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Contents

Review

Examining the Effectiveness of Web-Based Interventions to Enhance Resilience in Health Care Professionals: Systematic Review ([e34230](#))

Catherine Henshall, Edoardo Ostinelli, Jade Harvey, Zoe Davey, Bemigho Aghanenu, Andrea Cipriani, Mary-Jane Attenburrow. 3

Original Papers

Aligning the American Health Information Management Association Entry-level Curricula Competencies and Career Map With Industry Job Postings: Cross-sectional Study ([e38004](#))

Susan Fenton, David Marc, Angela Kennedy, Debra Hamada, Robert Hoyt, Karima Lalani, Connie Renda, Rebecca Reynolds. 18

Practices, Perceived Benefits, and Barriers Among Medical Students and Health Care Professionals Regarding the Adoption of eHealth in Clinical Settings: Cross-sectional Survey Study ([e34905](#))

Long Nguyen, Lien Nguyen, Tham Nguyen, Vu Trong Dam, Thuc Vu, Hao Nguyen, Giang Vu, Carl Latkin, Roger Ho, Cyrus Ho. 27

Patterns of Skills Acquisition in Anesthesiologists During Simulated Interscalene Block Training on a Soft Embalmed Thiel Cadaver: Cohort Study ([e32840](#))

Graeme McLeod, Mel McKendrick, Tedis Tafili, Mateo Obregon, Ruth Neary, Ayman Mustafa, Pavan Raju, Donna Kean, Gary McKendrick, Tuesday McKendrick. 38

Assessment as Learning in Medical Education: Feasibility and Perceived Impact of Student-Generated Formative Assessments ([e35820](#))

Ritu Lakhtakia, Farah Otaki, Laila Alsuwaidi, Nabil Zary. 59

Implementing Remote Collaboration in a Virtual Patient Platform: Usability Study ([e24306](#))

Jan Kiesewetter, Inga Hege, Michael Sailer, Elisabeth Bauer, Claudia Schulz, Manfred Platz, Martin Adler. 73

A Stroke Rehabilitation Educational Program for Occupational Therapy Students and Practitioners: Usability Study ([e35637](#))

Valerie Newcomer, Megan Metzinger, Sydney Vick, Caroline Robertson, Taylor Lawrence, Amanda Glass, Lauren Elliott, Ansleigh Williams. 8

An Innovative Use of Twitter to Disseminate and Promote Medical Student Scholarship During the COVID-19 Pandemic: Usability Study ([e33767](#))

Gary Allen, Jenna Garris, Luan Lawson, Timothy Reeder, Jennifer Crotty, Johanna Hannan, Kori Brewer. 94

Defining Potentially Unprofessional Behavior on Social Media for Health Care Professionals: Mixed Methods Study (e35585)	
Tea Vukuši Rukavina, Lovela Machala Poplašen, Marjeta Majer, Danko Reli , Joško Viski , Marko Mareli	101
The Use of Telegram in Surgical Education: Exploratory Study (e35983)	
Marcus Soon, Laura Martinengo, Junde Lu, Lorainne Car, Clement Chia.	122
The Role of Metacognitive Beliefs in Predicting Academic Procrastination Among Students in Iran: Cross-sectional Study (e32185)	
Yahya Safari, Nasrin Yousefpoor.	133
Using Mobile Virtual Reality Simulation to Prepare for In-Person Helping Babies Breathe Training: Secondary Analysis of a Randomized Controlled Trial (the eHBB/mHBS Trial) (e37297)	
Beatrice Ezenwa, Rachel Umoren, Iretilola Fajolu, Daniel Hippe, Sherri Bucher, Saptarshi Purkayastha, Felicitas Okwako, Fabian Esamai, John Feltner, Olubukola Olawuyi, Annet Mmboga, Mary Nafula, Chris Paton, Veronica Ezeaka.	141
Comparing the Psychological Effects of Manikin-Based and Augmented Reality–Based Simulation Training: Within-Subjects Crossover Study (e36447)	
Shannon Toohey, Alisa Wray, John Hunter, Ian Waldrop, Soheil Saadat, Megan Boysen-Osborn, Gabriel Sudario, Jonathan Smart, Warren Wiechmann, Sarah Pressman.	151
Informatics in Undergraduate Medical Education: Analysis of Competency Frameworks and Practices Across North America (e39794)	
David Chartash, Marc Rosenman, Karen Wang, Elizabeth Chen.	165
Use of Social Media for Implementing Diagnoses, Consultation, Training, and Case Reporting Among Medical Professionals to Improve Patient Care: Case Study of WeChat Groups Across Health Care Settings (e26419)	
Lai Tso.	179
Assessing Medical Student Readiness to Navigate Language Barriers in Telehealth: Cross-sectional Survey Study (e36096)	
Leena Yin, Fiona Ng, Mateo Rutherford-Rojas, Mia Williams, Susannah Cornes, Alicia Fernandez, Maria Garcia, Elaine Khoong.	193
 Viewpoint	
Opioid Use Disorder Education for Students and the Future of Opioid Overdose Treatment (e37081)	
Neha Balopal, Amala Ankem, Saishravan Shyamsundar, Shuhan He.	161

Review

Examining the Effectiveness of Web-Based Interventions to Enhance Resilience in Health Care Professionals: Systematic Review

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Abstract

Background: Internationally, the impact of continued exposure to workplace environmental and psychological stressors on health care professionals' mental health is associated with increased depression, substance misuse, sleep disorders, and posttraumatic stress. This can lead to staff burnout, poor quality health care, and reduced patient safety outcomes. Strategies to improve the psychological health and well-being of health care staff have been highlighted as a critical priority worldwide. The concept of resilience for health care professionals as a tool for negotiating workplace adversity has gained increasing prominence.

Objective: This systematic review aims to examine the effectiveness of web-based interventions to enhance resilience in health care professionals.

Methods: We searched the PubMed, CINAHL, PsycINFO, and Ovid SP databases for relevant records published after 1990 until July 2021. We included studies that focused on internet-delivered interventions aiming at enhancing resilience. Study quality was assessed with the Risk of Bias 2 tool for randomized controlled trial designs and Joanna Briggs Institute critical appraisal tool for other study designs. The protocol was registered on PROSPERO (International Prospective Register of Systematic Reviews; CRD42021253190). PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed.

Results: A total of 8 studies, conducted between 2014 and 2020 and involving 1573 health care workers, were included in the review. In total, 4 randomized controlled trial designs and 4 pre- and postdesign studies were conducted across a range of international settings and health care disciplines. All of these studies aimed to evaluate the impact of web-based interventions on resilience or related symptoms in health care professionals involved in patient-facing care. Interventions included various web-based formats and therapeutic approaches over variable time frames. One randomized controlled trial directly measured resilience, whereas the remaining 3 used proxy measures to measure psychological concepts linked to resilience. Three pretest and posttest studies directly measured resilience, whereas the fourth study used a proxy resilience measure. Owing to the heterogeneity of outcome measures and intervention designs, meta-analysis was not possible, and qualitative data synthesis was undertaken. All studies found that resilience or proxy resilience levels were enhanced in health care workers following the implementation of web-based interventions. The overall risk of bias of all 8 studies was low.

Conclusions: The findings indicate that web-based interventions designed to enhance resilience may be effective in clinical practice settings and have the potential to provide support to frontline staff experiencing prolonged workplace stress across a range of health care professional groups. However, the heterogeneity of included studies means that findings should be interpreted with caution; more web-based interventions need rigorous testing to further develop the evidence base.

Trial Registration: PROSPERO CRD42021253190; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=253190

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KEYWORDS

resilience; health care professionals; depression; psychological stress; internet; mental health

Introduction

Background

Internationally, “emergency” levels of staff burnout and stress have recently been described and are linked to decreased job satisfaction, absenteeism, and increasing numbers of health care staff leaving their professions [1]. Health care professionals are facing increased pressure to provide high-quality, complex patient care while dealing with staff and infrastructure shortages and chronic, excessive workloads [2-4]. The potential impact of continued exposure to workplace environmental and psychological stressors on the mental health of health care professionals is substantial and is associated with increased depression, substance misuse, sleep disorders, and posttraumatic stress [5]. This picture exists across global health care settings, with staff burnout linked to poor quality health care and reduced patient safety outcomes [6]. The challenges outlined have intensified over the last 18 months owing to the COVID-19 pandemic, with the shock waves initiated undermining the resilience of health systems and the people working within them [7]. Health care professionals have had to support the delivery of expert patient care while rapidly responding to considerable health care challenges, such as understaffing, sickness, personal protective equipment requirements, rapidly changing clinical care policies, and increased patient care demands [8,9]. The psychological impact of delivering health care during COVID-19 has been substantial, with health care professionals working during the pandemic reporting increased levels of stress, distress, anxiety, fear, and depression [10-13]. Rates of burnout among nurses have risen as high as 80% globally during the pandemic [14] and an American study found that physicians’ feelings of burnout reached 61% [15]. As such, the development of strategies to improve the psychological health and well-being of health care staff and mitigate future burnout have been highlighted as key priorities [16,17]. A recent commentary published by the Lancet recommended a series of actions to mitigate this crisis among the health care workforce. These actions included health care practitioners being provided with regular Balint group sessions to discuss clinician-patient relationships with colleagues in comfortable environments, as well as access to resilience training programs for frontline health care staff [18].

The concept of resilience for health care professionals as a tool for negotiating workplace adversity has gained profile over the last decade, with increased importance placed on its benefits [5,19,20]. The term resilience is a dynamic construct that has been framed in several different ways [21]. However,

conceptualizing resilience as “coping successfully despite adverse circumstances” recognizes that the tools that health care professionals use to remain resilient are affected by the daily challenges they encounter [22]. The purpose of this review is to measure changes in resilience that relate to relevant psychological constructs such as workplace stress and anxiety. As such, resilience can be defined as an individual’s ability to “adjust to adversity, maintain equilibrium, retain some sense of control over their environment, and continue to move on in a positive manner” [22,23]. Fostering resilience has been highlighted as important in promoting psychological health and well-being, as well as having additional benefits for the recruitment and retention of health care staff [5,22,24]. The protective role of resilience for health care professionals in coping with the ongoing pressures of the COVID-19 pandemic has also been identified [17,25-28].

In England, the National Health Service (NHS) Health and Wellbeing Framework sets the standards for how NHS organizations should support staff to feel well, healthy, and happy at work and advocate for delivering evidence-based staff health and well-being plans [29]. Several interventions have been developed to enhance resilience among health care professionals in both group and individual programs [21,30-36]. Resilience training programs and interventions aimed at health care professionals, such as resilience-building wellness apps [37], have also been developed so that they can be delivered in a range of contexts, including both face-to-face and web-based platforms, and using blended models of delivery [38]. The development of effective, evidence-based digital interventions was identified as playing a potentially important role during the COVID-19 pandemic when the introduction of new infection and prevention control measures constrained the provision of face-to-face interventions within health care organizations and the wider community [39].

A recent Cochrane review of interventions to support the resilience and mental health of frontline health and social care professionals during and after a disease outbreak, epidemic or pandemic, found a lack of evidence to inform the selection of interventions that are beneficial to the resilience and mental health of frontline workers and identified that research to determine the effectiveness of interventions is a high priority. However, the review did not specifically focus on web-based interventions in enhancing resilience among health care professionals [23]. Similarly, a systematic review of interventions aimed at reducing workplace stress in health care workers found limited evidence for reduction in stress levels [40]. Another systematic review found that mindfulness-based

stress reduction techniques were associated with improvement in burnout, stress, anxiety, and depression in health care staff [41]. These reviews did not focus specifically on web-based interventions. In addition, another Cochrane review examining the effectiveness of psychological interventions in fostering resilience in health care professionals suggested positive effects of resilience training but low certainty evidence that it resulted in higher levels of resilience and lower levels of depression, stress, or stress perception [38]. None of the reviews focused specifically on web-based training interventions.

Objectives

This review aimed to assess the effectiveness of web-based interventions in enhancing resilience or reducing anxiety, depression, psychological distress, and trauma in health care professionals. It also seeks to identify whether specific components of web-based interventions effectively enhance resilience, evaluate the acceptability and tolerability of web-based interventions, and assess their potential economic impact. The review included studies dating back to 1990, with an expectation that the findings will be of use in developing

mental health interventions for health care professionals during the pandemic.

Methods

We conducted this systematic review following the recommendations of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 statement [42]. The protocol was registered on PROSPERO (International Prospective Register of Systematic Reviews; CRD42021253190).

Search Strategy

We searched PubMed, CINAHL, PsycINFO, and Ovid SP for published and unpublished evidence on web-based interventions to enhance resilience in health care professionals, with keywords relevant to “internet,” “resilience,” and “health care professionals.” Details of the full search strategy are presented in [Textbox 1](#). We restricted the search to records published between 1990 and July 2021, given that internet interventions did not exist before this year [43]. We inspected relevant reviews and reference lists of the included studies as additional sources of potentially eligible studies for inclusion in the review.

Textbox 1. Search strategy for the systematic review.

Full search strategy
1. PubMed
<ul style="list-style-type: none"> (Internet*[tiab] OR online*[tiab] OR “Internet-Based Intervention” [Mesh]) AND (resilien*[tiab] OR coping[tiab] OR cope*[tiab] OR “information processing bias” [tiab] OR adapt*[tiab] OR ruminat*[tiab] OR “Resilience, Psychological” [Mesh]) AND (healthcare worker*[tiab] OR paramedic*[tiab] OR medic*[tiab] OR nurse*[tiab] OR ambulance*[tiab] OR frontline[tiab] OR “Front Line”[tiab] OR “Health Personnel” [Mesh]) AND (“1990/01/01”[Date—Publication]; “3000”[Date—Publication])
2. CINAHL
<ul style="list-style-type: none"> AB ([internet* OR online*] AND [resilien* OR coping OR cope* OR adapt* OR ruminat*] AND [healthcare worker* OR paramedic* OR medic* OR nurse* OR ambulance* OR frontline]) AND EM 199001-
3. PsycINFO
<ul style="list-style-type: none"> ([Internet* OR online*] and [resilien* OR coping OR cope* OR adapt* OR ruminat*] AND [health care worker* OR paramedic* OR medic* OR nurse* OR ambulance* OR frontline]). ab. Limit 1 to yr=“1990-Current”
4. Ovid SP
<ul style="list-style-type: none"> ([internet* OR online*] AND [resilien* OR coping OR cope* OR adapt* OR ruminat*] AND [healthcare worker* OR paramedic* OR medic* OR nurse* OR ambulance* OR frontline]). ab. Limit 1 to yr=“1990-Current”

Eligibility Criteria

Study Types

We included all primary analytical research studies without limitations regarding study design or publication status. No language or further restrictions were applied to our search strategy.

Population

Health care professionals aged ≥ 18 years were included, regardless of age and sex. Health care professionals were

broadly defined as registered personnel directly involved with delivering patient care (eg, nurses, physicians, allied health professionals, and midwives working in any health care setting and clinical specialty).

Intervention

Any psychological, behavioral, or educational intervention designed to enhance resilience, with or without an active comparator, was eligible for inclusion. This was because of the limited number of randomized controlled trial studies examining the effectiveness of web-based resilience interventions in the health care setting and the prevalence of studies that used a

pre-post test design. We included both fully web-based and partially web-based interventions (eg, mixed web-based and face-to-face delivery or combined web-based and other remote delivery). As resilience is a broad term, interventions include those aimed at enhancing resilience and those aimed at reducing or preventing anxiety, depression, psychological distress, and trauma in the population of interest.

Outcome

We investigated the efficacy of web-based interventions in enhancing the resilience in health care professionals. We included any type of outcome measurement or description of resilience and well-being domains that were used as proxy measures of resilience, such as validated and nonvalidated scales of anxiety, depression, well-being, stress, trauma, and posttraumatic stress disorder. As secondary outcomes, we also assessed whether specific components of web-based interventions (eg, length, interactivity, and design features) could enhance resilience in health care professionals, the acceptability and tolerability of interventions, and whether there were any direct or indirect measures of economic impact related to the intervention of interest.

Study Selection and Data Extraction

Titles and abstracts of the identified records were screened independently by at least 2 members (JH, BA, and ZD) of the review team. The full texts of the potentially eligible studies were subsequently reviewed (JH, BA, MJA, CH, and EO). Any discrepancies were resolved by consensus with a third review team member. Non-English papers were assessed by individuals proficient in that language. Where needed, the original authors were contacted to clarify eligibility and data availability further.

Two review team members (JH and BA) independently extracted study characteristics and outcome data using a digital data extraction form. Any discrepancies were resolved by consensus with a third review team member.

Risk-of-Bias Assessment

The quality of the included studies was assessed using the Risk of Bias 2 tool for randomized studies [44] and the Joanna Briggs Institute critical appraisal tool [45] for nonrandomized studies.

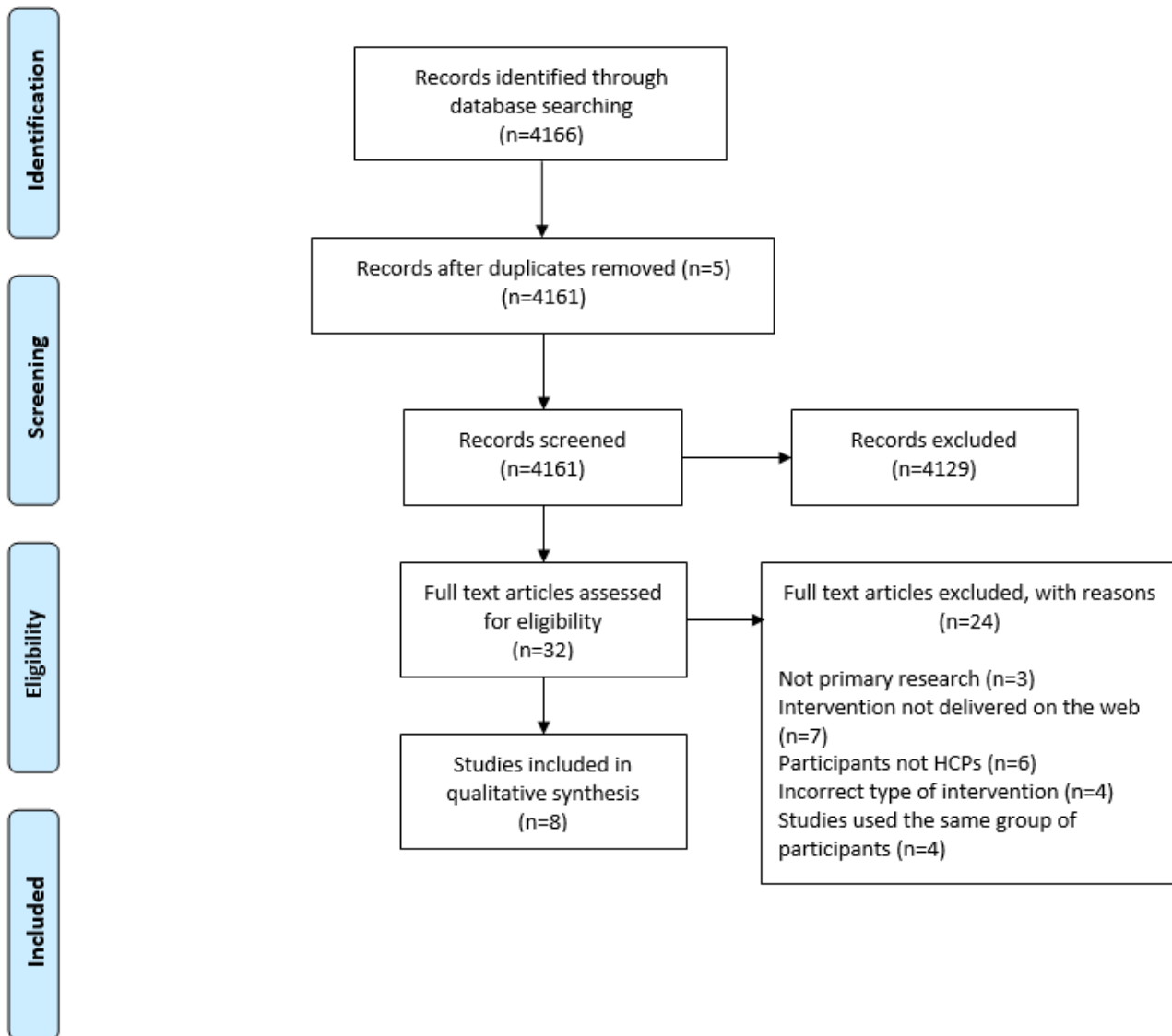
Data Synthesis

We conducted a quantitative synthesis by performing a random-effects pairwise meta-analysis. Where not possible, as specified a priori in our study protocol, a qualitative synthesis of the data set was undertaken. Data from the data extraction forms were synthesized and categorized according to the headings in the data extraction table. The qualitative synthesis process followed the recommendations of the Synthesis Without Meta-analysis reporting items PRISMA checklist extension [46].

Results

Study Characteristics

A total of 4166 papers were identified from the database search, and their titles and abstracts were screened for eligibility based on the inclusion and exclusion criteria. This resulted in 32 remaining studies. The full texts of these studies were screened against the eligibility criteria, leaving 8 studies for inclusion. The screening process is outlined in the PRISMA diagram shown in [Figure 1](#). Of the 8 studies included in this review, all had either randomized controlled trial (n=4, 50%) or pre-post study (n=4, 50%) designs.

Figure 1. PRISMA diagram outlining screening process used in review.

Study start dates ranged from 2014 to 2020; one study did not provide this information. The study durations ranged from 1 week to 15 months; one study did not report this information [47]. Studies were conducted across a variety of international settings; 4 were conducted in the United States [48-50], whereas the remainder were conducted in Iran [47], Germany [51], Australia [52], and the Netherlands [53]. Study participants included a range of health care professional disciplines (n=1573), and studies were carried out in academic university settings [49,50,54] or on study programs within health care

settings [48,51-53]; one study did not provide this information [47]. Of the 4 health care settings, 1 (25%) study was conducted in a rural primary care setting [52], 1 (25%) was conducted in hospital and ambulance departments [51], 1 (25%) was conducted across 2 urban hospitals and police and fire departments [48], and 1 (25%) was conducted across a variety of health care institutions [51]. The risk of bias for all studies was low, adding to our confidence in the study findings. Characteristics of the included studies are detailed in Table 1.

Table 1. Characteristics of studies included in the systematic review.

