore, role modeling can be integrated into the course and daily life of medical students to build up their career commitment and help them make better career choices, which will further increase human resources for health supply and promote social well-being.

Our results provide evidence-based support for the design and implementation of similar low-cost information interventions to improve medical students' communication with chronic patients. For example, patients, patients' family, and the medical and psychological team are the stakeholders of a comprehensive care system in the management of the hemophilic children. Large educational efforts and on-going medical and psychological support need to be offered to families (45). The information intervention based on role models who had rich experience in communication with patients may be a possible teaching method in the intensive training and education.

Limitations

The role model presented is based on informational interventions and is a light-touch, low-cost approach. Combining role models with different degrees of exposure may have more sustainable and long-term effects on medical students' career commitment. The actual commitment behaviors to the career of individuals might be used to measure career commitment more than intention. Our results speak to the immediate impacts when students are presented with new information. Tracking the participants over a longer time period and finding out whether or not the intervention has any effect on actual attrition would be an important direction for future work.

Conclusion

A randomized experiment was implemented to test the effect of an information intervention on the medical students' career commitment. The information intervention approach presented in this study is based on a role model, showing medical students the pro-social behavior of healthcare workers in the fight against the COVID-19 pandemic. The positive effect of the information intervention on medical students' career commitment was identified, and an analysis of this effect on its potential heterogeneous impact on medical students based on their gender and learning stage was also performed. The findings reported in this study enrich the evidence that information intervention could improve the career commitment of medical students in developing countries and bring about possible solutions to alleviate the global shortage of human resources in healthcare.

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Data availability statement

The raw data supporting the conclusions of this article will be made available from the corresponding author upon reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by PU IRB (approval number: IRB00001052-20069). The patients/participants provided their written informed consent to participate in this study.

Author contributions

CL, XY, CY, and HW designed the study and wrote the manuscript. HW performed the experiments. CL analyzed the data. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

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