Study and study title	Study country and setting	Study aim and design	Summary of intervention, analysis, and methods	Participants (n)	Total risk of bias score
Gollwitzer et al [51], 2018; Promoting the self-regulation of stress in health care providers: An internet-based intervention	All over Germany; web-based access	To determine whether health care professionals can downregulate workplace stress using the MCII ^a tool; randomized controlled trial	Self-regulation by mental contrasting with MCII to reduce stress. Three arms, including control. Surveys; inferential statistics	129	Low
Coifman et al [48], 2021; Boosting positive mood in emergency personnel during the COVID-19 pandemic: preliminary evidence of efficacy, feasibility, and acceptability of a novel online ambulatory intervention	United States; 2 urban hospital centers as well as police and fire departments	To test efficacy of web-based ambulatory intervention aimed at supporting psychological health and well-being of medical personnel and first responders during the COVID-19 pandemic; randomized controlled trial	Daily coping toolkit intervention (low or high dose). Participants undertook 3-6 minutes expressive writing, adaptive emotion regulation or positive emotion generation daily. Surveys; inferential statistics	28	Low
Koppe et al [52], 2016; How effective and acceptable is Web 2.0 Balint group participation for GPs and GP registrars in regional Australia? A pilot study	Australia; rural primary care setting	To evaluate a web-based Balint group for rural physicians and determine effect size for a full-scale trial; pilot randomized controlled trial study	2-hour fortnightly Balint group sessions delivered on the web. Open-ended surveys and thematic analysis; inferential statistics	26	Low
Van der Meer et al [53], 2020; Help in hand after traumatic events: a randomised controlled trial in healthcare professionals on the efficacy, usability, and user satisfaction of a self-help app to reduce trauma-related symptoms	Netherlands; 15 hospitals and 8 ambulance regions	Examining efficacy and evaluating usability and user satisfaction of "SUPPORT Coach" app to reduce trauma-related symptoms; randomized controlled trial	Stand-alone SUPPORT Coach app without use instructions; surveys; inferential statistics	1175	Low
Dehkordi et al [47], 2020; Online Balint groups in health care workers caring for Covid-19 patients in Iran	Iran; virtual	To evaluate the impact of web-based Balint groups on health care workers caring for patients with COVID-19; pre-post study	Web-based Balint group; 1-hour session via Skype 2-3 times a week for 6-8 sessions; surveys; inferential statistics; thematic analysis of free text quantitative data	48-72	Low
Kemper et al [50], 2015; Acute effects of online Mind-Body Skills Training (MBST) on resilience, mindfulness, and empathy	United States; Ohio State University Health Center	To evaluate effect of 1-hour web-based elective MBST for health care professionals on mindfulness, resilience, and empathy; pre-post study	Web-based educational program in MBST: 12x1 hour mind body training modules; 14 hours herbs or dietary supplements; self-reflection surveys; inferential statistics	513	Low
Kopp [49], 2020; Efficacy of mindfulness-based intervention in reducing burnout and increasing resilience in nurses caring for patients with haematologic malignancies	United States; a cancer research institute	To determine feasibility and efficacy of a mindfulness-based intervention program in reducing burnout and increasing resilience in hematology nurses; pre-post study	30-minute web-based mindfulness intervention session; guided 20-minute web-based recording. 5-7 minutes self-guided practice for 1 month; surveys; inferential statistics	40	Low
Hategan and Riddle [54], 2020; Bridging the gap: Responding to resident burn out and restoring well-being	United States; an urban research institution	To promote awareness about wellness and mitigate burn out through learning and building peer support; pre-post pilot study	90-minute web-based resilience curriculum, peer groups, wellness newsletters; survey; thematic analysis	71	Low

^aMCII: Mental Contrasting with Implementation Intentions.

Description of Randomized Controlled Trial Study Interventions

Of the 4 randomized controlled trial studies included in the review, all aimed to evaluate the impact of a web-based resilience, or proxy resilience, intervention in health care professionals directly involved in delivering patient care. One

study focused on an intervention aimed at health care workers in general [53], one focused on physicians [52], one focused on nurses [51], and one focused on medical personnel and first responders during the COVID-19 pandemic [48]. The duration of the interventions varied, ranging from 1 week to 1 month.

The interventions of the studies were delivered via a variety of formats. These included web-based groups [52], mobile apps

[48,53], and other web-based platforms [51]. Some studies adopted specific therapeutic approaches or techniques, including the Balint groups [52], the Mental Contrasting with Implementation Intentions technique [51], and a daily coping toolkit [48]. One study introduced ways to manage emotions and experiences, but the exact content or method implemented was unclear [53].

Participants

A total of 470 participants were recruited to the randomized controlled trial studies included in the review. However, there was variation in the number of participants recruited to individual studies, ranging from 26 [52] to 287 [53]. The recruited health care workers included nurses, physicians, and first responders.

There was also variance in the proportion of health care workers directly involved in delivering patient care. Three studies involved only health care workers involved in providing direct patient care [51-53]. The fourth study also included participants (31%) who were not directly involved in care delivery, including support staff and health care professionals [48]. One study reported a 100% participant retention rate [48]. The participant completion rates in the remaining studies varied between 64% and 81%.

Study Outcomes

Differences in outcome measures and intervention designs prevented undertaking a quantitative meta-analysis. One study [53] used an outcome measure, the Resilience Evaluation Scale, to directly measure resilience and found that resilience levels were enhanced in health care workers following implementation of the web-based intervention (Table 2). Three studies used proxy resilience measurement scales to measure the psychological concepts linked to resilience, such as stress, work engagement, professional isolation, and positive outcomes. These included the Burnout Screening Scales II Inventory [51], the Perceived Stress Questionnaire [51], Warr Work-Related Affect Scale [52], the Psychological Medicine Inventory [52], the Professional Isolation Scale [52], posttraumatic stress disorder symptoms using the Posttraumatic Stress Disorder Checklist for Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [53], and the Peritraumatic Cognitions Inventory [53]. All studies found improvements in these outcome measures after the intervention (Table 2). Some studies used nonstandardized Likert scales to measure specific emotions and concepts such as stress and resilience [48,54], with one study measuring self-rated positive and negative emotion ratings in health care workers [48]. The findings showed that positive emotions significantly increased by 9.4% and negative emotions decreased by 7.8% between the intervention and control groups.

Table 2. Outcomes of studies included in the review.

Study	Study title	Study outcome measures	Study results
Coifman et al [48], 2021	Boosting positive mood in emergency personnel during the COVID-19 pandemic: preliminary evidence of efficacy, feasibility, and acceptability of a novel online ambulatory intervention	Daily emotion ratings	Positive emotion ratings showed statistically significant increase in high-dose group compared with low-dose group (mean difference 0.47, SE 0.18). No significant difference in negative emotion ratings between high- and low-dose groups; however, negative emotions decreased more in high compared with low-dose group (mean difference -0.39, SE 0.19).
Gollwitzer et al [51], 2018	Promoting the self-regulation of stress in health care providers: An Internet-based intervention	Overall stress: PSQ-20 ^a and BOSS II ^b ; UWES-9 ^c	No significant difference in changes to overall stress among control (time point 1: mean 0.16, SD 0.65; time point 2: mean 0.22, SD 0.73), MCII ^d (time point 1: mean -0.09, SD 0.61; time point 2: mean 0.20, SD 0.63), and IIMCII ^e (time point 1: mean -0.04, SD 0.41; time point 2: mean 0.05, SD 0.46) groups. No significant differences in UWES-9 scores among control (time point 1: mean 4.06, SD 1.23; time point 2: mean 4.03, SD 1.40), MCII (time point 1: mean 4.22, SD 1.18; time point 2: mean 4.11, SD 1.01), and IIMCII (time point 1: mean 4.43, SD 1.21; time point 2: mean 4.63, SD 1.27) groups.
Koppe et al [52], 2016	How effective and acceptable is Web 2.0 Balint group participation for GPs ^f and GP registrars in regional Australia? A pilot study	WWAS ^g ; PMI ^h ; PIS ⁱ	Significantly higher scores on the WWAS between the intervention (mean 4.09, SD 0.09) and control (mean 3.60, SD 0.12) group; effect size=0.50. Significantly higher scores on PMI scale between the intervention (mean 6.49, SD 0.20) and control (mean 5.43, SD 0.26) group; effect size=0.46. No significant difference on the PIS between the intervention (mean 3.70, SD 0.14) and control (mean 3.63, SD 0.19) group.
Van der Meer et al [53], 2020	Help in hand after traumatic events: a randomised controlled trial in healthcare professionals on the efficacy, usability, and user satisfaction of a self-help app to reduce trauma-related symptoms	RES ^j ; SSL-6 ^k ; Posttraumatic Stress Disorder Checklist for DSM-5 ^l PCL-5 ^m ; PTCI ⁿ	RES scores significantly differed; the intervention showed greater increase in RES total scores (psychological resilience; time point 1: mean 24.87, SD 4.67; time point 2: mean 26.54, SD 4.82) compared with control (time point 1: mean 24.88, SD 4.77; time point 2: mean 25.49, SD 5.46). SSL-6 total scores did not differ significantly between the intervention (time point 1: mean 8.38, SD 2.68; time point 2: mean 8.16, SD 2.88) and control (time point 1: mean 8.75, SD 2.95; time point 2: mean 8.16, SD 2.88) groups. No statistically significant differences between intervention (time point 1: mean 10.73, SD 8.17; time point 2: mean 6.08, SD 8.48) and control (time point 1: mean 12.80, SD 12.08; time point 2: mean 8.54, SD 12.74) PCL-5 scores between baseline and follow-up. PTCI total scores significantly differed; intervention showed greater decline in PTCI scores (negative cognitions; time point 1: mean 61.13, SD 23.00; time point 2: mean 49.99, SD 22.78) compared with control (time point 1: mean 63.66, SD 28.66; time point 2: mean 60.83, SD 28.10)
Dehkordi et al [47], 2020	Online Balint groups in healthcare workers caring for Covid-19 patients in Iran	CD-RISC ^o ; Corona Disease Anxiety Scale	Significant difference in mean Corona Disease Anxiety Scale score before (mean 35.80, SD 5.09) and after (mean 9.7, SD 2.75) group work. Significant difference pre- (mean 22.80, SD 8.51) and posttest (mean 75.60, SD 6.63) for CD-RISC.
Kemper et al [50], 2015	Acute effects of online Mind-Body Skills Training (MBST) on resilience, mindfulness, and empathy	PSS ^p ; BRS ^q ; CAMS-R ^r	Significant improvement in PSS scores between the start (mean 17.8, SD 4.9) and end of the module (mean 13.8, SD 6.1). Significant improvement in BRS scores between the start (mean 22.4, SD 4.3) and end of the module (mean 23.3, SD 4.4). Significant improvement in CAMS-R scores between the start (mean 28.0, SD 5.7) and end of the module (mean 29.3, SD 5.2).
Kopp [49], 2020	Efficacy of mindfulness-based intervention in reducing burnout and increasing resilience in nurses caring for patients with haematologic malignancies	CD-RISC; MBI ^s -Health Service Survey	Significant increases in resilience from pretest (mean 28.10) to posttest (mean 30.65), $z=2.49$ ($df=19$). No significant difference in any MBI subscales from pre- to postintervention: emotional exhaustion (3.51 vs 3.23), depersonalization (2.07 vs 2.02), and personal accomplishment (5.06 vs 5.03).

Study	Study title	Study outcome measures	Study results
Hategan and Riddle [54], 2020	Bridging the gap: Responding to resident burn out and restoring well-being	Self-rated stress on a 10-point Likert scale	Self-rated stress decreased from 5.5/10 to 2.75/10; this represents a 50% reduction from pre- to postintervention.

^aPSQ: Perceived Stress Questionnaire.

^bBOSS II: Burnout Screening Scales II Inventory.

^cUWES-9: Utrecht Work Engagement Scale.

^dMCII: Mental Contrasting with Implementation Intentions.

^eIIMCII: Mental Contrasting with Implementation Intention (that specified when and where participants planned to execute MCII exercises).

^fGP: general practitioner.

^gWWAS: Warr Work-Related Affect Scale.

^hPMI: Psychological Medicine Inventory.

ⁱPIS: Professional Isolation Scale.

^jRES: Resilience Evaluation Scale.

^kSSL: Social Support List.

^lDSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition.

^mPCL-5: Posttraumatic Stress Disorder Checklist for DSM-5.

ⁿPTCI: Peritraumatic Cognitions Inventory.

^oCD-RISC: Connor-Davidson-Resilience Scale.

^pPSS: Perceived Stress Scale.

^qBRS: Brief Resilience Scale.

^rCAMS-R: Cognitive and Affective Mindfulness Scale-Revised.

^sMBI: Maslach Burnout Inventory.

Description of Pre-Post Test Study Interventions

All pre-post test studies aimed to evaluate the impact of an intervention, delivered either partially or fully on the web, on resilience or related symptoms in health care professionals directly involved in delivering patient care. The duration of interventions generally lasted a few weeks, but one study allowed web-based access to a resilience curriculum throughout an academic year [54].

The interventions in the studies were delivered via a variety of formats including web-based videoconferencing platforms [47], web-based platforms [49], web-based resilience training, peer groups, and wellness newsletters [50,54]. Some studies adopted specific therapeutic approaches or techniques including Balint groups [47] and mindfulness-based interventions [49,50]. One study introduced a way to manage emotions and experiences, but the exact content or method implemented was unclear [54].

Three studies used an outcome measure that directly measured resilience, including the Connor-Davidson Resilience Scale, Brief Resilience Scale, and self-rating of resilience on a visual analog scale [47,50,54]. Other outcomes measured psychological concepts linked to resilience, including the Perceived Stress Scale [50], the Corona Disease Anxiety Scale [47], and Maslach Burnout Inventory [49]. One study used nonstandardized Likert scales to measure specific emotions and concepts such as stress and resilience [54].

Participants

In total, 1103 participants were recruited to the pre-post studies; however, across studies, this ranged from 10 [47] to 1031 [50]. Two studies focused recruited health care workers in general [47,50], one focused on recruiting physicians only [54], and

one focused on recruiting nurses only [49]. Of the 4 studies, 3 (75%) studies included only health care workers involved in providing direct patient care [47,49,54], but 1 (25%) study included participants who were not directly involved in care delivery [50].

The participant completion rate in the pre- and poststudies varied between 50% and 85%. One study involved a web-based module where the completion rate was 50% when defined as the completion of at least a single module; however, this dropped to a completion rate of 4% when considering all the modules [50]. One study did not provide this information [47].

Study Outcomes

Of the 4 studies, 3 (75%) studies [47,49,50] that directly measured resilience as an outcome measure found that resilience levels were enhanced in health care workers following the implementation of web-based interventions (Table 2). The remaining study used a proxy resilience measurement Likert scale of self-rated stress [54]. The study reported improved psychological well-being for resident physicians, with a postintervention 50% self-reported reduction in stress. However, data analysis included participants who attended in-person groups and had access to web-based resources, with no information reported on the extent of their web-based resource use. Therefore, the extent to which the results were because of the in-person element or the web-based content is unclear. However, one participant commented that “The online resilience curriculum and wellness newsletters were appreciated, and the in-person peer groups were extremely well received.” This suggests that the web-based content was well received, but no further details about its direct benefits were provided [54].

Discussion

Principal Findings

The exploratory study findings reported in this review indicate that web-based interventions designed to enhance resilience in health care professionals may be effective in clinical practice settings across a range of health care professional groups. The findings from all included studies showed that web-based interventions significantly improved either resilience or proxy measures of resilience, such as anxiety, depression, well-being, stress, work engagement, or positive emotions. However, the heterogeneity and limited number of randomized controlled trial studies included means that these findings should be interpreted with caution because of a lack of definitive evidence. More randomized controlled trials are needed to produce a robust evidence base on which to develop recommendations related to building resilience among health care professionals. Nonetheless, our review provides a snapshot of the evidence related to this important topical area [18]. The findings may have positive implications regarding the potential of certain types of web-based resilience enhancement interventions in providing support to health care professionals experiencing acute and prolonged stressful conditions in the workplace. This may have long-term benefits in terms of protecting the safe functioning of health systems by preserving the mental health and well-being of staff [7]. The interventions included in this review were tested on health care professionals directly involved in clinical care, demonstrating their potential applicability to clinicians working on the frontline, which warrants further testing in future studies. The included studies were conducted across a range of international settings, ranging from university to hospital, community, urban, and rural environments, and included a wide range of health care professional disciplines, increasing the generalizability of the findings.

The study findings indicate that web-based resilience enhancement interventions may be tolerable and acceptable to a wide range of health care professionals; the importance of resilience enhancement interventions has been cited in recent literature [18]. However, the review findings should be interpreted with caution, with only 50% (4/8) of the included studies having a randomized controlled trial design and 25% (2/8) using nonvalidated outcome measure tools. All interventions were conducted in real-life settings, showing that they are feasible to implement across a variety of health care contexts. In addition, most health care professional participants remained in the study until study completion, with 2 studies having a 100% completion rate, indicating that web-based interventions can be sustained over time and incorporated into the workplace environment. One study included qualitative comments indicating that the web-based components of the intervention were very well received [54]. These findings are important and indicate that web-based interventions can be implemented across health care systems as a valuable, effective, and feasible mechanism for supporting health care professionals to cope with the daily stressors imposed on them. This is especially important in the post-COVID-19 pandemic era, where many face-to-face interventions are impractical, challenging, and pose a potential safety risk. As such, the relevance of

web-based training tools and interventions is gaining prominence, and this review provides clear evidence that they can be an important tool for supporting increased resilience in the health care workforce.

Regarding whether specific components of web-based interventions enhance resilience in health care professionals, our findings demonstrated that various formats and therapeutic approaches could effectively improve resilience levels. A range of web-based formats, including videoconferencing, modules, and curricula, were successfully implemented. In addition, a range of intervention techniques, including Balint-style groups, mindfulness, and reflecting on emotions, led to positive changes in resilience or proxy resilience. Although most studies took a purely web-based approach, one was mixed and incorporated additional face-to-face peer group sessions with web-based resilience curricula and wellness newsletters [54]. This suggests that a variety of web-based components can be used to enhance resilience in health care professional groups. However, many of the interventions included interactions with peers or intervention facilitators, suggesting that person-to-person interaction, whether face-to-face or on the web, may increase the likelihood of successful outcomes. This corresponds to previous studies that have demonstrated the benefits of web-based learning [36,55]. The findings point to the benefits of interactive person-to-person features as the key to enhancing intervention acceptability and effectiveness. Future studies should consider ways to incorporate this interactive element within web-based resilience intervention designs to maximize the potential for effectiveness. In addition, consideration should be given to the context within which resilience enhancement interventions are delivered, as health care workers are likely to respond differently when placed under acute versus chronic stressors, as evidenced during the COVID-19 pandemic [56]. The varying durations of interventions included in this review are an indicator of these differing contexts and environments. Thus, interventions that may be effective in acutely stressful environments may have design-different features to interventions that are designed for staff working under chronically stressful conditions; effective interventions offering support for health care workers should account for these differences [56]. None of the studies included in the review measured the economic impact of the intervention within the setting in which it was implemented; therefore, no firm conclusions can be drawn about this. Future research should directly assess the extent to which the implementation of web-based resilience interventions can be cost-effective by considering their long-term impact on staff retention and recruitment, sickness and patient care outcomes, and safety. This aligns with key policy priorities, such as the NHS Long Term Plan and the NHS People Plan, which emphasize that health care staff should be valued, supported to thrive, and treated with respect in the workplace [57,58].

Limitations

This systematic review has been undertaken rigorously and to a high standard; however, some limitations remain. First, it was not possible to conduct a meta-analysis because of the heterogeneity of the study outcome measurement tools, participant demographics, and study settings. The variation in the characteristics of individual study populations and

interventions makes it difficult to draw meaningful comparisons between the included studies, reducing the external validity of the findings. Only 50% (4/8) of the studies included in the review were randomized controlled trial designs. Furthermore, 25% (2/8) of the included studies used nonvalidated scales as outcome measures; this is a potential limitation as it reduces the internal validity of the findings. In addition, 2 studies included a proportion of participants who were not health care workers involved in direct care delivery. For these 2 studies, it was not possible to break down the study findings between direct care and nondirect care staff; therefore, the study findings need to be interpreted with caution as the outcomes could be diluted or exaggerated as a result. Generally, retention rates across the studies were high, demonstrating widespread acceptability of the web-based interventions; however, no data were presented on participants who dropped out of the study and their reasons for this. This information would be helpful to identify any barriers to completion, which could be used to enhance the design features, content, and format of any interventions in the future.

Comparison With Prior Work

The study findings complement other work in this area that has examined both the effectiveness of resilience enhancement interventions in the health care setting and web-based interventions. Several face-to-face and web-based resilience enhancement interventions for health care professionals have been tested in the workplace environment, with previous systematic reviews finding that they can positively improve psychological well-being [19,23,38,59-63]. McDonald et al [32] successfully developed and implemented a work-based educational intervention to support the development of personal resilience in nurses and midwives in Australia. The intervention led to improvements in colleagues' levels of honest communication regarding workplace issues, greater respect for each other's skills and experiences, and a collaborative learning environment, something which is conducive to improved teamwork. It also benefitted participants' personal and professional lives by enhancing their confidence, self-awareness, assertiveness, and self-care [32]. Henshall et al [21] developed a resilience enhancement program for nurses, consisting of various workshops and tackling areas such as building hardiness, maintaining a positive outlook, achieving work-life balance, reflective and critical thinking, and enabling spirituality. Levels of personal resilience were significantly higher after the program than before the program, with nurses reporting a marked impact on their resilience, self-awareness, confidence, and professional relationships [21].

Many studies have focused on the benefits of interventions in promoting mental health in health care professionals, by reducing depression and anxiety, increasing well-being, and reducing stress, with positive findings. A systematic review exploring interventions to address mental health issues in health care workers during infectious disease outbreaks found that

some digital interventions were effective in improving confidence, self-efficacy, anxiety, posttraumatic stress disorder, and ways of coping [61]. Another review found that mindfulness-based interventions had the potential to reduce stress among health care professionals, though the review was not limited to web-based interventions and the quality of the evidence was mixed [59]. A third systematic review to examine the mental health impact of the COVID-19 pandemic on health care workers, and interventions to help them, identified a perceived need and preferences from health care workers for interventions aimed at preventing or reducing negative impacts on mental health. The review included some web-based interventions, but no data on their effectiveness in improving the mental health of participants were collected [60]. These findings reinforce the need for, and potential value of, interventions targeted at health care staff to improve their mental health and promote well-being, something that has been identified in this review.

Despite much literature emphasizing the important benefits of resilience enhancement interventions and web-based learning tools among the health care workforce, no studies to our knowledge have specifically examined the value of web-based resilience enhancement interventions for health care professionals. Our study, therefore, adds to the body of evidence in this field by indicating that web-based resilience interventions can be valuable tools for supporting the psychological well-being of health care professionals working in clinical care settings and can be considered effective, feasible, and acceptable mechanisms for use across a variety of health care settings.

Conclusions

This review has identified that web-based resilience interventions for health care professionals may be effective tools for enhancing resilience in this population group, are acceptable to the health care workforce, and can be implemented across a range of health care settings and environments. It has been highlighted that a variety of intervention components may be successfully used, but interactive person-to-person features are important design features that should be considered for enhancing success of the intervention. The review findings are important for health care practice as they indicate that simple, yet effective, web-based interventions may play an important role in increasing resilience in the health care workforce. This, in turn, may play a role in protecting health care workers from the pressures and challenges they face in delivering care. Hospital managers, clinicians, and well-being leads should carefully consider using these interventions to enhance resilience and staff well-being in the workplace; however, more web-based interventions need to be tested to enhance confidence in their value and the evidence base. The development of credible resilience enhancement web-based interventions may, in the future, lead to widespread improvements in staff motivation, retention, and recruitment, ultimately improving patient care outcomes.

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Authors' Contributions

All authors made substantial contributions to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work. All authors contributed to the first draft of the manuscript, and CH critically reviewed and revised it for important intellectual content. All authors approved the final version of the manuscript to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

Conflicts of Interest

None declared.

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Abbreviations

NHS: National Health Service

NIHR: National Institute for Health Research

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROSPERO: International Prospective Register of Systematic Reviews

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Original Paper

Aligning the American Health Information Management Association Entry-level Curricula Competencies and Career Map With Industry Job Postings: Cross-sectional Study

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Abstract

Background: The field of health information management (HIM) focuses on the protection and management of health information from a variety of sources. The American Health Information Management Association (AHIMA) Council for Excellence in Education (CEE) determines the needed skills and competencies for this field. AHIMA's HIM curricula competencies are divided into several domains among the associate, undergraduate, and graduate levels. Moreover, AHIMA's career map displays career paths for HIM professionals. What is not known is whether these competencies and the career map align with industry demands.

Objective: The primary aim of this study is to analyze HIM job postings on a US national job recruiting website to determine whether the job postings align with recognized HIM domains, while the secondary aim is to evaluate the AHIMA career map to determine whether it aligns with the job postings.

Methods: A national job recruitment website was mined electronically (web scraping) using the search term "health information management." This cross-sectional inquiry evaluated job advertisements during a 2-week period in 2021. After the exclusion criteria, 691 job postings were analyzed. Data were evaluated with descriptive statistics and natural language processing (NLP). Soft cosine measures (SCM) were used to determine correlations between job postings and the AHIMA career map, curricular competencies, and curricular considerations. ANOVA was used to determine statistical significance.

Results: Of all the job postings, 29% (140/691) were in the Southeast, followed by the Midwest (140/691, 20%), West (131/691, 19%), Northeast (94/691, 14%), and Southwest (73/691, 11%). The educational levels requested were evenly distributed between high school diploma (219/691, 31.7%), associate degree (269/691, 38.6%), or bachelor's degree (225/691, 32.5%). A master's degree was requested in only 8% (52/691) of the postings, with 72% (42/58) preferring one and 28% (16/58) requiring one. A Registered Health Information Technologist (RHIT) credential was the most commonly requested (207/691, 29.9%) in job postings, followed by Registered Health Information Administrator (RHIA; 180/691, 26%) credential. SCM scores were significantly higher in the informatics category compared to the coding and revenue cycle ($P=.006$) and data analytics categories ($P<.001$) but not significantly different from the information governance category ($P=.85$). The coding and revenue cycle category

had a significantly higher SCM score compared to the data analytics category ($P < .001$). Additionally, the information governance category was significantly higher than the data analytics category ($P < .001$). SCM scores were significantly different between each competency category, except there were no differences in the average SCM score between the information protection and revenue cycle management categories ($P = .96$) and the information protection and data structure, content, and information governance categories ($P = .31$).

Conclusions: Industry job postings primarily sought degrees, with a master's degree a distant fourth. NLP analysis of job postings suggested that the correlation between the informatics category and job postings was higher than that of the coding, revenue cycle, and data analytics categories.

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KEYWORDS

health information management; health workforce; healthcare industry; natural language processing; medical education; professional education; job recruitment; job website; web scraping; data mining

Introduction

The field of health information management (HIM) originated in 1928, when the American College of Surgeons identified a need to improve clinical documentation and established the Association of Record Librarians of North America. Now known as the American Health Information Management Association (AHIMA), the organization delineates HIM as “the practice of acquiring, analyzing, and protecting digital and traditional medical information vital to providing quality patient care” [1].

Health information management, sometimes called medical records, continues to evolve rapidly due to many driving forces. The widespread adoption of electronic health record (EHR) systems has helped catalyze this movement [2]. As reported by the Office of the National Coordinator for Health Information Technology (ONC), by 2017, 96% of nonfederal acute care hospitals in the United States used certified EHRs [3]. Other recent technologies impacting the HIM field include the increased use of application programming interfaces (APIs), machine learning, artificial intelligence, natural language processing (NLP), voice recognition, and the Internet of Medical Things (IoMT). Newer data standards such as HL7's Fast Healthcare Interoperability Resources (FHIR) often result in more data exchange among patients and hospitals [4]. The ONC certified an FHIR API intended to expedite patients' requests for EHR data that required more HIM expertise and training [5]. The United States anticipates transitioning to the International Classification of Diseases 11th Revision (ICD-11) in the next few years, which will require further HIM expertise and training [6]. An increasing secondary use of health care data necessitates an increase in data management, governance, and analytics, usually under the purview of HIM [7].

Like most industries today, the health care sector, including HIM, is experiencing unprecedented technological innovations that are causing many downstream changes in job definitions and required skill sets. This changing landscape demands a more technologically oriented and knowledgeable workforce. For example, there is a growing need for better data literacy and analytical skills [2]. Education in essential domains provides a foundational skill set, allowing HIM professionals to develop and grow professionally. In 2015, Gibson reported HIM graduates require skills and knowledge in record management, data quality, health information analysis, access, privacy,

confidentiality, and information systems and technology [8]. A recent study noted a demand for ongoing health information technology (HIT) education, as well as a variety of EHR skills, a knowledge of operational medical terminology, and an ability to communicate with senior management [9].

According to the US Bureau of Labor Statistics (BLS), jobs in medical records and health information specialties are projected to grow 9% between 2020 and 2030 [10]. There is a need for more HIM workers who are “industry ready.” Establishing and incorporating HIM core competencies can help achieve this goal. The AHIMA Council for Excellence in Education is tasked with setting these core curricula competencies. AHIMA's HIM curricula competencies are divided into 6 domains for associate, undergraduate, and graduate degree levels. Typically, the Bloom taxonomy level for competency increases with the degree level of education across the domains. The AHIMA HIM curricula domains include 6 domains: (1) Domain I: data structure, content, and information governance; (2) Domain II: information protection: access, use, disclosure, privacy, and security; (3) Domain III: informatics, analytics, and data use; (4) Domain IV: revenue cycle management; (5) Domain V: health law and compliance; and (6) Domain VI: organizational management and leadership [11].

The AHIMA interactive career map displays career paths for HIM professionals. The current version has 4 categories of HIM job-related positions: (1) coding and revenue cycle, (2) informatics, (3) data analytics, and (4) information governance [12]. Presently, no academic literature has been identified that evaluates the usefulness of such career maps. One study by Madlock-Brown et al [13] compared the AHIMA career map to job postings to identify gaps.

An important question that needs to be addressed is whether the current training for HIM professionals in this evolving field is congruent with industry demands. Previous workforce research reviewed the jobs of AHIMA members, evaluated the workforce projections of the BLS, and examined the top skills of AHIMA members [14]. This study was based on the AHIMA membership data and not from actual job postings. Another study by Marc et al [15] reviewed global job categories in health informatics and information management. In this study, we sought to answer the question of training compared with industry demands by mining Indeed, a popular online job recruitment

website for data on current job postings in HIM [16]. Indeed was chosen as a platform for extracting job posting data due to the volume of HIM-related jobs found on the website. An evaluation of other job posting websites yielded a lower return than Indeed. Additionally, Indeed was used previously for evaluating HIM-related job postings [15].

The primary aim of this study is to assess the alignment of current AHIMA curricula domains and HIM job postings identified from Indeed, and the secondary aim is to evaluate how well the AHIMA career map aligns to current HIM job postings found on Indeed.

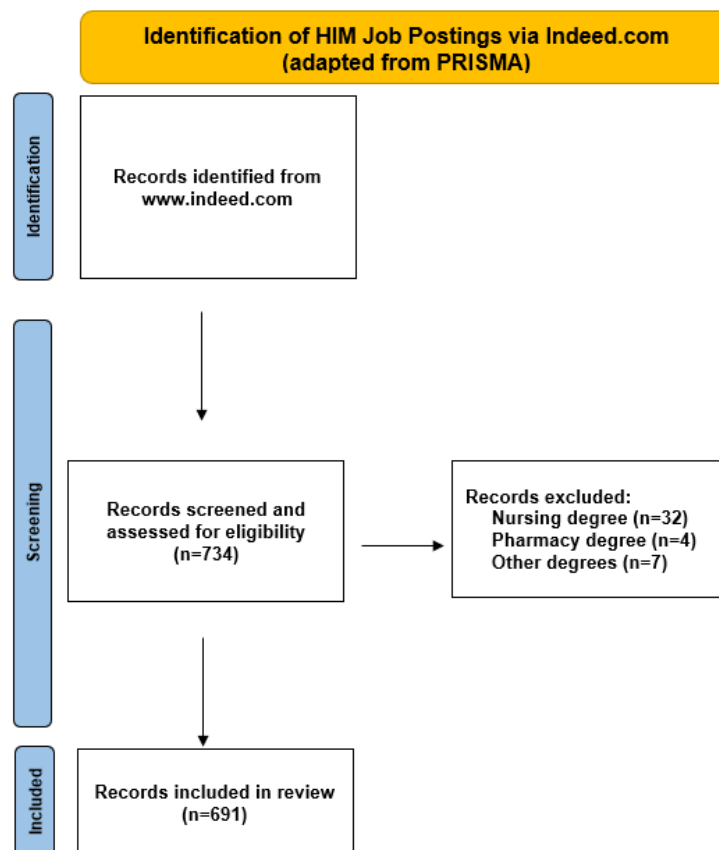
Methods

Collection and Cleaning of Job Postings

On June 18, 2021, job posting data were queried from Indeed using the keyword “health information management” (HIM) to

extract the job title and any descriptive text from the job postings. The data were filtered to only full-time jobs posted within the last 14 days. A total of 734 job postings were returned from the query. The data were screened by expert review from 2 HIM management professionals for inclusion criteria. Subsequently, 43 job postings not relevant to HIM were removed, including 32 that required a nursing degree, 4 that required a pharmacy degree, and 7 that required other education not relevant to health information management. The remaining 691 job postings were included in the study. [Figure 1](#) adapts the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram to display the inclusion and exclusion processes for job postings extracted from Indeed.

Figure 1. Identification of HIM job postings adapted from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).



Descriptive Statistics of Job Postings

The frequency and percentage of job postings were analyzed by geographic region, desired educational level, desired credentials, and length of time the positions were posted. Jobs were then categorized into geographical regions consistent with the categorization reported by the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM), the HIM accreditation body ([Multimedia Appendix 1](#)).

AHIMA curricular competencies for each educational level (associate, bachelor’s, and master’s) were organized by

competency statement, domain, and Bloom taxonomy level for each competency statement. AHIMA career map positions were organized by domain, level, position, description, responsibilities, and skills required.

Ethical Considerations

This study analyzed job postings and other publicly available job-related data. As such, it does not constitute human subjects research so no ethics approval was sought.

Statistical Analysis of Job Postings

The team utilized natural language processing (NLP) to analyze the textual job posting data. The *requests* Python library was used to send an HTTP request to query Indeed for job postings using a URL to search for the keyword “health information management” and restrict the results to “full-time” and posted within the last “14 days.” The resulting HTML text was extracted to a CSV file using the *BeautifulSoup* Python library to extract specific `<a>` class text within the HTML files that corresponded to the job posting ID, title, company, location, day posted, URL to the posting, and job description.

The text in the resulting CSV file was preprocessed using the *re* Python library by first tokenizing the data sources into individual words, removing common English stop words and aberrant characters, converting the text to lowercase, and performing a lemmatizing protocol. Lemmatization is the process of finding the base form of a word to create a connection between related words to establish grammatical and semantic relationships.

The *gensim* Python library [17,18] was used to compute a word embedding similarity matrix by computing the cosine similarities between word embedding and retrieving the most similar terms for a given term using the pretrained Global Vectors for Word Representation (GloVe) embedding “glove-wiki-gigaword-50” [19]. A sparse term similarity matrix was generated that mapped terms and the indices of rows and columns based on the dictionary of all the text documents (job postings, AHIMA career map, and curricular competency categories) and the embedding similarity matrix. When creating the sparse term similarity matrix, a term frequency inverse document frequency (TFIDF) was used to specify the relative importance of the terms in the dictionary whereby the columns of the term similarity matrix were built in a decreasing order of importance of terms.

SCM was used as a measure of similarity between 2 documents. First described by Sidorov et al [20] in 2014, SCM utilizes a standard bag-of-words vector space model method but includes an evaluation of term similarity. SCM offers an evaluation of similarity between 2 documents even when they have no words in common, but the meaning of the words is the same. That is, SCM was used to measure the similarities between the text for each job posting and the text for each of the 4 AHIMA career map category and the text for each job posting and the text for each of the 6 AHIMA curricular competency categories.

The SCM score ranges from 0 to 1. The closer the value is to 1, the more similar the job posting documents are to a category. All 691 job postings received a SCM score for each of the 4 AHIMA career map and 6 curricular competency categories. A matrix of all SCM scores was generated to obtain statistics regarding the similarities of the job postings to the AHIMA career map and curricular categories.

Using the R Statistical programming language (R Core Team), SCM scores were summarized based on each AHIMA career map and curricular competency category [21]. Additionally, one-way ANOVA, which does not assume equal variance, was utilized to determine whether the SCM scores were significantly different among the AHIMA career map and curricular

competency categories. Tukey HSD was used as a post hoc analysis to test for pairwise comparisons of SCM scores among categories [22]. The Python IDE PyCharm version 2022.1.1, RStudio version 2022.02.0 with R version 4.1.0 was used for analysis.

Results

Statistical Analysis of Job Postings

Table 1 depicts the descriptive statistics when comparing the average soft cosine measure (SCM) scores for job postings by each AHIMA career map category. One-way ANOVA established that the average SCM scores by AHIMA career map category resulted in significance ($F_3=48.21$, $P<.001$). The Tukey honestly significant difference (HSD) test showed that SCM scores were significantly higher in the coding and revenue cycle category compared to the informatics ($P=.006$; 95% CI 0.004-0.04) and data analytics ($P<.001$; 95% CI 0.058-0.092) categories but not significantly different from the information governance category ($P=.07$; CI 0.001 to 0.033). The informatics category had a significantly higher SCM score than the data analytics category ($P<.001$; 95% CI 0.036-0.070). Additionally, the information governance category was significantly higher than the data analytics category ($P<.001$; 95% CI 0.042-0.076). There were no statistically significant differences between the information governance and informatics categories ($P=0.85$; 95% CI 0.012-0.022). Together, these results indicate that job postings are most strongly related to the coding and revenue cycle category of the AHIMA career map, followed by information governance, informatics, and data analytics categories.

Table 1 includes the average SCM for each AHIMA career map category. The coding and revenue cycle category had the highest mean SCM score (0.53), followed by the information governance (0.50) and informatics (0.50) categories. The data analytics category had the lowest mean SCM score (0.44) compared to the other categories.

Table 2 depicts the descriptive statistics when comparing the average SCM scores for job postings by AHIMA competencies. One-way ANOVA established that the average SCM scores by AHIMA competencies resulted in significance ($F_5=82.72$, $P<.001$). Tukey HSD test showed that SCM scores were significantly different between each competency category, except there were no differences in the average SCM score between Domain III and Domain VI ($P=.29$; 95% CI 0.004-0.029) and between Domain III and Domain IV ($P=.513$; 95% CI 0.007-0.027). More specifically, Domain I had a significantly lower average SCM score compared to Domain II ($P<.001$; 95% CI 0.095-0.128), Domain III ($P<.001$; 95% CI 0.050-0.084), Domain IV ($P<.001$; 95% CI 0.040-0.074), Domain V ($P<.001$; 95% CI 0.021-0.055), and Domain VI ($P<.001$; 95% CI 0.063-0.096). Domain V had a significantly lower average SCM score compared to Domain II ($P<.001$; 95% CI 0.057-0.090), Domain III ($P<.001$; 95% CI 0.012-0.046), Domain IV ($P=.02$; 95% CI 0.002-0.036), and Domain VI ($P<.001$; 95% CI 0.025-0.058). Domain IV had a significantly lower average SCM score compared to Domain II ($P<.001$; 95% CI 0.034-0.071) and Domain VI ($P=.002$; 95%

CI 0.006-0.039). Finally, Domain II had a significantly higher average SCM score compared to Domain III ($P<.001$; 95% CI 0.028-0.061) and Domain VI ($P<.001$; 95% CI 0.015-0.049). These results indicate that the job postings are most strongly related to information protection competencies, followed by competencies in organizational management and leadership/informatics/analytics/data use, revenue cycle management, health law and compliance, and then the data structure/content/information governance categories.

Table 2 includes the average SCM for each domain. Domain II was the highest (0.43), followed by Domain VI (0.40), Domain III (0.39), Domain IV (0.38), Domain V (0.36), and Domain I (0.32).

While job titles were not isolated for analysis, we analyzed selected postings to gain further insight into their unique resulting attributes. Two job postings, Data Analyst IV and

Clinical Systems Analyst, matched 50% or more of all 6 AHIMA curriculum domains. Both positions required a bachelor's degree and articulated the need for applicants to work independently. The foci of the positions were on data management and information system development. Four positions did not match across the 6 AHIMA curriculum domains; by position title, these included Senior Medical Coder, Document Imaging Medical Records Specialist, Quality Data Analyst, and Medical Record Clerk. The top matching positions within each AHIMA curriculum domain included Domain 1: Manager of NCQA Accreditation and Health Informatics; Domain II: Clinical Informatics Educator; Domain III: Senior Health Informatics Analyst; Domain IV: Data Analyst; Domain V: Clinical Informatics Educator; and Domain VI: Clinical System Analyst. Qualitatively, the significant presence or absence of domain matching for these HIM postings reflects potential current HIM workforce trends.

Table 1. Summary of soft cosine measure (SCM) scores by the American Health Information Management Association (AHIMA) career map.

	Coding and revenue cycle	Informatics	Data analytics	Information governance
Minimum	0.04	0.03	0.03	0.01
First quartile	0.45	0.41	0.37	0.43
Median	0.53	0.51	0.44	0.52
Mean	0.52	0.50	0.44	0.50
Third quartile	0.61	0.59	0.52	0.59
Maximum	0.78	0.84	0.74	0.80

Table 2. Summary of SCM scores by AHIMA curricula domains.

	Domain I	Domain II	Domain III	Domain IV	Domain V	Domain VI
Minimum	0	0	0	0	0	0
First quartile	0.27	0.34	0.32	0.33	0.29	0.34
Median	0.33	0.44	0.39	0.39	0.37	0.41
Mean	0.32	0.43	0.39	0.38	0.36	0.40
Third quartile	0.39	0.53	0.46	0.45	0.44	0.48
Maximum	0.52	0.84	0.67	0.60	0.63	0.65

Descriptive Statistics of Job Postings

Our data include the 691 jobs extracted from Indeed. The results of the geographic distribution, demonstrates that most of the jobs posted were in the Southeast (203/691, 29%), followed by the Midwest (140/691, 20%), West (131/691, 19%), Northeast (94/691, 14%), and Southwest (73/691, 11%) regions. The “national” regional category was added to our analysis to represent jobs listed as entirely remote, meaning they could be accomplished anywhere in the United States and were not geographically categorized. National jobs represented 7% (50/691) of all job postings.

Within the 14-day time frame from when the job postings were collected, 19.7% (136/691) had been posted 2 days prior to the data collection, followed closely by those posted 1 day prior (100/691, 14.5%) and then posted on the same day (74/691, 10.7%). The percentage of jobs posted declined the further the

day of the data collection was from the date of posting, with only 1.5% (10.4/691) of jobs posted 14 days prior to collection.

The educational level requested in the job postings was generally evenly distributed between high school diploma (219/691, 31.7%), associate degree (269/691, 38.6%), or bachelor's degree (225/691, 32.5%). A master's degree was requested in only 8% (58/691) of the postings, with 72% (42/58) listing the degree as preferred and 28% (16/58) as required. Finally, the frequency and percentage of job postings that listed specific credentials in the qualifications and whether they were required or preferred were reported. The most requested credential was Registered Health Information Technologist (RHIT) at 29.9% (207/691), followed closely by the Registered Health Information Administrator (RHIA) at 26.0% (180/691). Additionally, the Certified Coding Specialist (CCS) credential was included in 18.1% (125/691) of job postings, the Certified Professional in Healthcare Quality (CPHQ) credential was requested in 0.6%

(4/691) of the postings, and the Certified Professional in Healthcare Information and Management Systems (CPHIMS) credential was only required in 0.3% (2/691) of the postings. We examined only the RHIT and RHIA credentials to determine whether they were required or preferred. When requesting either credentials, 14% (98/691) required one or the other, while 9%

(66/691) preferred either the RHIT or RHIA. When focused on a single credential, the numbers were much smaller, with 3% (23/691) requiring the RHIT and 2% (20/691) listing the credential as preferred. Only 1% (7/691) of the postings required the RHIA and 1% (9/691 postings) listed the credential as preferred (Tables 3-5).

Table 3. Educational levels requested.

Degree required	Value, n (%) ^a
High school diploma	219 (31.7)
Associate degree	269 (38.9)
Bachelor's degree	225 (32.5)
Master's degree	58 (8.4)

^aPercentage totals more than 100% as more than 1 educational requirement may be mentioned in the same job posting.

Table 4. Credentials.

Credential listed	Value, n (%)
RHIA ^a	180 (26.0)
RHIT ^b	207 (29.9)
CCS ^c	125 (18.1)
CPHIMS ^d	2 (0.5)
CPHQ ^e	4 (0.6)

^aRHIA: Registered Health Information Administrator.

^bRHIT: Registered Health Information Technologist.

^cCCS: Certified Coding Specialist.

^dCPHIMS: Certified Professional in Healthcare Information and Management Systems.

^eCPHQ: Certified Professional in Healthcare Quality.

Table 5. Required versus preferred credentials

Credential	n, %
Either RHIA ^a /RHIT ^b required	98 (14.2)
Either RHIA/RHIT preferred	66 (9.6)
RHIT required	23 (3.3)
RHIA required	7 (1.0)
RHIT preferred	20 (2.9)
RHIA preferred	9 (1.3)

^aRHIA: Registered Health Information Administrator.

^bRHIT: Registered Health Information Technologist.

Discussion

Principal Findings

Our study results indicate that most HIM jobs require an associate degree or above. Many require an RHIT or RHIA credential with more opportunities in the Southeast region and a number of jobs closely aligned with coding and revenue cycle related careers. This aligns with the study by Madlock-Brown et al [13], which compared the AHIMA career map to Simply Hired job postings in 2019 [13]. However, the Indeed job

postings did not strongly associate with any of the AHIMA curricular competencies despite significant differences amongst the categories. Additionally, the results indicate a similarity to informatics. Given that informatics is often identified as a skill set leveraged across professions, it was not addressed in singularity but brings up a potential research question that will require focus and analysis in a future study.

AHIMA curricular competencies had significant differences among the categories. Potential causes include delays between the time of job analysis, development competencies by the

AHIMA CEE, and additional time to implement revised competencies for accreditation. There may be an opportunity to have the CAHIIM educational programs provide feedback to AHIMA regarding the educational program implementation of curricular competencies.

A SCM score closer to 1 indicates stronger similarity between the job postings and the categories evaluated. The mean scores for the comparison of the job postings to the AHIMA career map ranged from 0.44 to 0.53, while the mean scores for the comparison of the job postings to the AHIMA curricular competencies ranged from 0.32 to 0.43. These SCM scores indicate that the job postings have a moderate similarity to the AHIMA career map and a moderate to low similarity to the AHIMA curricular competencies.

The moderate similarity of the job postings to the AHIMA career map categories reveals that coding and revenue cycle jobs are prominent in these professions. However, the career map does not appear to fully capture the range of jobs for which HIM professionals are potentially qualified [13]. This may be due to the fast pace of change in health care and variances in the jobs that HIM professionals hold.

Our study findings indicate a moderate to low similarity of job postings to the curricular competencies. This suggests that the qualifications and requirements listed in job postings do not closely align with the AHIMA curricular competencies. This misalignment can be attributed to a number of factors, including a variability in the terminology used in higher education and industry. Another consideration is the time delay for curriculum to be vetted and disseminated, which typically lags behind the fast pace of change in the industry and in job postings. Another factor is the range from entry-level positions in HIM to higher level positions resulting in varied job qualifications and inconsistent terminology.

Strengths and Limitations

One of the strengths of this research is that it is the first of its kind that aims to determine the usability and accuracy of the AHIMA career map, as it applies to health information management job postings found on Indeed. This study analyzed HIM job postings for all 50 US states and the District of Columbia, using data from Indeed, providing a snapshot of results based upon CAHIIM Annual Program Analysis Report (APAR) regions. Another strength of this study is its cross-sectional design, which provides a snapshot of the prevalence of HIM jobs nationally during a 2-week period.

As with all research studies, this study has some limitations. First, this study analyzed job posts on one job posting website and was limited to a certain time frame. Additionally, its nonexperimental design precludes establishing cause and effect relationships. Specific sampling decisions driven by practicality and time constraints are acknowledged. Establishing the search criteria of “health information management” potentially excluded HIM domain positions that did not include this title, such as Assistant Vice President (VP) of Revenue Integrity and Information Management.

There are limitations to using the AHIMA career map for comparison, as these jobs represent only AHIMA members and

do not include those in the workforce that are not AHIMA members. The emerging roles on the career map were developed by focus groups and do not represent AHIMA member data, and the career map was last updated in 2016. Further, frequencies of specific job titles are not included in the AHIMA career map. Madlock-Brown et al [13] studied the AHIMA career map and found that many of the job titles found therein were not in the Simply Hired job search. Another challenge of the AHIMA career map is the inclusion of jobs from entry-level to higher levels, so the job varies from entry-level Patient Registration Clerk to VP of Compliance.

Areas of Future Research

Researchers can use our study results to expand the literature and gaps in knowledge in this area in HIM workforce studies. One area of future research is to expand the search criteria for job postings from “health information management” to other search terms, such as “health data analyst,” or to search skills required beyond the degree. Another area of future research is to analyze HIM job postings for all 50 US states and the District of Columbia based on US Census regions. Additionally, future research can also explore usage of other NLP techniques, such as sentiment analysis or keyword extraction.

With the wide range of positions in HIM, educators may find it useful to identify jobs requiring on-the-job training. Exploring HIM professional job roles and attempting to eliminate the clerical roles associated with some tasks may be more meaningful to educators and students who are exploring the skills needed for the future HIM workforce.

This study highlights an opportunity to further explore content-based accreditation to meet the needs of end users, such as employers. There is also a need to explore educational programs primarily via competencies as opposed to degree title.

Conclusions

The HIM field is continually evolving. This study analyzed HIM job postings to examine alignment with HIM domains and found that industry job postings primarily sought educational qualifications at or below the bachelor’s degree level. This is inconsistent with the 2017 AHIMA whitepaper, *HIM Reimagined*, in which the CEE calls for the percentage of AHIMA members with graduate degrees to double from 10% to 20% by 2027 [23]. The NLP analysis suggested the correlation between informatics and job postings was higher compared to the revenue cycle, coding, and data analytics categories. These findings should be reviewed carefully by the AHIMA CEE to ensure the accreditation competency domains are congruent with jobs offered by employers. At the same time, educators need to engage fully with those who employ their graduates. The accreditation competency domains represent the baseline for educational programs. Therefore, HIM educators should incorporate additional content to meet the needs of employers. There is great diversity in the job titles, educational requirements, and skills for jobs when searching for HIM positions. This is both exciting and challenging, as jobs titles and skills will continue to change to meet workforce needs. As jobs and competencies continue to evolve in the big data, machine learning, and artificial intelligence era, professional

associations such as AHIMA, accreditors such as CAHIIM, the HIM workforce needs of the health care industry with HIM educators, and industry leaders must collaborate to align educational programs.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM) Annual Program Analysis Report (APAR) region assignments.

[PNG File , 34 KB - [mededu_v8i3e38004_app1.png](#)]

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Abbreviations

AHIMA: American Health Information Management Association
AI: artificial intelligence
APAR: Annual Program Analysis Report
API: application programming interface
BLS: US Bureau of Labor Statistics
CAHIIM: Commission on Accreditation for Health Informatics and Information Management Education
CEE: Council for Excellence in Education
CPHIMS: Certified Professional in Healthcare Information and Management Systems
CPHQ: Certified Professional in Healthcare Quality
EHR: electronic health records
FHIR: Fast Healthcare Interoperability Resources
GloVe: Global Vectors for Word Representation
HIM: health information management
HIT: health information technology
HSD: honestly significant difference
ICD-11: International Classification of Diseases 11th Revision
IoMT: Internet of Medical Things
ML: machine learning
NLP: natural language processing
ONC: Office of the National Coordinator for Health Information Technology
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RHIA: Registered Health Information Administrator
RHIT: Registered Health Information Technologist
SCM: soft cosine measures
TFIDF: term frequency inverse document frequency
VP: vice president

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Original Paper

Practices, Perceived Benefits, and Barriers Among Medical Students and Health Care Professionals Regarding the Adoption of eHealth in Clinical Settings: Cross-sectional Survey Study

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Abstract

Background: eHealth is increasingly becoming an indispensable part of health practice and policy-making strategies. However, the use of eHealth tools in clinical practice and the perceptions of eHealth among medical students and health care professionals in Vietnam are not well understood.

Objective: This study aims to investigate perceptions and practices regarding eHealth and their associated factors among medical students and health care professionals.

Methods: A web-based cross-sectional study was conducted on 523 medical students and health care professionals. Information about the practices for, perceived barriers to, and benefits of eHealth application in clinical practices was collected. Multivariate Tobit and logistic regression models were used to determine factors associated with perceptions and practices.

Results: In total, 61.6% (322/523) of participants used eHealth tools in clinical practices, with moderate levels of eHealth literacy. The score for the perceived benefits of eHealth tools was low. The most common barrier for eHealth utilization was human resources for IT (240/523, 45.9%), followed by security and risk control capacity (226/523, 43.2%) and no training in eHealth application (223/523, 42.6%). Age, eHealth literacy, and the use of the internet for updating medical knowledge were positively associated with using eHealth tools in clinical practices.

Conclusions: eHealth tools were moderately used in clinical practices, and the benefits of eHealth were underestimated among health care professionals and medical students in Vietnam. Renovating the current medical education curriculum to integrate eHealth principles should be required to equip health care professionals and medical students with essential skills for rapid digital transformation.

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KEYWORDS

eHealth; literacy; perception; practices; health care professional

Introduction

eHealth refers to the use of information and communication technologies (ICTs) to improve health care, health, well-being [1]. ICTs are widely known as important tools in the health sector [2-6]. Their application is increasingly common, particularly in managing and caring for people's health at low cost, and they have the ability to be scaled up to different settings [7-13]. *eHealth* tools help to ensure access to care, equity, patient-centeredness, and the quality of care [13,14]. The use of *eHealth* in health care not only helps health care professionals with medical examinations and treatments but also increases patients' medication adherence and overall quality of life [15-17]. The World Health Organization reports that universal health coverage can be rapidly achieved through *eHealth* strategies and policies [18].

The use of *eHealth* tools in health care is widely available in high-income countries, such as Europe and the United States, but it is limited in resource-constrained settings. Surveys from several European countries have reported that approximately 99.7% of general practitioners use computers in clinical practice [19]. Meanwhile, in Tanzania and Ghana, only 29.4% and 60% of health care workers have ever used computers, respectively [20]. Effective *eHealth* adoption requires the development of an ICT system, as well as the appropriate awareness and attitudes among health care workers. To facilitate *eHealth* application, the increasing perceptions and practices toward *eHealth* among health care professionals should be given attention. Prior literature has revealed that most medical students and health care professionals have a positive outlook on *eHealth* [21-23]. For instance, in India, 60% of physicians have a high awareness of the benefits of adopting *eHealth* tools [24]. Another study in Saudi Arabia showed that about 90% of physicians agree on the benefits of *eHealth* [25]. In terms of medical students, prior studies have found that they have positive attitudes toward *eHealth* and the integration of *eHealth* into medical curricula [21]. A study in Austria indicated that compared to health care professionals, medical students have less belief in the usefulness of *eHealth* in improving patients' knowledge but are convinced that *eHealth* could diminish health care costs [26]. Similarly, a study in China showed that medical students perceive more potential drawbacks with *eHealth* tools for telemedicine than health care professionals [27]. Several factors that determine positive perceptions and attitudes toward the use of *eHealth* include age, sex, living area, clinical experience, and the receipt of training for *eHealth* [19]. However, health care professionals have realized that there are still barriers and challenges to *eHealth* application in clinical clerkships, such as finance and information technology skills [28,29].

eHealth and ICT applications have been deployed in Vietnam's health sector, mainly in urban areas [30]. A national *eHealth* strategy was developed via a collaboration between the World Health Organization, the International Telecommunication Union, and the Ministry of Health of Vietnam. This strategy

includes (1) a national *eHealth* vision; (2) an implementation road map for identifying key priorities in the national *eHealth* context; and (3) a plan for monitoring and implementing risk management, assurances with long-term investment, and support [31]. Although *eHealth* has been regarded as a useful tool for clinical practices, evidence about perceptions of and practices for *eHealth* among prospective and current medical professionals in Vietnam is scarce. A prior study in 2018 reported limited knowledge about *eHealth* among Vietnamese medical students, which was the result of students lacking computer skills and the intention to seek *eHealth* information [32]. There remains no exploration of perceptions and current practices regarding *eHealth* tools among health care professionals in Vietnam. This study aims to investigate perceptions and practices regarding *eHealth* and their associated factors among current and prospective medical professionals.

Methods**Study Setting and Sampling**

In February 2020, we conducted a web-based cross-sectional survey among health care professionals and medical students in Vietnam. Participants were recruited if they met the following inclusion criteria: (1) living in Vietnam, (2) studying or working at hospitals or medical universities in Vietnam and having clinical experiences, (3) having either an email account or an account on social networking sites for inviting peers, and (4) providing electronic consent to participate in this study. The snowball sampling technique was used to recruit participants. Initially, a core group of health care professionals and students from three universities (Hanoi Medical University, University of Medicine and Pharmacy at Ho Chi Minh City, and Hue University of Medicine and Pharmacy) representing the three regions of Vietnam was selected for recruitment. These participants were selected due to their wide social and peer networks, which were important for the sampling technique. A web-based survey link containing a structured questionnaire was sent to the core group from the three universities via their emails. We asked participants to invite any acquaintances who met the selection criteria to participate in this web-based survey. A total of 523 health care professionals and medical students met the above criteria and were recruited in this study.

Ethics Approval

The study protocol was approved by the Institutional Review Board of Vietnam Youth Research Institute (decision number: 177 QĐ/TWĐTN-VNCTN; date: December 28, 2018).

Measurements**Overview of the Questionnaire**

We designed a structured questionnaire on the SurveyMonkey platform (Momentive Inc). The contents of the questionnaire were piloted on 10 medical students and health care professionals. After revising the questionnaire based on their feedback, the final version of the questionnaire was approved

and uploaded to the web-based platform. The structured questionnaire consisted of three question groups related to general socioeconomic characteristics, perceptions, and practices toward eHealth in diagnosing and treating diseases.

Sociodemographic Variables

The socioeconomic variables included age, living area (city or town, rural area, or mountainous area), specialty (clinical medicine or other), type of occupation (health care professionals or medical students), years of clinical experience, and city or province (Hanoi, Ho Chi Minh City, or other).

Internet Use Purposes and Perceived Level of eHealth Literacy

Participants were asked to report whether they used the internet to update their medical knowledge, read the news, or use social networks. Moreover, they were asked to report the frequency of using computers and smartphones for work and studies. Skills related to web-based medical document literacy were self-assessed on a 10-point scale. These included the following: identifying a medical problem, searching for medical information, evaluating the quality of a medical information source, evaluating the quality of medical information, and using medical information in clinical practice. These items had a Cronbach α value of .95, suggesting excellent internal consistency.

Using eHealth Tools in Clinical Practices

We asked participants to report whether they used eHealth tools in clinical practices. In this study, the use of eHealth tools was defined as the use of electronic means in consultations, examinations, diagnoses, screening, the classification of diseases, the provision of treatment regimens, and the monitoring of a patient's treatment.

Perceptions About Benefits of eHealth Tools

We investigated perceptions about the benefits of eHealth tools among medical professionals and medical students based on clinical practice aspects (ie, using eHealth tools to reduce medical error, to improve diagnostic quality, to improve the quality of treatment, and to provide data for clinical and public health studies), patient aspects (ie, using eHealth tools to increase patient compliance, to increase patient satisfaction, and to increase the accessibility of medical services and the benefit of eHealth for patients), and economic and organizational aspects (ie, using eHealth tools to limit unnecessary or duplicate laboratory tests or services, to increase the number of patients using daily services, to reduce costs by avoiding duplication, to increase coordination between departments in health care facilities, and to increase work productivity due to quick access to patient data).

The perception scores for the clinical practice aspects (4 items), patient aspects (3 items), and economic and organizational aspects (5 items) of the benefits of eHealth were calculated by summing the scores of all items in each domain. The scores for the three domains ranged from 0 to 4, from 0 to 3, and from 0 to 5, respectively. A higher score indicated a higher level of perceived benefits for each aspect. The Cronbach α of the scale was .87.

Perceptions About Barriers to Adopting eHealth Tools

We explored the perceptions of participants regarding potential barriers to applying eHealth tools in clinical practices with the following items: (1) the lack of standard procedures, (2) the lack of regulation, (3) the capacity to deploy information technology, (4) no funding, (5) security and risk control capacity, (6) not enough time, (7) difficult to use, (8) medical staff lacks information technology skills, (9) no training in eHealth application, and (10) human resources for information technology.

Data Analysis

Both descriptive and analytical statistics were performed by using Stata 15 (StataCorp LLC). Continuous variables were presented as means and SDs, while categorical variables were presented as frequencies and percentages. We used the Wilcoxon rank-sum test for continuous variables and the chi-square test for categorical variables to compare differences between participants who were using and not using eHealth tools in clinical practices. A multivariate Tobit censored regression was performed to determine factors associated with the three domain scores and the overall score for the perceptions toward the benefits of eHealth application. Additionally, a multivariate logistic regression model was carried out to examine determinants of eHealth tool use in clinical practices. We applied a stepwise forward strategy, which involved using a log-likelihood ratio test in which the P value was set at .20, to select variables for the reduced models. The collinearity between variables in the model was tested by using the *collin* packages in the Stata software [33]. The number of years of clinical experience was found to have collinearity with age; thus, we excluded the years of clinical experience variable. Afterward, the variance inflation factor of predictor variables was less than 10, and the average of the variance inflation factor was 3.6, suggesting that there was no collinearity. The statistical significance was set at an α level of .05.

Results

Table 1 shows that a total of 91.2% (476/522) of the recruited participants were medical students. Over 70% (367/523, 70.2%) of participants were female, 90.1% (471/523) of participants lived in urban areas, and more than half of the participants (268/523, 51.2%) were specializing in clinical medicine. The mean age was 21.7 (SD 4.5) years, and the mean number of years of clinical experience was 3.7 (SD 4.5). Further, 61.6% (322/523) of participants reported that they have used eHealth tools for clinical practice. There was a significant difference in the usage of eHealth tools by sex ($P=.02$), specialty ($P<.001$), the number of years of clinical experience ($P<.001$), and the type of occupation ($P<.001$). **Table 1** also shows that 40.2% (210/523) of the sample used the internet for updating their medical knowledge. The proportion of participants who were using computers and smartphones for work and studies regularly was 78.8% (406/515). Participants showed a moderate level of skills for searching, evaluating, and using medical documents on the internet, and participants who had ever used eHealth tools in clinical practices gave significantly higher scores than those given by participants who were not using eHealth tools.

Table 1. Characteristics of the respondents.

Characteristics	Using eHealth tools for clinical practice			P value
	No ^a	Yes ^a	Total ^b	
Participants, n (%)	201 (38.4)	322 (61.6)	523 (100)	N/A ^c
Sex, n (%)				.02
Male	48 (30.8)	108 (69.2)	156 (29.8)	
Female	153 (41.7)	214 (58.3)	367 (70.2)	
Specialty, n (%)				<.001
General practitioner	83 (31)	185 (69)	268 (51.2)	
Other	118 (46.3)	137 (53.7)	255 (48.8)	
Type of occupation, n (%)				<.001
Health care professionals	5 (10.9)	41 (89.1)	46 (8.8)	
Medical students	196 (41.2)	280 (58.8)	476 (91.2)	
Living area, n (%)				.77
City	182 (38.6)	289 (61.4)	471 (90.1)	
Town, rural area, or mountainous area	19 (36.5)	33 (63.5)	52 (9.9)	
Region, n (%)				.39
Northern region	53 (41.4)	75 (58.6)	128 (25.3)	
Southern region	120 (39.6)	183 (60.4)	303 (59.9)	
Central region	24 (32)	51 (68)	75 (14.8)	
Purpose of using the internet, n (%)				
To update medical knowledge	53 (25.2)	157 (74.8)	210 (40.2)	<.001
To read the news	106 (36.3)	186 (63.7)	292 (55.8)	.26
To use social networks	174 (39.6)	265 (60.4)	439 (83.9)	.20
Frequency of using computers or smartphones for work or studies, n (%)				.055
Yes, regularly	149 (36.7)	257 (63.3)	406 (78.8)	
Yes, sometimes	51 (46.8)	58 (53.2)	109 (21.2)	
Age (years), mean (SD)	20.7 (2.8)	22.3 (5.2)	21.7 (4.5)	<.001
Years of clinical experience, mean (SD)	2.7 (2.8)	4.3 (5.2)	3.7 (4.5)	<.001
Perceived levels of eHealth literacy (score; range 0-10), mean (SD)				
Using eHealth tools to identify a problem	6.0 (2.2)	6.8 (1.8)	6.5 (2.0)	<.001
Using eHealth tools to search for medical information	6.2 (2.0)	6.7 (1.9)	6.5 (2.0)	.003
Using eHealth tools to evaluate the quality of a medical information source	5.6 (2.2)	6.4 (2.0)	6.1 (2.1)	<.001
Using eHealth tools to evaluate the quality of medical information	5.7 (2.2)	6.4 (1.9)	6.1 (2.0)	<.001
Using eHealth tools to use medical information in clinical practice	5.5 (2.3)	6.4 (2.0)	6.0 (2.2)	<.001

^aPercentages in this column were calculating by using the *Total* column value as the denominator.

^bThe totals do not add up to 523 throughout this column due to missing or multiple responses.

^cN/A: not applicable.

Table 2 shows that the benefits of eHealth tools were perceived by both groups equally (ie, all *P* values are >.05). With regard to organizational and economical aspects, increased work productivity due to quick access to patient data was the most common perceived benefit (314/523, 60%), followed by increased coordination between departments in health facilities (301/523, 57.6%). In terms of clinical practice aspects, the

proportion of participants who perceived the benefit that eHealth tools provide data for clinical and public health studies was the highest (33/523, 63.1%), followed by the proportion who perceived that eHealth tools improve diagnostic quality (283/523, 54.1%). With regard to patient aspects, the most common benefit was increasing the accessibility of medical services for patients (267/523, 51.1%). However, overall,

participants believed that using eHealth tools was not quite beneficial in clinical settings (score out of 12: mean 5.4, SD 3.6).

Table 3 shows potential barriers for eHealth application. The most common barrier was human resources for IT (240/523, 45.9%), followed by security and risk control capacity (226/523, 43.2%) and no training in eHealth application (223/523, 42.6%). There were no differences in the perceived barriers between participants who were using and not using eHealth tools in clinical practices (ie, all *P* values are >.05; **Table 3**).

Table 4 presents the factors associated with the three perception domain scores and the use of eHealth tools in clinical practice. There was a positive correlation between age and the use of eHealth tools for clinical practice (odds ratio 1.09, 95% CI 1.02-1.18). The use of the internet to update medical knowledge and higher scores for identifying a problem in web-based documents were associated with a higher likelihood of using eHealth tools for clinical practice.

Female participants had significantly lower scores for the perceptions regarding the patient-related aspects of eHealth

compared to those of male participants (coefficient=-0.45, 95% CI -0.88 to -0.02; *P*=.04). Medical students had lower scores compared to those of health care professionals for the perceptions regarding the clinical aspects (coefficient=-0.94, 95% CI -1.78 to -0.10; *P*=.004) and organization and economic aspects (coefficient=-1.40, 95% CI -2.19 to -0.61; *P*=.001) of eHealth usage. Using the internet to update medical knowledge, read the news, and use social networks was associated with higher perceptions regarding clinical practice aspects, and using the internet to read the news was also positively related to higher perceptions about the organization and economic aspects of eHealth usage (coefficient=0.65, 95% CI 0.21-1.09; *P*=.004). Perceptions about the patient aspects of eHealth use positively correlated with the perceived levels for the evaluation of an information source (coefficient=0.40, 95% CI 0.16-0.65; *P*=.001) but negatively correlated with the perceived levels for the evaluation of information (coefficient=-0.35; 95% CI -0.60 to -0.10; *P*=.006). Perceptions about the organization and economic aspects of eHealth positively correlated with the perceived levels for identifying a problem (coefficient=0.14, 95% CI 0.03-0.25; *P*=.02).

Table 2. Perceptions on the use of eHealth.

Perceptions about benefits of eHealth tools	Using eHealth tools for clinical practice			<i>P</i> value
	No (n=201)	Yes (n=322)	Total (N=523)	
Organizational and economical aspects, n (%)				
Using eHealth tools to increase work productivity due to quick access to patient data	120 (59.7)	194 (60.2)	314 (60)	.90
Using eHealth tools to increase coordination between departments in health facilities	114 (56.7)	187 (58.1)	301 (57.6)	.76
Using eHealth tools to reduce costs by avoiding duplication	69 (34.3)	129 (40.1)	198 (37.9)	.19
Using eHealth tools to increase the number of patients using daily services	58 (28.9)	100 (31.1)	158 (30.2)	.59
Using eHealth tools to limit unnecessary or duplicate laboratory tests or services	63 (31.3)	127 (39.4)	190 (36.3)	.06
Clinical practice aspects, n (%)				
Using eHealth tools to provide data for clinical and public health studies	122 (60.7)	208 (64.6)	330 (63.1)	.37
Using eHealth tools to improve the quality of treatment	89 (44.3)	140 (43.5)	229 (43.8)	.86
Using eHealth tools to improve diagnostic quality	107 (53.2)	176 (54.7)	283 (54.1)	.75
Using eHealth tools to reduce medical error	93 (46.3)	162 (50.3)	255 (48.8)	.37
Patient aspects, n (%)				
Using eHealth tools to increase patients' access to medical services	103 (51.2)	164 (50.9)	267 (51.1)	.95
Using eHealth tools to increase patient satisfaction	67 (33.3)	111 (34.5)	178 (34)	.79
Using eHealth tools to increase patient compliance	37 (18.4)	72 (22.4)	109 (20.8)	.28
Organizational and economical aspects score (range 0-5), mean (SD)	2.1 (1.6)	2.3 (1.7)	2.2 (1.7)	.28
Clinical aspects score (range 0-4), mean (SD)	2.0 (1.5)	2.1 (1.5)	2.1 (1.5)	.52
Patient aspects score (range 0-3), mean (SD)	1.0 (1.0)	1.1 (1.1)	1.1 (1.1)	.76
Total score (range 0-12), mean (SD)	5.2 (3.6)	5.5 (3.5)	5.4 (3.6)	.28

Table 3. Barriers for eHealth application.

Barriers	Using eHealth tools for clinical practice, n (%)			P value
	No (n=201)	Yes (n=322)	Total (N=523)	
Organizational and economical barriers				
Lack of standard procedure	51 (25.4)	103 (32)	154 (29.4)	.11
Lack of regulation	66 (32.8)	106 (32.9)	172 (32.9)	.98
The capacity to deploy IT	72 (35.8)	128 (39.8)	200 (38.2)	.37
No funding	76 (37.8)	141 (43.8)	217 (41.5)	.18
Security and risk control capacity	96 (47.8)	130 (40.4)	226 (43.2)	.10
Clinical and technical barriers				
Not enough time	25 (12.4)	36 (11.2)	61 (11.7)	.66
Difficult to use	33 (16.4)	54 (16.8)	87 (16.6)	.92
Medical staff lacks IT skills	83 (41.3)	124 (38.5)	207 (39.6)	.53
No training in eHealth application	89 (44.3)	134 (41.6)	223 (42.6)	.55
Human resources for IT	98 (48.8)	142 (44.1)	240 (45.9)	.30

Table 4. Factors associated with practice and positive perceptions.

Variables	Using eHealth tools for clinical practice, OR ^a (95% CI)	Perceptions about the use of eHealth, coefficient (95% CI)		
		Clinical aspects	Patient-related aspects	Organization and economic aspects
Age (per year)	1.09 ^b (1.02 to 1.18)	N/A ^c	N/A	N/A
Sex				
Male	N/A	N/A	Reference	N/A
Female	N/A	N/A	-0.45 ^b (-0.88 to -0.02)	N/A
Specialty				
Clinical medicine	Reference	N/A	N/A	N/A
Other	0.64 ^d (0.43 to 0.97)	N/A	N/A	N/A
Type of occupation				
Health care professionals	N/A	Reference	N/A	Reference
Medical students	N/A	-0.94 ^b (-1.78 to -0.10)	N/A	-1.40 ^d (-2.19 to -0.61)
Purpose of using the internet				
Update medical knowledge (yes vs no)	2.24 ^d (1.45 to 3.46)	0.69 ^d (0.20 to 1.19)	N/A	N/A
Read the news (yes vs no)	N/A	0.64 ^d (0.17 to 1.12)	0.34 ^e (-0.06 to 0.74)	0.65 ^d (0.21 to 1.09)
Social networks (yes vs no)	0.68 (0.39 to 1.19)	1.00 ^d (0.40 to 1.60)	N/A	0.49 ^e (-0.09 to 1.07)
Perceived levels of eHealth literacy				
Using eHealth tools to identify a medical problem (per point)	1.20 ^d (1.08 to 1.33)	N/A	N/A	0.14 ^b (0.03 to 0.25)
Using eHealth tools to evaluate the quality of a medical information source (per point)	N/A	N/A	0.40 ^d (0.16 to 0.65)	N/A
Using eHealth tools to evaluate the quality of medical information (per point)	N/A	N/A	-0.35 ^d (-0.60 to -0.10)	N/A

^aOR: odds ratio.

^bSignificant at the $P < .05$ level.

^cN/A: not applicable.

^dSignificant at the $P < .01$ level.

^eSignificant at the $P < .10$ level.

Discussion

Principal Findings

Health technology and eHealth have been becoming indispensable components in hospital operation and patient care. This study contributed to the current literature to facilitate the use of eHealth principles in Vietnamese clinical settings. Our findings indicated that eHealth tools were widely used among the health care professionals, but only more than half of the medical students (280/476, 58.8%) frequently used these tools in their clinical practices. Perceived benefits and barriers in using eHealth were also explored, and the results of the multivariate analysis indicated further implications for facilitating the use of eHealth in clinical practices.

Promoting the development of the eHealth system in Vietnam plays an important role in improving the quality of patient care and hospital efficiency [34]. Current eHealth systems are being applied in Vietnam, such as telemedicine systems that help support patients remotely during the COVID-19 pandemic; artificial intelligence systems that help diagnose cancer and lung diseases; and other eHealth systems, including an eHealth book system that helps manage disease status [35-37]. Especially in the context of emergency events and disasters, such as the COVID-19 pandemic, the use of eHealth tools has become even more urgent [38]. This requires current physicians and medical students to be fully equipped with sufficient eHealth literacy, which is needed to adapt to the increasing demands of these systems.

The use of eHealth tools in clinical settings was commonly observed among health care professionals but was still limited among medical students. However, our proportion of participants who were using eHealth tools was higher than that of a 2017 study in China, which revealed that only 51.1% of health care professionals and 41.6% of medical students had heard of telehealth [27]. Prior research in Tanzania and Ghana found that only 29.4% and 60% of health care workers have ever used computers, respectively [20]. Another study in the United States showed that merely 17.4% of medical students had experience with telemedicine [39]. Our results were understandable since, in recent years, the advancement and popularity of the internet and electronic devices (eg, laptops, smartphones, or tablets) has increasingly allowed health care professionals and medical students to conveniently access a variety of eHealth tools that are available on the internet. Moreover, the national strategy on eHealth has promoted the use of eHealth tools in clinical settings, which provides opportunities for these groups to approach and use such tools. Nonetheless, compared to findings from European countries, where 99.7% of practitioners use computers in clinical practice [19], the proportion of participants who were using eHealth tools in our study was considerably lower, suggesting that there is a huge gap that needs to be filled for the success of digital transformation in health care.

The results of this study show that the participants' levels of eHealth literacy were moderate. Given the nature of eHealth tools and systems to be innovative and to change continuously, these results indicate a potential barrier to the use and adaptation of eHealth tools [40]. Indeed, nearly half of the participants found a lack of ICT skills (207/523, 39.6%) and a lack of training (223/523, 42.6%) to be considerable challenges to using eHealth tools in clinical practices. This phenomenon could be explained by the fact that eHealth capabilities have not been systematically integrated into the current undergraduate and graduate medical curricula in Vietnam and only appear in several continuing medical education training programs. This gap can become serious if the curricula are not reformed, due to the rapid development of medical technology. Providing the most foundational eHealth skills to medical students and medical practitioners will help them adapt to the digital transformation and proficiently use eHealth tools to serve their practices [34,40].

The findings of this study also show that a great barrier to the application of eHealth in Vietnam was that physicians and medical students did not recognize the roles and benefits of eHealth tools in clinical practices. Specifically, the scores for the perceived benefits of eHealth tools were below moderate, suggesting that the benefits of eHealth for participants were not quite clear. This issue might be justified by the fact that although a national eHealth strategy had been proposed and implemented, eHealth systems in hospitals at the time of this study were still in their beginning stages, despite the major presence of the eHealth management system. Only a few central hospitals and private hospitals adopt advanced eHealth systems, such as artificial intelligence systems. Therefore, it is understandable that the physicians and medical students, particularly the latter, did not have much exposure to eHealth tools and were not fully aware of the role of eHealth. However, the COVID-19 pandemic

has accelerated the digital transformation process in all levels of the Vietnamese health care system [38]. Further, all hospitals benefited from this innovation. These benefits included the implementation of telemedicine and remote disease management and diagnosis, which fostered cooperation and technology transfer between central hospitals and primary health care facilities [37,41]. Therefore, it is expected that the perceptions of health care professionals will change and that they will quickly prepare for the process of adapting to future eHealth technologies.

In our study, medical students had lower scores for the perceptions about the organization and economic aspects and clinical aspects of the usefulness of eHealth. This study was different from a study in Austria, wherein the authors found that medical students were more optimistic about the use of eHealth to reduce health care costs but more pessimistic about the use of eHealth to improve patients' knowledge when compared to health care professionals [26]. Another study in China reported that medical students have more concerns about telehealth than health care professionals, which might be due to their low awareness and utilization of telehealth [27]. A study in the United States found that increasing exposure to telemedicine could raise the awareness and attitudes of medical students regarding telemedicine [39]. Given their bridging role between health care professionals and patients, medical students are suggested to have more positive views of eHealth application than those of other groups. Moreover, medical schools and hospitals should offer more opportunities to medical students that expose them to eHealth tools in clinical settings. This might improve their opinions about eHealth and provide them with the capacity to perform clinical practices in the future.

This study demonstrates the important role of systematically building and integrating eHealth capacities into current medical training curricula. This would be useful for physicians and medical students who can adapt to the great digital transformation of health care in Vietnam. These individuals may have good ICT skills, but they may also have limitations in evaluating the medical information they find and using medical information in clinical practice. Further studies on the development of practical training frameworks for eHealth techniques that narrow the gaps between academia and reality should also be considered and implemented.

This study has several limitations that need to be considered when interpreting the results. First, our cross-sectional survey was based on self-reported information, which might result in recall bias. Second, this study had the limitations of a cross-sectional design, which did not allow us to draw causal relationships between eHealth practices, perceived benefits of eHealth, and associated factors. Third, the snowball sampling method limited the generalizability of the study results to health care professionals and medical students in Vietnam. Fourth, the sample of health care professionals was small. To develop a full picture of the perceptions and practices regarding the application of eHealth in diagnosis and treatment among health care workers in Vietnam, additional studies should be conducted with larger sample sizes. Moreover, qualitative research should be performed to more comprehensively understand the

perceptions of these populations regarding the use of eHealth tools.

Conclusion

This paper informs that in Vietnam, eHealth tools are moderately used in clinical practices, and the benefits of eHealth are

underestimated among health care professionals and medical students. Renovating the current medical education curriculum to integrate eHealth principles should be required to equip health care professionals and medical students with essential skills for rapid digital transformation.

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Conflicts of Interest

None declared.

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Abbreviations

ICT: information and communication technology

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Original Paper

Patterns of Skills Acquisition in Anesthesiologists During Simulated Interscalene Block Training on a Soft Embalmed Thiel Cadaver: Cohort Study

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Abstract

Background: The demand for regional anesthesia for major surgery has increased considerably, but only a small number of anesthesiologists can provide such care. Simulations may improve clinical performance. However, opportunities to rehearse procedures are limited, and the clinical educational outcomes prescribed by the Royal College of Anesthesiologists training curriculum 2021 are difficult to attain. Educational paradigms, such as mastery learning and dedicated practice, are increasingly being used to teach technical skills to enhance skills acquisition. Moreover, high-fidelity, resilient cadaver simulators are now available: the soft embalmed Thiel cadaver shows physical characteristics and functional alignment similar to those of patients. Tissue elasticity allows tissues to expand and relax, fluid to drain away, and hundreds of repeated injections to be tolerated without causing damage. Learning curves and their intra- and interindividual dynamics have not hitherto been measured on the Thiel cadaver simulator using the mastery learning and dedicated practice educational paradigm coupled with validated, quantitative metrics, such as checklists, eye tracking metrics, and self-rating scores.

Objective: Our primary objective was to measure the learning slopes of the scanning and needling phases of an interscalene block conducted repeatedly on a soft embalmed Thiel cadaver over a 3-hour period of training.

Methods: A total of 30 anesthesiologists, with a wide range of experience, conducted up to 60 ultrasound-guided interscalene blocks over 3 hours on the left side of 2 soft embalmed Thiel cadavers. The duration of the scanning and needling phases was defined as the time taken to perform all the steps correctly. The primary outcome was the best-fit linear slope of the log-log transformed time to complete each phase. Our secondary objectives were to measure preprocedural psychometrics, describe deviations from the learning slope, correlate scanning and needling phase data, characterize skills according to clinical grade, measure learning curves using objective eye gaze tracking and subjective self-rating measures, and use cluster analysis to categorize performance irrespective of grade.

Results: The median (IQR; range) log-log learning slopes were -0.47 (-0.62 to -0.32 ; -0.96 to 0.30) and -0.23 (-0.34 to -0.19 ; -0.71 to 0.27) during the scanning and needling phases, respectively. Locally Weighted Scatterplot Smoother curves showed wide variability in within-participant performance. The learning slopes of the scanning and needling phases correlated: $\rho=0.55$ (0.23 - 0.76), $P<.001$, and $\rho=-0.72$ (-0.46 to -0.87), $P<.001$, respectively. Eye gaze fixation count and glance count during the

scanning and needling phases best reflected block duration. Using clustering techniques, fixation count and glance were used to identify 4 distinct patterns of learning behavior.

Conclusions: We quantified learning slopes by log-log transformation of the time taken to complete the scanning and needling phases of interscalene blocks and identified intraindividual and interindividual patterns of variability.

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KEYWORDS

regional anesthesia; ultrasonography; simulation; learning curves; eye tracking

Introduction

Background

Ultrasound-guided regional anesthesia (UGRA) is a complex ultrasound-based needle intervention that requires extensive training to deliver safe, high-quality pain relief and the best possible perioperative outcomes [1]. The demand for UGRA has increased considerably during the COVID-19 pandemic because surgery can be conducted awake on insensate limbs, thus avoiding opioids, intubation, and ventilation [2]. However, there is a variation in the ability to perform UGRA among anesthesiologists. Training is sporadic: skills are first learned (and errors made) on patients, then honed intermittently over many years.

However, only a weak relationship exists between experience and actual measured performance [3] and potentially harmful behavior may be hidden in independent, isolated practice.

Simulation Training

Simulation training may improve the UGRA performance [4]. Cadaver-based training courses are common but unstructured, and only basic skills are taught. Trainee:trainer ratios are high, and skills are acquired at different rates [5]. Thus, clinical educational outcomes prescribed by the Royal College of Anaesthetists training curriculum 2021 may be difficult to reach within short time frames [6,7].

A clear need exists for UGRA simulation training to compensate for the shortfall in clinical exposure to UGRA [8]; identify personal strengths and weaknesses using an expert performance approach [9]; gain insight into which personal characteristics and psychometric mechanisms impact performance; and categorize the learning patterns of a broad, general selection of anesthesiologists.

Current Evidence

To date, our work has validated the physical and functional alignment of the Thiel embalmed cadaver simulator [10], developed and validated checklist and eye tracking metrics that reflect skills performance [11], introduced mastery learning and dedicated 1:1 training to regional anesthesia [5], measured learning curves using new needle technology [5], and showed translation of skills from cadavers to patients 3 weeks after training. We also used eye tracking to measure the performance of the simulators and patients [4]. Eye tracking measures the number of fixations (points at which the visual system takes in detailed information), duration (dwell time), and saccades (rapid movement between fixations). Our eye tracking data have shown

construct validity and inverse correlation of fixations with the successful execution of checklist items [11].

The extended learning curves of anesthesiologists have not been established on a high-fidelity simulator of regional anesthesia using validated, quantitative metrics and educational paradigms associated with enhanced skill acquisition.

As the time taken to perform a task decreases with the number of repetitions of that task, learning follows the power law: log-log transformation yields a linear slope that can be easily interpreted.

Primary Objective

Therefore, our primary objective was to measure the learning slopes of a wide range of anesthesiologists trained on an interscalene block on a soft embalmed Thiel cadaver, using an expert performance approach encompassing mastery learning and dedicated practice.

Thus, our primary outcome measure was the slope of the best-fit linear lines through log-log transformed data during the scanning and needling phases of the simulated interscalene nerve block.

Methods

The study was conducted over a 3-week period at the Centre for Anatomy and Human Identification (CAHID) at the University of Dundee, governed by the Anatomy Act 2006 (Scotland). Reporting followed the Reporting Mastery Education Research in Medicine [12] guidelines, the Guidelines for Health Care Simulation Research [13], and the Strengthening the Reporting of Observational Studies in Epidemiology statements [14].

Ethics Approval

The study was approved by the University of Dundee Non-Clinical Ethics Committee.

Study Population

We invited anesthesiologists with a broad range of experience to participate in this study. They included trainees from years 1 to 7 in the East of Scotland School of Anesthesia, general consultant anesthesiologists, one expert regional anesthesiology fellow, who had completed the 7-year training program, and 2 consultant regional anesthesiologists who routinely practiced nerve blocks. We subdivided anesthesiology trainees into their 3 grades within the East of Scotland anesthesiology training program. Basic training occurred in years 1 to 2, intermediate training occurred in years 3 to 4, and higher training occurred in years 5 to 7.

All trainees and general consultants had basic or intermediate UGRA proficiency according to the Dreyfus and Dreyfus lexicons [15]. They had minimal background knowledge of regional anesthesia, struggled to address problems during nerve blocks using their own judgment, and were hesitant. They were representative of the population of anesthesiologists who may have infrequently conducted supervised or unsupervised nerve blocks and routinely used ultrasound to insert central venous lines. In contrast, consultant regional anesthesiologists practiced unsupervised nerve blocks on a regular basis, provided excellence with relative ease, recognized patterns, took responsibility for going beyond current standards, and developed ways of dealing with unique problems [15].

Study Interventions

Before training, participants completed the self-reporting International Personality Item Pool (IPIP) and the State-Trait Anxiety Inventory tests. The IPIP consists of 50 statements describing 5 types of behavior: extraversion, agreeableness, conscientiousness, emotional stability, and intellect and imagination. Statements are answered using a 5-point categorical score from *very inaccurate* to *very accurate*. The State-Trait Anxiety Inventory consists of an S-Anxiety scale that uses 20 statements to evaluate on a 4-point descriptive scale how participants feel “right now, at this moment” and the T-Anxiety scale that uses 20 statements to assess on a 4-point descriptive scale how participants feel generally.

Simulator

The Anatomy Scientific Officer selected 2 soft embalmed cadavers for this study. In CAHID, cadavers are soaked in vats for 6 months using the Thiel method with a mixture of salts and acids [16] and then stored for up to 3 years. Cadavers exhibit physical fidelity and functional alignment with simulated tasks [17]. Elasticity is similar to that of patients [18]: perineural injection distends and relaxes tissues, fluid drains away from the site, with minimal change in anatomy, allowing hundreds of repeated injections <0.5 mL [17] without cadaver damage.

The study was conducted in a quiet, well-lit, ventilated room in a mortuary at CAHID. An ultrasound machine (Zonare) was positioned on the right side of the neck, and the volunteers sat on the left side of the cadaver adjacent to the trainer. Volunteers wore SMI ETG 2w wireless eye tracking glasses (SensoMotoric Instruments). Psychologists sat behind a table at the head of the cadaver with study laptop computers that received live streaming of data from eye tracking glasses. Near-infrared light was projected onto the eyes, and integrated high frame-rate cameras detected the frequency and duration of eye gaze fixations, the period during which attention is relatively stable and focused at a given location; saccades, the rapid motion of the eye from one fixation to another; dwell time, the total amount of attention to an area of interest; and glances, the number of shifts in attention between the monitor and tools.

Before beginning each interscalene block, an eye tracking software calibration procedure was performed. Eye tracking data were masked from the viewpoints of the trainer and operator and downloaded to the raw data files.

Study Procedure

Before the study started, trainers demonstrated the essential steps that were conducive to good practice and the errors that should be avoided. The participants started the study when they felt confident in doing so. The essential steps included preprocedural transducer handling and scanning skills; identification of target nerves; alignment of the needle to the transducer; visualization of the needle tip on needle movement and appropriate adjustment of its position when misaligned; observation of the needle tip during local anesthetic injection; recognition of tissue type and local anesthetic spread; and accidental intraneural injection.

Each volunteer conducted a maximum of 60 interscalene blocks within a 3-hour period. We chose this extended time frame to accommodate the wide range of competencies we expected to see and identify the dynamics of individual learning curves. Three experts performed 20 blocks because we expected them to perform at the top of their learning curve. We restricted the number of cadavers because we anticipated considerable variance in data both between and within participants over time as performance improved. Thus, the variance owing to the simulator was kept to the minimum possible. For the same reasons, we used only 2 expert regional anesthesiologists to supervise performance.

Educational Approach

We applied the expert performance approach and used mastery learning and dedicated practices [6]. Participants had clear learning objectives and received continuous, proximate instructor feedback during each procedure [19]. All errors were identified by the trainer, communicated immediately, and steps outlined earlier were repeated by participants until successful, irrespective of time. Successful block was judged by the trainer as completion of all steps and accurate injection of a test dose of approximately 0.5-mL embalming solution between the C5 and C6 nerve roots. The injection times were recorded. As all tasks were completed successfully regardless of the time taken, scanning and needling durations were used as measures of block performance. All participants, including the experts, underwent the same training and testing. Thus, this was not a study comparing novices and experts, but a study designed to capture the range of performance of all participants. The demarcation between the scanning and needling phases was defined as the time of placement of the needle tip on the skin. A 5-minute break was taken every 30 minutes to minimize operator fatigue.

Study Objectives

Our primary objective was to measure the learning slopes of the scanning and needling phases of the interscalene block conducted repeatedly on a soft embalmed Thiel cadaver over a 3-hour period of training.

Our secondary objectives were as follows:

- Measure preprocedural psychometrics
- Describe deviations from the learning slope
- Correlate scanning and needling phase data
- Measure learning curves using objective eye gaze tracking and subjective self-rating measures

- Use cluster analysis to categorize performance

End Points

Our primary outcome measure was the slope of the best-fit linear lines using log-log transformed time data during the scanning and needling phases of the simulated interscalene nerve block.

Secondary end points were as follows:

- Eye metrics: eye gaze fixation count, relative amount of attention to the monitor (%), number of glances to the monitor, and relative amount of time (%) spent on the monitor (dwell) recorded during the scanning and needling phases.
- Self-confidence before and after each block [20] on a 10-point scale ranging from 1 “not at all confident” to 10 “extremely confident.”
- Anxiety was measured on a scale from 1 “extremely anxious” to 10 “extremely calm.”
- Global technical skills proficiency [21] after the first block was used as a baseline measure, then repeated after the final block. The assessment consisted of four scores: 1, unable to perform the procedure under supervision; 2, able to perform the procedure under supervision; 3, able to perform the procedure with minimum supervision (needed occasional help); and 4, competent to perform the procedure unsupervised (and could deal with any complications that arose).

Data were recorded during both the search and needle insertion phases of interscalene nerve block. The demarcation between the phases was defined as the time of needle tip placement on the skin. Eye tracking data were masked from the viewpoints of the trainer and operator and downloaded to the raw data files.

Transformation of End Points

The ideal learning curve follows a power distribution. To analyze and interpret learning more easily, we log-transformed the data and plotted graphs. The primary and secondary endpoints were represented on the *y axis* and the procedure number on the *x axis*. The best-fit linear line was inserted through the data points. From each graph, we identified key features of the intercept (*b*), the slope (*a*), the SE of the slope, and the asymptote. The slope of the log-log plots constituted a measure of the rate of learning: a flat slope constituted no learning, and a steep slope indicated rapid learning.

The SE of each participant’s regression slope was taken as a measure of individual variability, and the asymptote, the average performance during the last 5 trials, was regarded as an indicator of the best performance.

Statistical Analysis

Paired parametric data were analyzed using a paired 2-tailed *t* test and are presented as the difference between the means (95% CI). Paired nonparametric data were analyzed using the Wilcoxon test and are presented as the median of the differences (95% CI). The Kruskal-Wallis test was used to compare >2 groups. Linear models of log-log plots were assessed for fit using adjusted R^2 , the proportion of variation in the outcome explained by the predictor variables. The correlation between the intercept, slope, and asymptote in the scanning and needling phases was determined using the Spearman rank coefficient (ρ). Hierarchical clustering analysis was used to discriminate between the performances. The values were centered and scaled so that the magnitudes could be compared. Statistical analysis was performed using RStudio and GraphPad Prism.

Power Analysis

As no previous anesthesia study had measured learning curves in such detail and the within-subject and between-subject errors of our data were not known, we made no prior assumptions about the data and recruited all willing participants.

Results

Participant Characteristics

In total, 33 anesthesiologists opted-in to the study and provided written informed consent. Participants 6, 26, and 29 did not participate in the study, and therefore, data from 30 participants were analyzed. Their personal characteristics are listed in [Table 1](#). The median (IQR; range) ultrasound experience and anesthetic experience were 4 (3-6; 1-12) years and 4 (3-6; 1-29) years, respectively. The participants performed 51 (40-59; 28-60) blocks. IPIP scores were as follows: extraversion 28 (26-36; 11-43), agreeableness 38 (34-42; 23-48), conscientiousness 38 (34-42; 23-48), emotional stability 36 (29-40; 19-44), and intellect and imagination 35 (32-39; 23-45). The median (IQR; range) state anxiety score was 33 (27-37; 20-63) and trait anxiety score was 36 (22-42; 26-60).

Table 1. Participant characteristics.

Participant number	Age (years)	Sex	Grade	Anesthesia (year)	Repeat procedures (n)
1	33	Male	ST ^a 6	6	58
2	34	Male	ST 5	6	49
3	28	Female	CT ^b 2	2	28
4	27	Female	CT 1	1	30
5	32	Male	ST 4	4	51
7	27	Female	CT 1	1	50
8	29	Male	ST 3	3	40
9	30	Female	ST 4	4	34
10	35	Male	CT 2	2	30
11	30	Female	ST 4	4	37
12	29	Male	ST 4	4	44
13	31	Female	ST 6	6	58
14	30	Female	ST 4	4	60
15	30	Female	ST 3	3	54
16	30	Female	CT 2	2	28
17	30	Female	ST 3	3	60
18	29	Male	ST 4	4	60
19	32	Female	ST 4	4	47
20	26	Male	ST 4	4	53
21	32	Male	ST 4	4	60
22	36	Female	ST 4	4	60
23	35	Female	Con ^c	11	50
24	32	Male	ST 6	6	60
25	45	Male	Con	17	59
27	37	Female	Con	13	60
28	34	Female	ST 4	4	53
30	31	Male	CT 1	1	50
31	34	Female	Con	9	20
32	38	Male	Con	11	20
33	55	Male	Con	27	20

^aST: specialist trainee.

^bCT: core medical trainee.

^cCon: consultant.

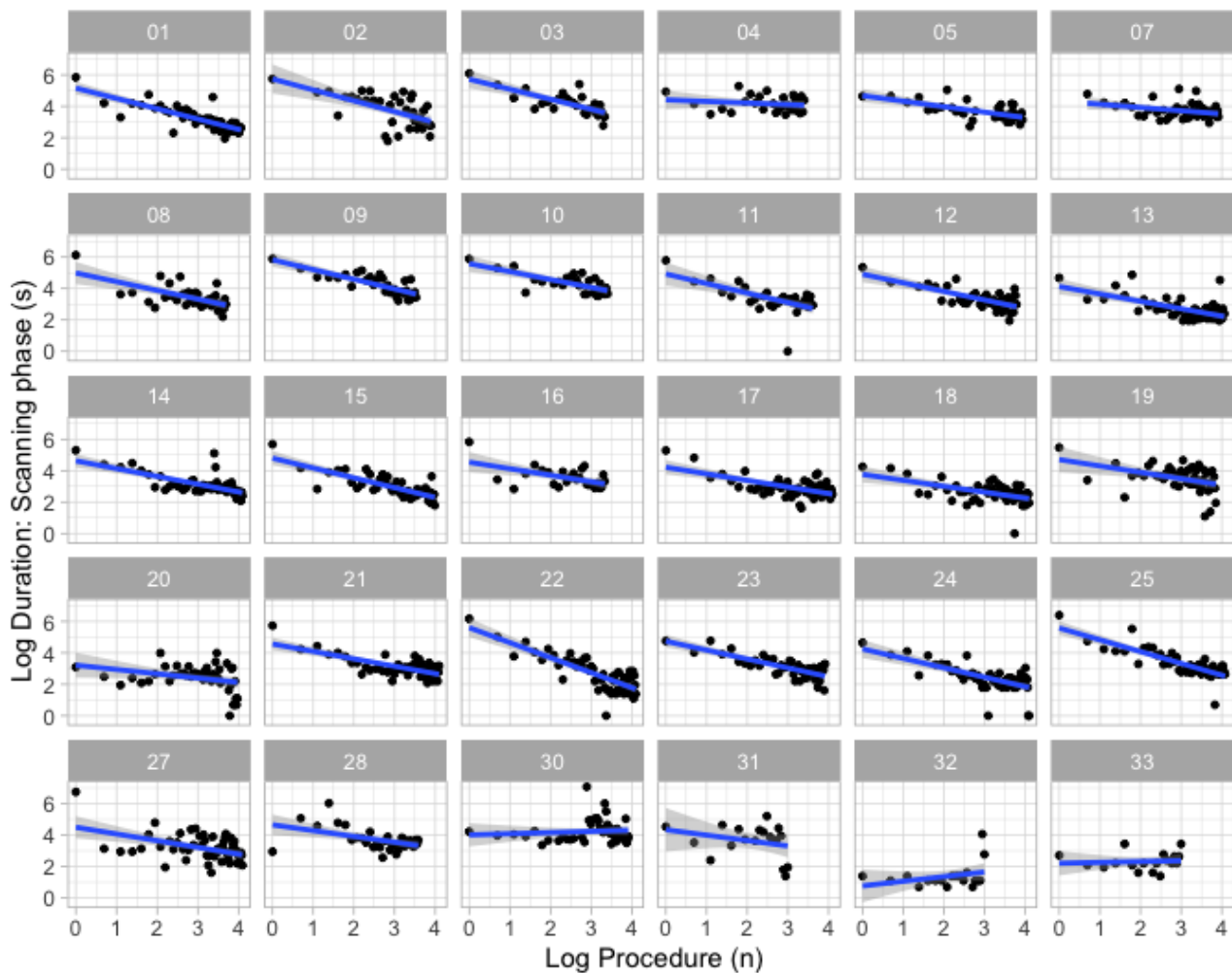
Cadaver Durability

Blocks were placed on the left neck of the 2 cadavers. No needle tracks were visualized on ultrasound images with repeated injections. We reported the durability of the first cadaver in this study in a previous publication [17]. It tolerated 934 interscalene blocks over 10 days without any discernible accumulation of perineural fluid compared with right-sided ultrasound control images. Tissue integrity had been attributed to tissue elasticity similar to that measured in humans [17,18].

Learning Slopes

We plotted the log times taken for 30 participants to complete the scanning and needling phases and the log number of repetitions over 3 hours. Figure 1 shows the best-fit linear learning slopes for scanning time. Performance is indicated by the linear slope (95% CI), intercept (95% CI), error, and asymptote of the best-fit line passing through log-log converted data.

Figure 1. Best-fit linear learning slopes demonstrated on log-log transformed (power) model from participants 1 to 33 during search phase of simulated interscalene block. Participants 6, 26, and 29 are excluded. Log time (duration) taken to complete all steps on y-axis, and log sequence of blocks (1 to 4) the x-axis. The blue straight line is the best-fit line through the data. The 95% CIs about the slope are shown in light gray.



During the scanning phase, the median (IQR; range) slope was -0.47 (-0.62 to -0.32 ; -0.96 to 0.30) and median (IQR; range) log intercept was 4.70 (4.30 - 5.00 ; 0.76 - 5.80). During the needling phase, median (IQR; range) slope was -0.23 (-0.34 to -0.19 ; -0.71 to 0.27) and the median (IQR; range) log intercept was 4.20 (3.90 - 4.50 ; 2.90 - 5.80). Both the slope and

SE of expert anesthesiologists (participant numbers 31, 32, and 33) notably had a relatively flat slope with little variation during scanning (Figure 1) and needling. Two novice anesthesiologists (participant numbers 12 and 17) also had a flat slope, but this was associated with marked variability, indicative of poor performance. The results are shown in Table 2.

Table 2. Individual learning slope data for scanning and needling time.

Patient number	Scanning phase					Needling phase				
	Line intercept	Slope (SE; 95% CI)	Log asymptote	Adjusted R^2	LOESS ^a	Line intercept	Slope (SE; 95% CI)	Log asymptote	Adjusted R^2	LOESS
1	5.16 (4.75 to 5.56)	-0.66 (0.06; -0.78 to 0.53)	2.55	0.66	→ ^b	4.44 (3.96 to 4.98)	-0.31 (0.07; -0.46 to 0.16)	3.48	0.22	→↓
2	5.74 (4.81 to 6.66)	-0.69 (0.14; -1.00 to 0.39)	3.19	0.35	→↓	4.16 (3.58 to 4.73)	-0.20 (0.09; 0.39 to 0.02)	3.37	0.07	→↓
3	5.73 (5.14 to 6.31)	-0.64 (0.12; -0.87 to 0.41)	3.53	0.54	→↑	5.26 (4.64 to 5.88)	-0.50 (0.12; 0.72 to 0.26)	4.03	0.39	→↑
4	4.41 (3.81 to 5.01)	-0.10 (0.11; -0.33 to 0.13)	4.18	0.01	→↑	4.49 (3.70 to 5.29)	-0.19 (0.15; 0.49 to 0.13)	3.71	0.02	→↑
5	4.67 (4.25 to 5.10)	-0.35 (0.07; -0.49 to 0.21)	3.31	0.40	→	2.85 (2.26 to 3.44)	0.18 (0.01; 0.01 to 0.37)	3.76	0.07	↑
7	4.33 (3.82 to 4.85)	-0.21 (0.08; -0.37 to -0.04)	3.66	0.10	→↑	4.54 (3.70 to 5.29)	-0.28 (0.11; 0.51 to 0.05)	4.03	0.10	→↑
8	4.99 (4.28 to 5.69)	-0.55 (0.12; -0.80 to 0.31)	2.92	0.37	→↑	5.25 (4.53 to 5.94)	-0.35 (0.12; 0.59 to 0.11)	4.10	0.19	→↑
9	5.82 (5.38 to 6.28)	-0.62 (0.08; -0.78 to -0.45)	3.89	0.64	→	4.43 (3.93 to 4.93)	-0.27 (0.09; 0.45 to 0.09)	3.69	0.20	→↓
10	5.58 (5.06 to 6.11)	-0.51 (0.10; -0.70 to -0.31)	3.85	0.49	→	4.20 (3.66 to 4.75)	-0.23 (0.10; 0.44 to 0.03)	3.31	0.14	→↓
11	4.92 (4.18 to 5.67)	-0.61 (0.13; -0.87 to -0.34)	3.14	0.37	→	4.24 (3.69 to 4.80)	-0.28 (0.10; 0.48 to 0.08)	3.14	0.17	→
12	4.91 (4.40 to 5.42)	-0.55 (0.08; -0.72 to -0.38)	3.34	0.50	→	4.29 (3.64 to 4.95)	-0.07 (0.10; 0.29 to 0.15)	4.05	0.42	→
13	4.12 (3.62 to 4.62)	-0.47 (0.08; -0.63 to -0.32)	2.42	0.39	→↑	4.56 (4.12 to 4.99)	-0.44 (0.07; 0.58 to 0.30)	2.89	0.42	→
14	4.63 (4.20 to 5.06)	0.50 (0.07; -0.63 to -0.36)	2.43	0.49	→	4.30 (4.01 to 4.71)	-0.39 (0.05; 0.50 to 0.28)	2.81	0.47	→
15	4.80 (4.34 to 5.25)	-0.62 (0.07; -0.77 to -0.48)	2.72	0.61	→↑	4.61 (4.22 to 4.98)	-0.42 (0.06; 0.50 to 0.30)	3.18	0.51	→
16	4.54 (3.89 to 5.19)	-0.42 (0.12; -0.67 to 0.16)	3.27	0.27	→↑	4.11 (3.55 to 4.67)	-0.20 (0.11; 0.42 to 0.02)	3.33	0.10	→↑
17	4.22 (3.78 to 4.68)	0.42 (0.07; -0.57 to -0.29)	2.61	0.39	→↑	4.16 (3.65 to 4.68)	-0.20 (0.08; 0.36 to 0.04)	3.16	0.08	→↑
18	3.40 (2.75 to 4.05)	-0.27 (0.10; -0.46 to 0.08)	2.38	0.13	→	3.64 (3.20 to 4.08)	-0.09 (0.06; 0.22 to 0.04)	3.23	0.02	→↑

Patient number	Scanning phase					Needling phase				
	Line intercept	Slope (SE; 95% CI)	Log asymptote	Adjusted R^2	LOESS ^a	Line intercept	Slope (SE; 95% CI)	Log asymptote	Adjusted R^2	LOESS
19	4.71 (3.89 to 5.53)	-0.41 (0.13; -0.68 to 0.10)	3.30	0.18	→ ↑ →	4.72 (4.05 to 5.38)	-0.34 (0.11; 0.56 to 0.12)	3.59	0.12	→ ↑ →
20	3.22 (2.42 to 4.01)	-0.27 (0.13; -0.53 to 0.02)	1.34	0.09	→ ↓	3.56 (3.03 to 4.10)	-0.19 (0.08; 0.37 to 0.02)	1.92	0.09	→ ↓
21	4.57 (4.16 to 4.97)	-0.47 (0.06; -0.60 to 0.35)	2.89	0.50	→ ↑	4.45 (3.65 to 5.24)	-0.23 (0.12; 0.46 to 0.01)	3.60	0.05	→ ↑
22	5.61 (5.00 to 6.22)	-0.96 (0.09; -1.14 to -0.77)	2.17	0.64	→	5.76 (5.18 to 6.34)	-0.71 (0.07; 0.88 to 0.53)	2.83	0.52	→
23	4.74 (4.33 to 5.16)	-0.57 (0.07; -0.70 to -0.44)	2.92	0.60	→	4.20 (3.66 to 4.74)	-0.22 (0.09; 0.39 to 0.04)	3.89	0.09	→ ↑
24	4.76 (4.11 to 5.42)	-0.75 (0.10; -0.95 to 0.55)	1.76	0.48	→	3.93 (3.61 to 4.26)	-0.23 (0.05; 0.32 to 0.12)	3.24	0.27	→
25	5.58 (5.14 to 6.03)	-0.75 (0.07; -0.90 to -0.62)	2.92	0.68	→	4.14 (3.79 to 4.49)	-0.30 (0.05; 0.41 to 0.20)	2.76	0.35	→
27	4.49 (3.78 to 5.20)	-0.42 (0.11; -0.64 to 0.21)	2.47	0.20	→ ↓	3.37 (2.86 to 3.82)	0.27 (0.08; 0.42 to 0.11)	2.47	0.16	→
28	4.65 (4.00 to 5.31)	-0.37 (0.12; -0.60 to -0.13)	3.53	0.21	↑ ↓	4.38 (3.80 to 4.95)	-0.18 (0.09; 0.36 to 0.01)	4.15	0.07	→ ↑
30	4.01 (3.27 to 4.75)	0.07 (0.12; -0.16 to 0.31)	4.14	0.01	→ ↑	3.29 (2.51 to 4.06)	-0.09 (0.13; -0.35 to 0.16)	3.58	0.00	→
31	4.34 (2.96 to 5.72)	-0.34 (0.23; -0.95 to 0.27)	3.43	0.20	→ ↑	3.55 (3.26 to 3.88)	-0.40 (0.06; -0.54 to 0.27)	2.43	0.62	→ ↑
32	0.76 (-0.28 to 1.80)	0.30 (0.22; -0.17 to 0.76)	2.81	0.40	→ ↑	3.11 (2.64 to 3.57)	0.02 (0.10; -0.18 to 0.24)	3.06	0.05	→ ↑
33	2.20 (1.43 to 2.98)	0.05 (0.16; -0.29 to 0.40)	2.73	0.05	→ ↑	3.92 (3.56 to 4.28)	-0.19 (0.07; -0.35 to 0.04)	3.37	0.05	→

^aLOESS: Locally Weighted Scatterplot Smoother.

^bLOESS fit described with arrows: → indicates good approximate fit to slope, ↓ indicates LOESS line persistently below the slope and accelerated learning, and ↑ indicates LOESS line persistently above the slope and slowed learning. Combinations of ↑, ↓, and → give an overview of learning dynamics.

Data Variability

Locally Weighted Scatterplot Smoother (LOESS) best-fit lines illustrate the dynamics of learning during the search phase and during the needling phase (Figure 2) and are summarized in Table 2. In the scanning phase, the slope of learning remained close to a straight line in 12 participants, dropped below the line in 4 participants (indicating improved performance), rose above the line in 13 participants (indicating slowed learning), and moved in a complex manner above and below the learning

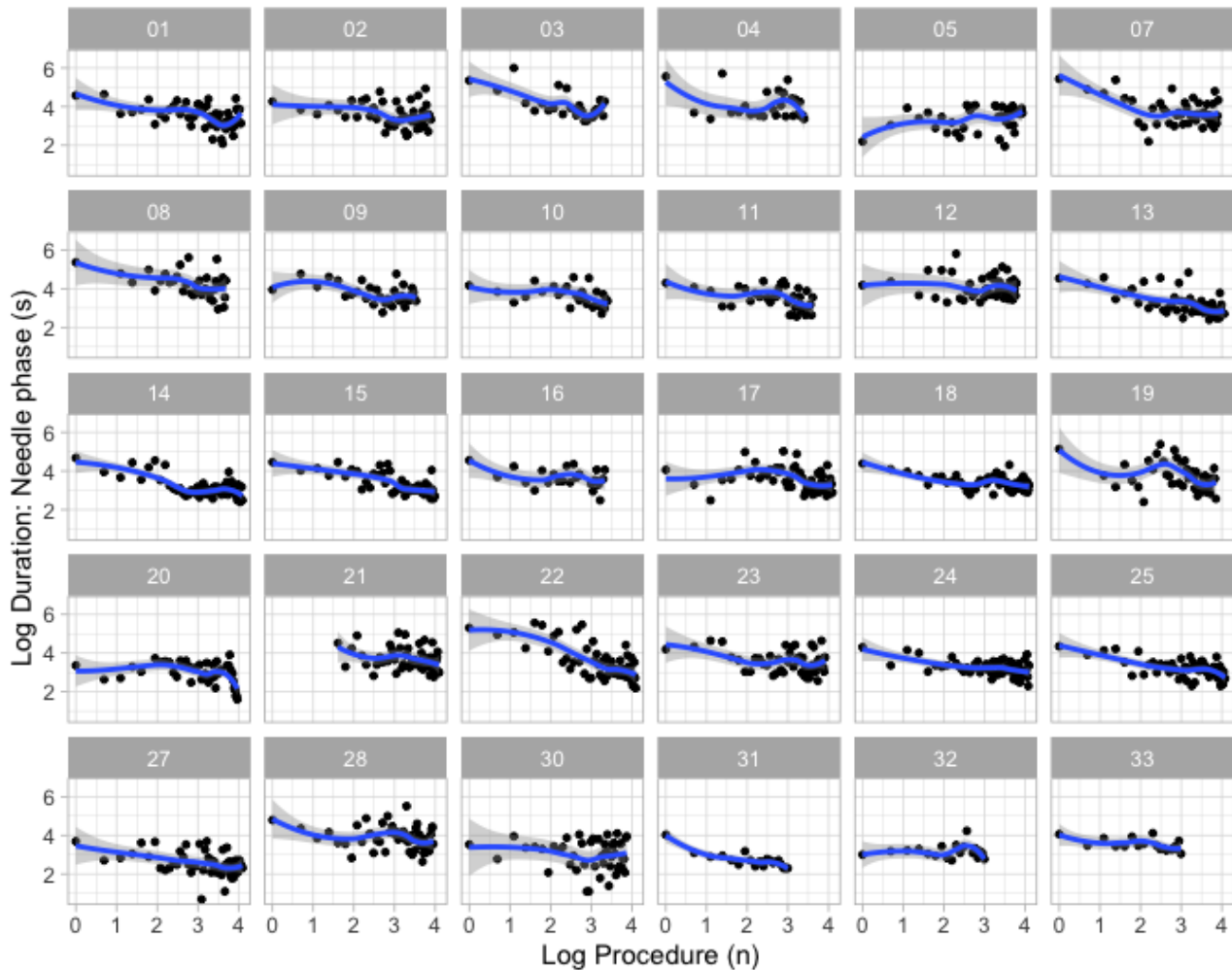
slope in 1 participant. During the needling phase, improvements approximated the slope of learning in 12 participants, improved in 6, and worsened in 11. One participant exhibited a complex pattern. Of the participants, 60% (18/30) showed similar patterns in the scanning and needling phases.

In Table 2, columns show participant characteristics and linear and LOESS best-fits. Linear model characteristics include intercept on y axis, and slope and described using adjusted R^2 . LOESS fit is described using arrows: → indicates good

approximate fit to slope, ↓ indicates LOESS line persistently below the slope and accelerated learning, and ↑ indicates LOESS line persistently above the slope and slowed learning.

Combinations of ↑, ↓, and → give an overview of learning dynamics.

Figure 2. Best-fit Locally Weighted Scatterplot Smoother learning slopes demonstrated on log-log transformed (power) model from participants 1 to 33 during needling phase of simulated interscalene block. Participants 6, 26, and 29 were excluded. Log time (duration) taken to complete all steps on y-axis, and log sequence of blocks (1 to 4) the x-axis. The blue straight line is the best-fit line through the data. The 95% CIs about the slope are shown in light gray.



Association Between Scanning and Needling Phases

The correlations between the intercept, slope, variation of the slope, and asymptote in the scanning and needling phases are shown in Table 3. The greater the initial time taken (intercept) to perform the interscalene block, the greater the rate of learning

in the scanning and needling phases $\rho=-0.87$ (-0.94 to -0.73), $P<.001$, and $\rho=-0.45$ (-0.70 to -0.09), $P=.01$.

The learning slopes of the scanning and needling phases correlated; $\rho=0.55$ (0.23 - 0.76), $P<.001$; and $\rho=-0.72$ (-0.46 to -0.87), $P<.001$, respectively.

Table 3. Correlation (ρ) between markers of learning in scanning and needling phases. Markers include the learning slope, the best-fit linear line through log-log data; the variability of the slope represented by the SE; and the asymptote, the mean of the last 5 times taken to complete the procedure.

	Scanning			Line asymptote	Needling		
	Line intercept	Slope	SE		Line intercept	Slope	SE
Scanning							
Slope (95% CI); <i>P</i> value	-0.87 (-0.94 to -0.73); <.001	N/A ^a	N/A	N/A	N/A	N/A	N/A
SE (95% CI); <i>P</i> value	-0.24 (-0.56 to 0.14); .20	0.38 (0.01 to 0.66); .04	N/A	N/A	N/A	N/A	N/A
Line asymptote (95% CI); <i>P</i> value	0.23 (0.15 to 0.56); .21	0.19 (0.18 to 0.53); .29	0.20 (-0.19 to -0.53); .30	N/A	N/A	N/A	N/A
Needling							
Line intercept (95% CI); <i>P</i> value	0.48 (0.14 to 0.72); .007	-0.44 (0.70 to -0.9); .01	-0.27 (0.58 to 0.11); .15	0.10 (-0.28 to 0.46); .59	N/A	N/A	N/A
Slope (95% CI); <i>P</i> value	-0.45 (-0.70 to -0.09); .01	0.55 (0.23 to 0.76); .001	0.17 (-0.21 to 0.51); .37	0.10 (-0.28 to 0.45); .61	-0.71 (-0.86 to -0.46); <.001	N/A	N/A
SE (95% CI); <i>P</i> value	0.01 (-0.36 to 0.38); .96	0.24 (0.14 to 0.56); .20	0.30 (-0.08 to 0.60); .11	0.57 (0.26 to 0.78); <.001	0.32 (-0.06 to 0.61); .09	0.10 (-0.28 to 0.45); .60	N/A
Line asymptote (95% CI); <i>P</i> value	0.26 (-0.12 to 0.57); .16	0.03 (0.34 to 0.39); .87	-0.12 (-0.47 to 0.26); .54	0.60 (0.29 to 0.79); .001	0.39 (-0.002 to 0.65); .04	0.54 (-0.24 to 0.49); .46	0.54 (0.21 to 0.76); .002

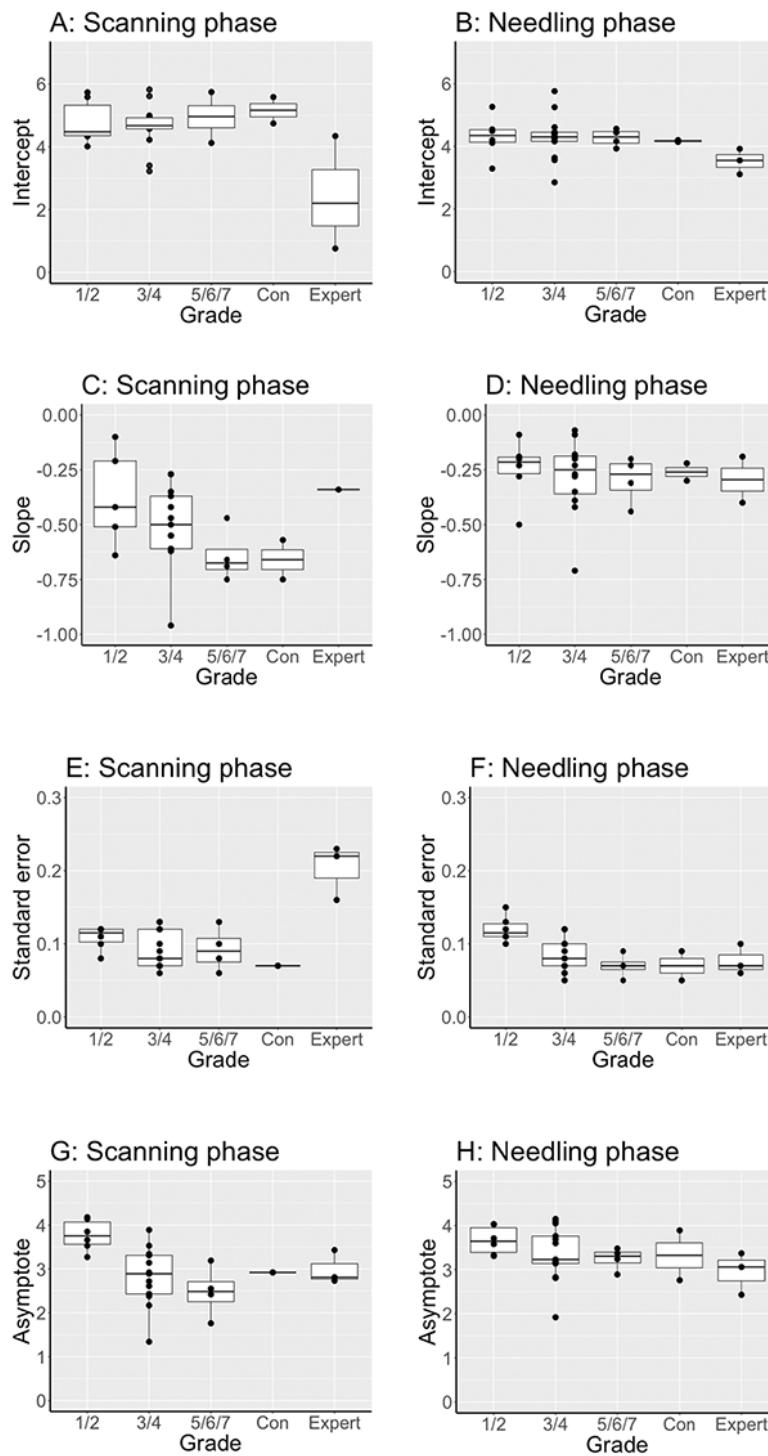
^aN/A: not applicable.

Effect of Grade of Anesthesiologist on Scanning and Needling

The relationship between anesthesiology grade and learning is shown in [Figure 3](#).

The experts had a flatter slope but greater variability during scanning but less variability during needling (all comparisons $P=.02$).

Figure 3. Grade. Experts had a flatter slope but greater variability during scanning, but less variability during needling (all comparisons $P=.02$). Novice anesthesiology trainees correspond to years 1 to 2 (1/2); intermediate anesthesiology trainees to years 3 to 4 (3/4); and higher anesthesiology trainees to years 5 to 7 (5/6/7). Consultant non-expert anesthesiologists designated as “Con”.

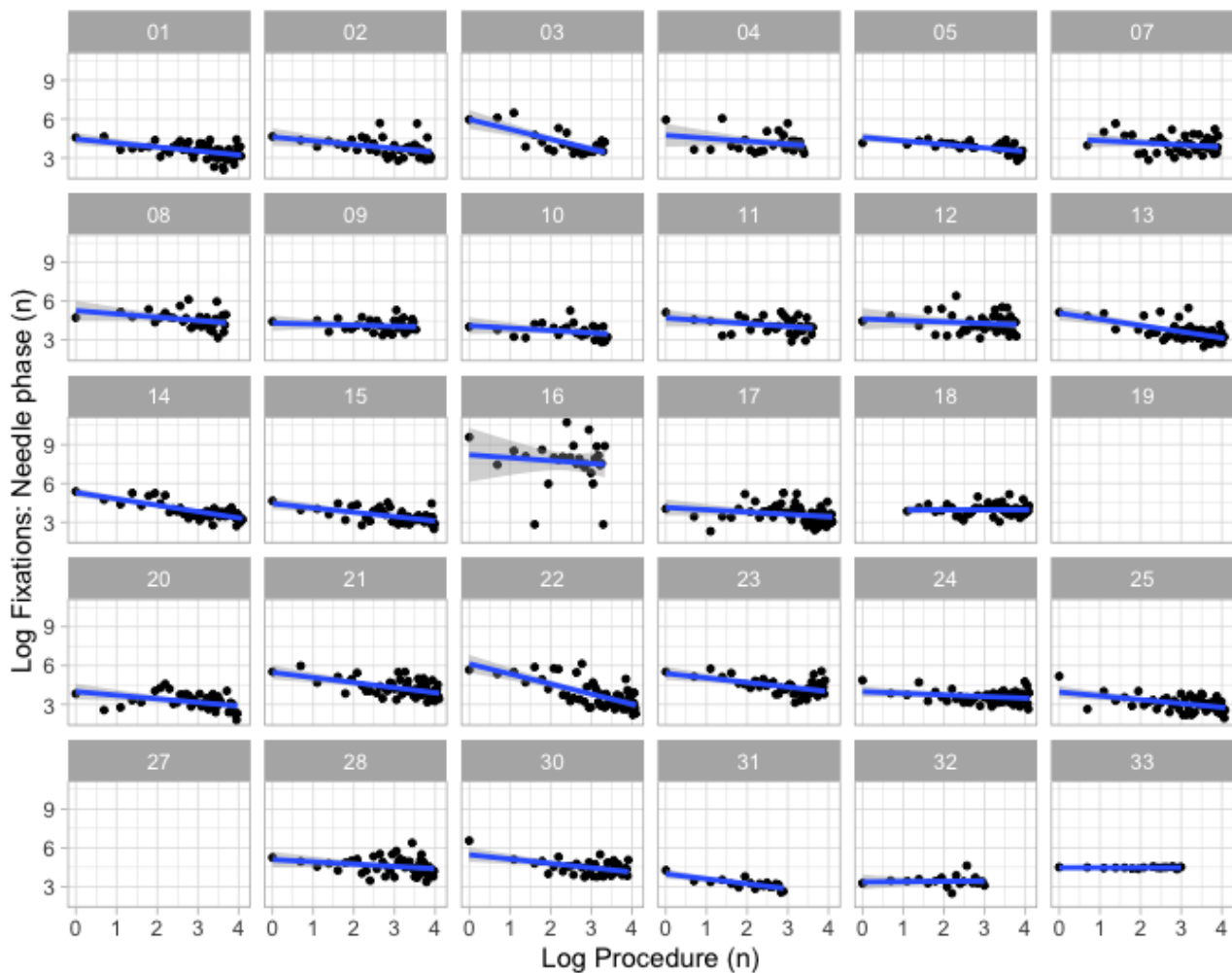


Secondary End Points

Linear slopes and LOESS best-fit lines were generated for our secondary endpoints (fixation count, relative fixation to the

monitor [%], glance count and relative dwell time [%], self-confidence, and anxiety scores). An example of using the best-fit linear slopes of eye fixation counts in the search phase is shown in [Figure 4](#).

Figure 4. Eye gaze fixation count. Best-fit linear learning slopes demonstrated on log-log transformed (power) model from participants 1 to 33 during search phase of simulated interscalene block. Participants 6, 26, and 29 were excluded. Fixation count on y-axis, and log sequence of blocks (1 to 4) the x-axis. The blue straight line is the best-fit line through the data. The 95% CI about the slope are shown in light gray.

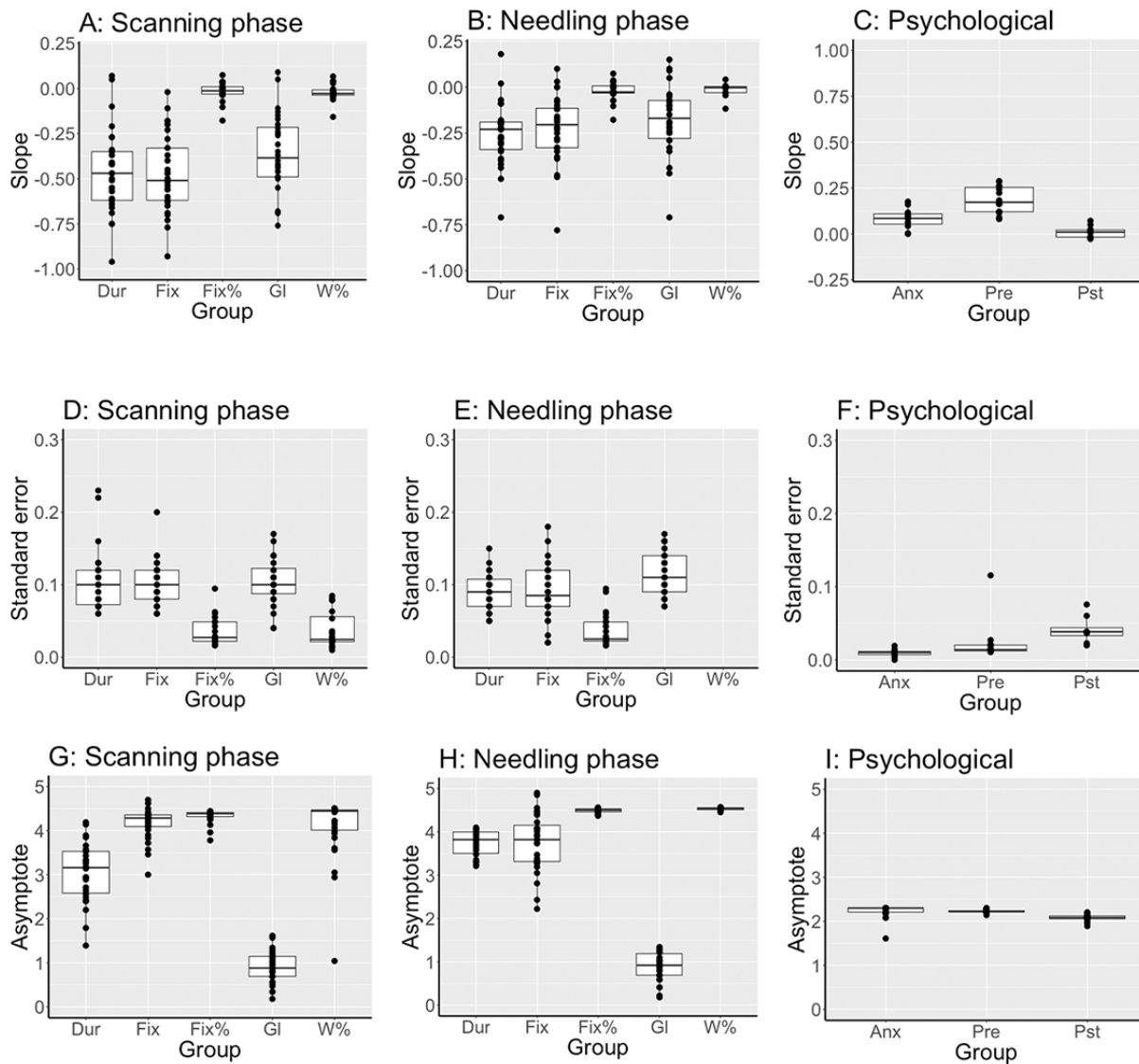


Data Distribution

The distribution of slope estimate, slope SE, and asymptote data (indicated by median (IQR; range) are shown for the primary endpoint (duration) and secondary endpoints (Figure 5). Eye gaze fixation count and glance count during the scanning and needling phases best reflected the median (IQR) block duration.

In contrast, relative fixation on the monitor (%), relative dwell time (%), self-confidence, and anxiety scores showed little variation. The wide distribution of fixation count and glance count reflected the wide distribution of time to complete scanning and needling. Therefore, block duration, fixation count, and glance count were chosen as quantitative markers for performance discrimination.

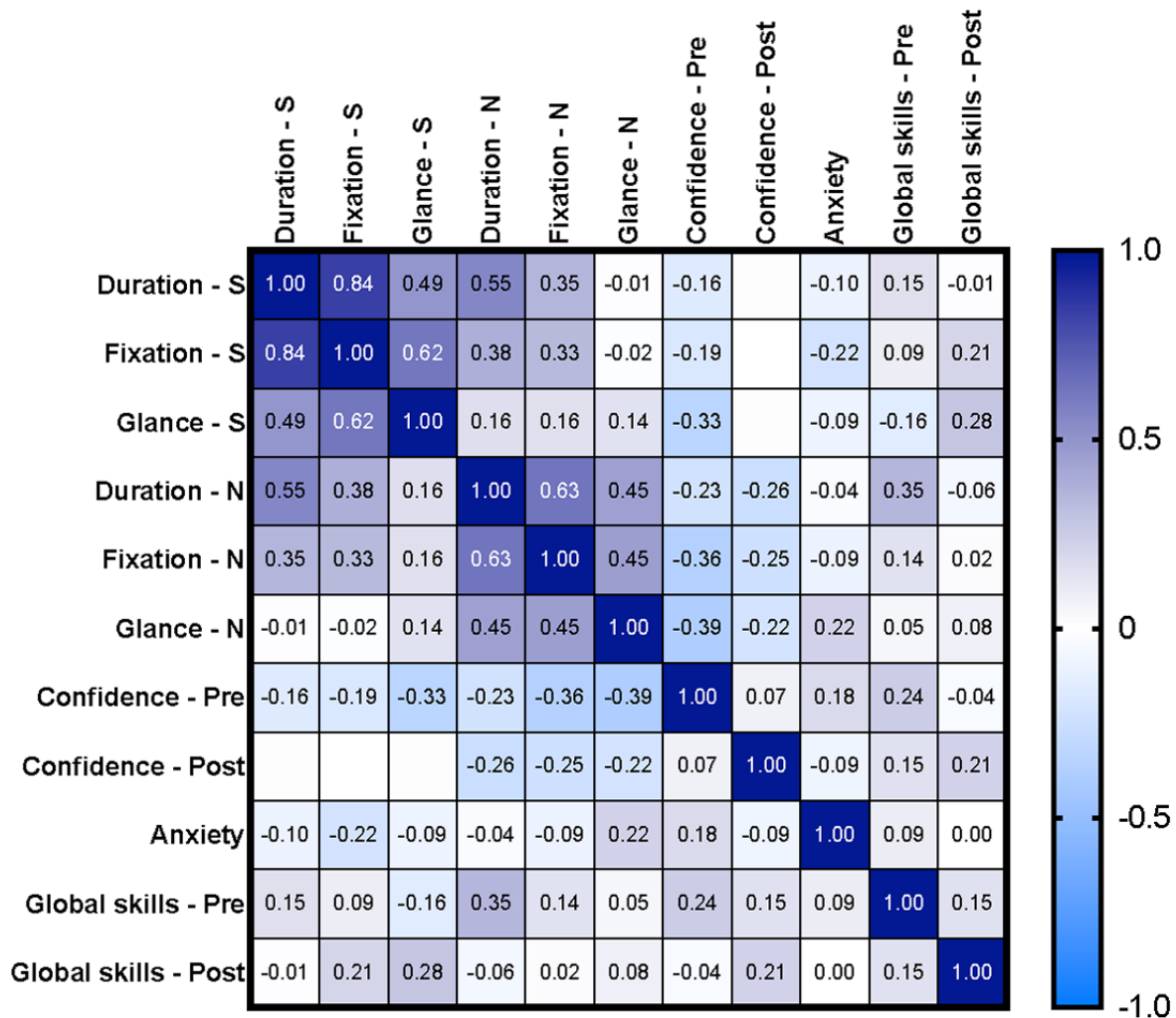
Figure 5. Slope estimate, slope standard error and asymptote of the primary end point, duration (Dur) and secondary end-points, median (IQR [range]). Secondary end-points include: eye gaze fixation count (Fix), relative fixation to the monitor (Fix%), glance count (G), and relative dwell time (W%) during the scanning and needling phases; and pre block anxiety (Anx) and self-confidence (Pre) and post block self-confidence (Pst). Large variation in effect with duration, fixation and glance count but not psychological variables.



Correlation Between End Points

Learning slopes (duration) correlated with eye fixation and glance slopes in both the scanning and needling phases (Figure 6) but not with confidence, anxiety, or global skills scores.

Figure 6. Correlation (ranging from -1 to +1) between procedural duration, fixation count, and glance count in the scanning (S) and needling (N) phases; mean pre- and postprocedural confidence; procedural anxiety; and initial and final proficiency. The scale indicated on the right is color mapped in shades of purple from 0 to +1 and shades of blue from 0 to -1. The largest correlations existed among procedural duration, fixation, and glance count in both the scanning and needling phases.



Clustering

A cluster analysis of preprocedural and procedural fixation and glance counts (Figure 7) identified 4 distinct performance groups within both the search and needling phases.

Groups were ranked according to performance (from best to worst) as A, B, C, and D in the scanning phase (Figure 8) and a, b, c, and d in the needling phase (Figure 9). Figure 9 outlines the characteristics (intercept, slope, error, and asymptote) of the learning slopes for the duration, eye fixations, and eye glances during the scanning phase. Distinct performance trends are observed for the best to worst performance. For example, better performance was associated with reductions in the asymptote of procedure duration (image J; $\chi^2_3=17.0$; $P<.001$); the intercept

(image B; $\chi^2_3=9.5$; $P=.02$) and asymptote (image K; $\chi^2_3=21.2$; $P<.001$) of eye gaze fixations; and the learning slope of eye glances (image F; $\chi^2_3=9.3$; $P=.03$).

Figure 9 outlines the characteristics (intercept, slope, error, and asymptote) of the learning slopes for duration, eye fixations, and eye glances during the needling phase according to groups defined by cluster analysis. The same trends in performance for the best to worst performance were observed using the intercepts and asymptotes as in the scanning phase. For example, better performance was associated with reductions in the SE (image H; $\chi^2_3=9.6$; $P=.02$), asymptote of procedure duration (image K; $\chi^2_3=14.4$; $P=.002$), intercept (image B; $\chi^2_3=12.8$; $P=.005$), and asymptote of eye gaze fixations (image L; $\chi^2_3=7.9$; $P=.04$).

Figure 7. Dendrograms created by cluster analysis of preprocedural and procedural fixation and glance counts. Search phase (groups A, B, C, D) and needle phase (groups a, b, c, d).

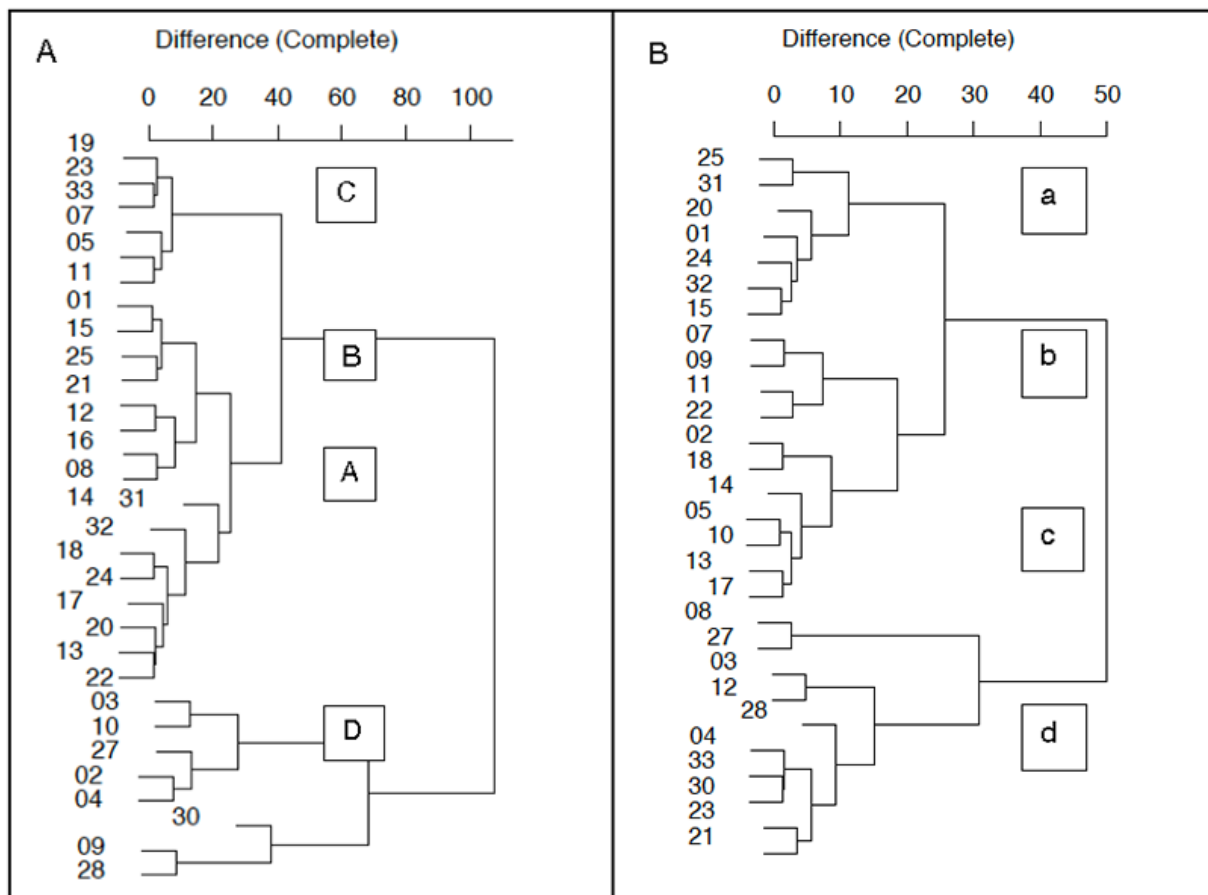


Figure 8. Characteristics of scanning phase learning slopes (procedure duration, eye fixation and glance) according to groups defined by cluster analysis. Characteristics include intercept, slope standard error and asymptote. Better performance was associated with reductions in: the asymptote of procedure duration (image J), (χ^2 17.0, $P < .001$); the intercept (image B), (χ^2 9.5, $P = .02$) and asymptote (image K), (χ^2 21.2, $P < .001$) of eye gaze fixations; and the learning slope of eye glances (image F), (χ^2 9.3, $P = .03$).

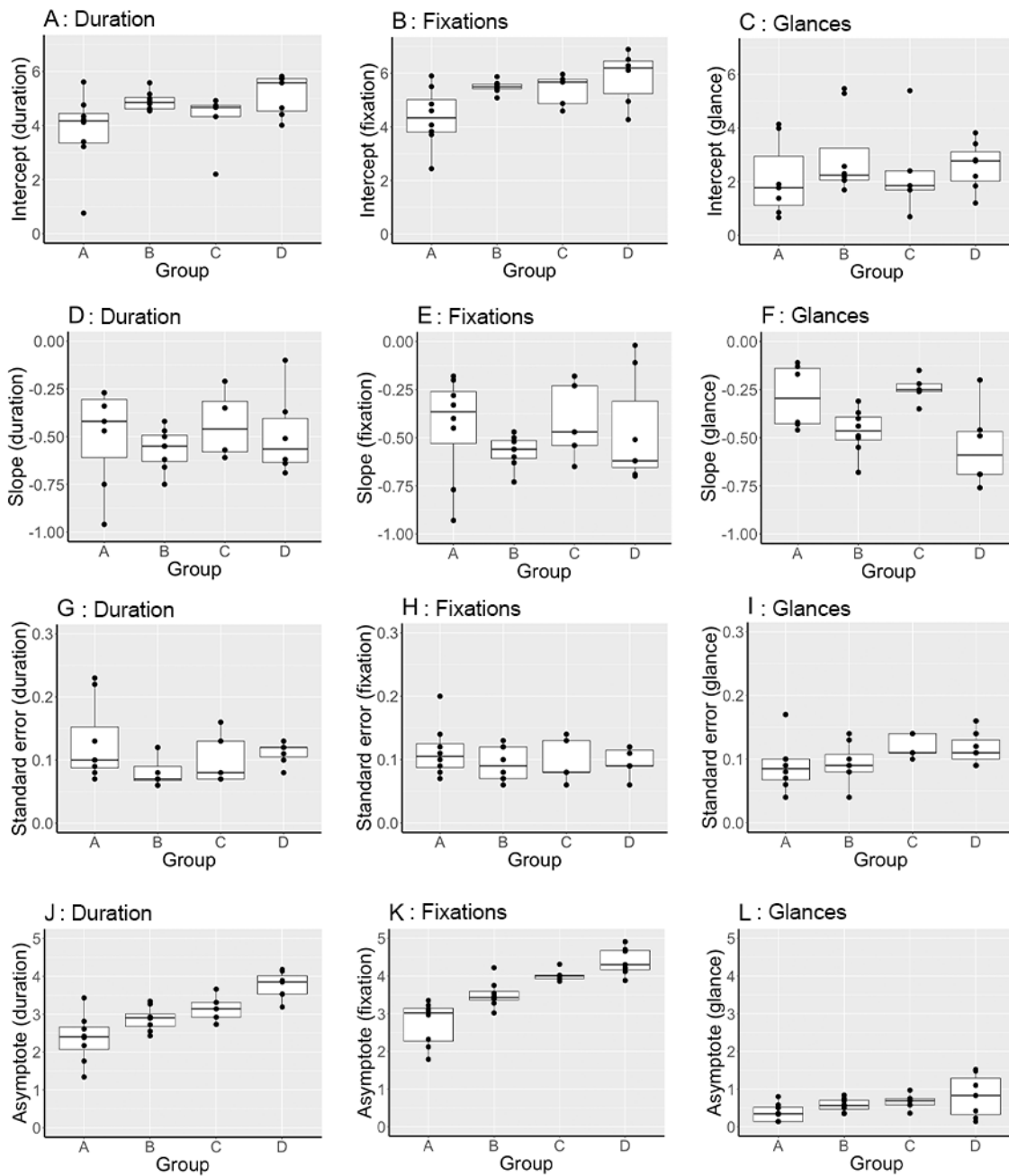
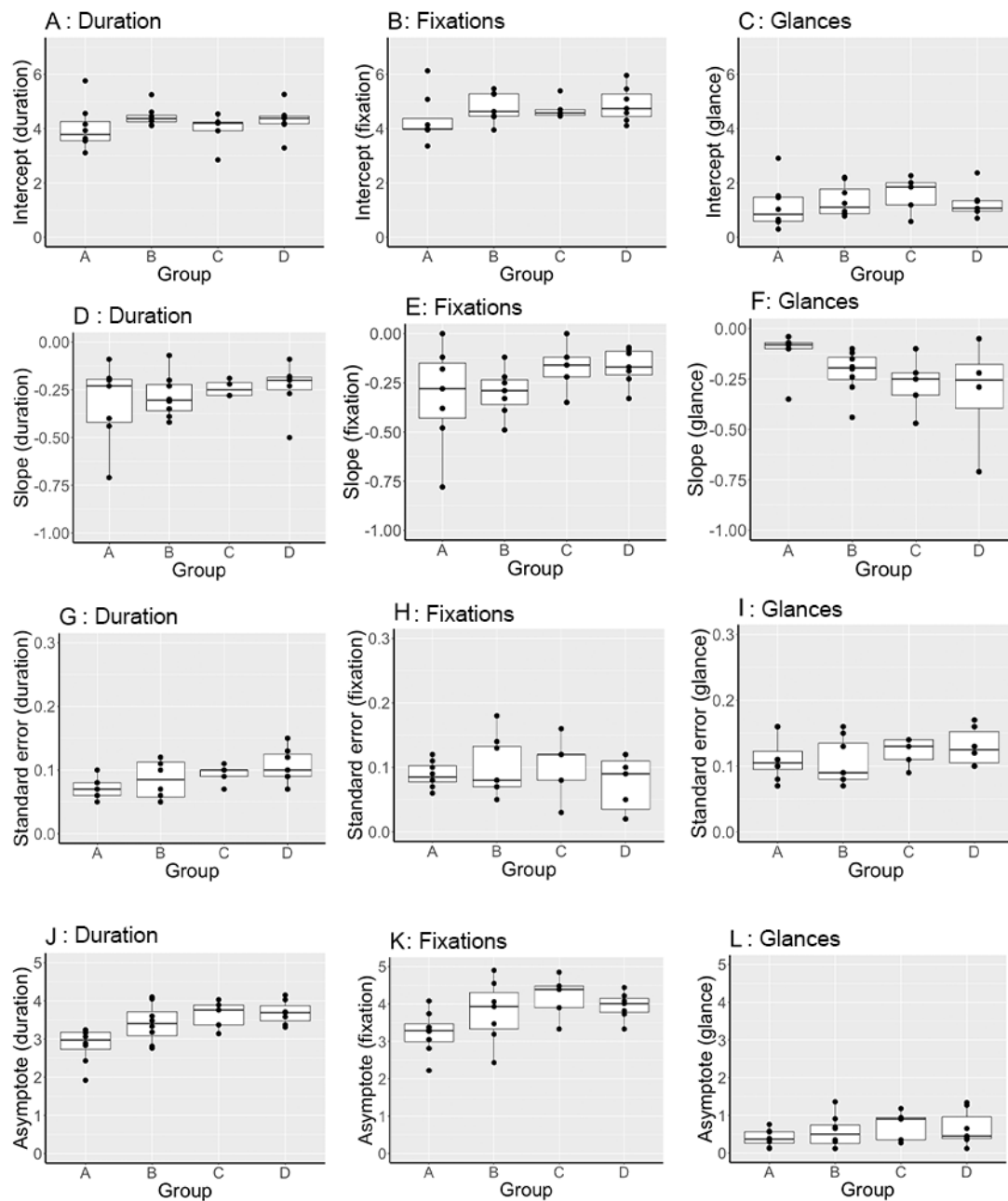


Figure 9. Characteristics (intercept, slope, error and asymptote) of the learning slopes for duration, eye fixations and eye glances during the needling phase, according to groups defined by cluster analysis. Better performance was associated with reductions in: the standard error (image H) (χ^2 9.6, P .02); and asymptote of procedure duration (image K) (χ^2 14.4, P =.002); and the intercept (image B) (χ^2 12.8, P =.005) and asymptote of eye gaze fixations (image L) (χ^2 7.9, P =.04).



Discussion

Principal Findings

We characterized the individual learning slopes of 30 anesthesiologists performing simulated interscalene blocks using log-log transformations of procedure-time data. The dynamic nature of learning was captured by LOESS best-fit lines. Needling performance paralleled scanning performance. Expert anesthesiologists were characterized by consistent and stable performance, whereas novice anesthesiologists took longer, and their performance varied. We identified 4 disparate skill groups for scanning and needling. The discrimination of performance

using eye gaze fixation count and glance count reflected the discrimination of performance using procedural time.

Strengths and Weaknesses

The strengths of our study were its educational and statistical approaches, application of quantitative metrics, and the use of a validated high-fidelity simulator.

Educational Approach

First, we applied mastery learning and dedicated practice as part of the expert performance approach to each preprocedural and procedural step, rather than the nerve block as a whole. Mastery learning is increasingly used in medical schools for skills training [22], and a recent review has recommended the

introduction of deliberate practice into anesthesia teaching [23]. Unlike traditional assessment approaches that set a threshold for pass or fail over a set time, mastery learning endeavors to achieve a predefined skill level for all participants, irrespective of time [24]. Thus, in our study, all blocks were conducted successfully, irrespective of training duration. In this way, the measurement of duration was regarded as a marker of block quality because all items were completed. However, a weakness of our approach is that we failed to measure the number of errors made. Only one study that investigated UGRA training measured tasks and errors [25]. In future work, we intend to test trainees using video analysis of errors, including those that may cause harm to the patient.

Statistical Approach

Second, we demonstrated that skill acquisition follows the power law of learning [26]. Although log-log conversion enabled a linear fit through all data sets, intraparticipant variability still occurred over time. Individual dynamics were most apparent using LOESS curves in both the scanning and needling phases and revealed a number of different learning patterns. Owing to the complexity of these patterns, we intend to analyze data sets in the future using nonlinear mixed-effects models, Bayesian methods, and machine learning [27,28]. Advanced modeling will enable us to better fit individual learning curves and capture both within- and between-participant variability in initial performance and any deterioration in performance due to fatigue.

Cluster analysis enabled us to discriminate performance irrespective of the grade (specialist trainee [ST]) and year of training. We identified 6 participants (participant numbers 13 [ST6], 17 [ST3], 18 [ST4], 20 [ST4], 22 [ST4], and 24 [ST6]) who matched expert scanning performance and 5 participants (participant numbers 1 [ST6], 15 [ST3], 20 [ST4], 24 [ST6], and 25 [consultants]) who matched expert needling performance. These best learners consistently improved, as indicated by the negative learning slope, even when starting from a low base. By contrast, the worst performers started out slowly and showed little improvement. They were characterized by high asymptotes and high data variability. The remaining trainees performed irregularly across trials, sometimes improving and sometimes worsening from trial to trial, indicated by rises and falls in the learning slope and the wide spread of data. Not all learners improved over the course of the teaching, and learning failed to stabilize during the asymptote (last 5 trials), even when repetitively performing tasks at the same site on the same cadaver.

Unlike Dreyfus and Dreyfus [29], we identified 4 rather than 5 disparate groups for both scanning and needling phases using cluster analysis techniques. No previous anesthesia studies have attempted to measure and categorize skills using the Dreyfus criteria. Therefore, our results provide a unique insight into the range of interscalene block skills from novice to expert and broadly reflect the descriptors defined by Dreyfus and Dreyfus [29].

Nevertheless, it must be borne in mind that we only defined the range of skills for a single interscalene block. We hypothesize that when faced with a new cadaver, new patient, or new block,

even more learning will be required, and fewer participants will be likely to plateau or match the performance of experts.

We recommend that skills training be built in a series of isolated steps so that performance can be measured while new skills are being acquired. We do not take the view that one course of mastery learning is sufficient, but that ongoing training and assessment are required to ascend the skills ladder proposed by Dreyfus and Dreyfus [29] and reduce the effects of skill drain. In future work, we intend to measure the rate of skill loss after training as a means of timing the need for retraining on the simulator.

Metrics

Third, we demonstrated a strong construct validity with respect to attentional focus. Most studies have demonstrated construct validity by comparing novices or even nonanesthesiologists to experts. In contrast, using a heterogeneous group of anesthesiologists, our study showed an improvement in attentional focus over several groups in the following order: experts>fellow>higher trainees>intermediate trainees>novice trainees (Figure 3). Experts focused intently on the monitor, had fewer fixations, shorter overall dwell time (less time spent attending to the screen or tool area), and fewer switches in attention between the target and tools compared with novices. This may indicate novice difficulty in handling tools (probe or needle) or greater cognitive processing. Some trainees were recruited after finishing the night on call and may have been tired. We admit that the failure to standardize trainee wakefulness left us with some background statistical *noise*. Nevertheless, we feel that this study at least represented everyday practice, and we were readily able to expose the variability and discriminatory properties of eye tracking metrics.

Simulator

Fourth, our study was made possible using our durable cadaver simulator. Unlike fresh frozen cadavers, the soft embalmed cadaver tolerated 934 injections over 2 weeks [16]. The fluid quickly drained away from the interscalene groove and provided good conditions for repetitive practice. Needle tracks were not seen, and external pressure marks resolved because the cadaver retained its elasticity. Images demonstrating this phenomenon are available in our previous publication [17]. Cadaver hire is not inexpensive, costing £250 (US \$300) per half-day of training, although it is possible for 2 training groups to be accommodated at either end of the cadaver. Our group has already successfully executed 4 courses to enhance proficiency by using mastery methods.

We chose to restrict the number of cadavers used. We expected large intraparticipant variance as performance improved with repetition (learning curve), and we foresaw large interparticipant variance because we were examining the widest possible range of skills between anesthesiologists. Therefore, the use of several cadavers would have introduced even more variance and necessitated a large study.

However, we do appreciate that the restriction of cadavers does not reflect the variation seen in clinical practice, and we would urge some caution when extrapolating data. We intend to conduct an RCT that also exposes participants to multiple

cadavers and study transference by allocating them to multiple nerve blocks.

Of interest to teachers is how many blocks does it take to attain the expertise of experts? To calculate this, one may assume a relationship between time (T) and the number of blocks (N) as a negative power learning curve in the form: $T = b * N^a$ or $N = b / T^a$.

From our data, assuming $b=60$ and $a=0.005$ derived from fitting curves to our data, expertise equivalent to our fellow is gained after 189 blocks and needs 284 or 550 blocks to resemble the performance of experts 2 and 1, respectively. Increasing b to 70 or 80 increases the requirement to 351 and 377, respectively, to match consultant 2.

Comparison With Prior Work

Our findings are consistent with the expert behavior observed in laparoscopy, radiology, and chess playing [9], and this is thought to be underpinned by the gradual build-up of memories of visual structures. We hypothesized that dedicated practice in a cadaver-based mastery learning environment provides an opportunity to repeatedly encode these visual memories. The best novices were more experienced and approached the performance of the regional fellow but not expert consultants. We suggest that experienced novices probably developed transferable skills from the general experience of ultrasonography, for example, during central line insertion.

Trainees characteristically tend to be *overloaded* with information psychomotor performance, spatial judgments, monitoring data, instruction, and intraoperative events [30,31]. Limited cognitive resources are available to enable decisive and correct decision-making. Thus, the automation of technical skills through mastery learning and feedback enables trainees to cope with the challenges of regional anesthesia by minimizing cognitive overload.

Two studies used eye tracking in UGRA and demonstrated, as in our study, greater attentional focus on targets during simulated tasks with experts than trainees [4,32]. Surgical disciplines have made progress in the application of attentional theory and practice to medical training. In laparoscopy training, experts achieved faster task completion in simulator training, greater attentional focus to the target, and fewer switches between the target and tools [33,34]. What is missing from the literature is the study of incremental steps toward competency and intermediate expertise.

Future Directions

Our results suggest that eye tracking can be regarded as a means of formative feedback (via visual feedback on gaze behavior) and assessment within the context of a mastery learning program. It provides a deeper understanding of why trainees learn at different rates based on their attentional patterns and allows reflection on performance. We suggest that an objective assessment of performance using eye movements can complement traditional methods by reducing assessment variability between trainers. Ultimately, this method could be adapted from face-to-face learning to remote web-based education.

Real-time eye tracking metrics are not yet available because the data must be analyzed by a statistician. With this in mind, our team is developing algorithms that would allow the translation of measurements to clinical environments and correlate eye tracking with motion analysis.

Conclusions

Our collaborative, translational approach to measuring technical skills performance fits well with recommendations within the recent Topol Report on Digital Medicine [35]. We have shown substantial improvements in skill acquisition and present data that demonstrate how technology can be used to quantify complex human performance.

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Authors' Contributions

G McLeod designed and managed the study and wrote the paper. MM obtained funding, designed and managed the study, and wrote the paper. G McKendrick provided engineering support. TT and DK provided psychology support. AM, PR, and RN were involved with anesthesia supervision. TM collated eye tracking data. All authors read and approved the final manuscript.

Conflicts of Interest

MM is the chief executive officer of Optomize.

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Abbreviations

CAHID: Centre for Anatomy and Human Identification

IPIP: International Personality Item Pool

LOESS: Locally Weighted Scatterplot Smoother

ST: specialist trainee

UGRA: ultrasound-guided regional anesthesia

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Original Paper

Assessment as Learning in Medical Education: Feasibility and Perceived Impact of Student-Generated Formative Assessments

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Abstract

Background: Self-regulated learning (SRL) is gaining widespread recognition as a vital competency that is desirable to sustain lifelong learning, especially relevant to health professions education. Contemporary educational practices emphasize this aspect of undergraduate medical education through innovative designs of teaching and learning, such as the flipped classroom and team-based learning. Assessment practices are less commonly deployed to build capacity for SRL. Assessment *as* learning (AaL) can be a unique way of inculcating SRL by enabling active learning habits. It charges students to create formative assessments, reinforcing student-centered in-depth learning and critical thinking.

Objective: This study aimed to explore, from the learners' perspectives, the feasibility and perceived learning impact of student-generated formative assessments.

Methods: This study relied on a convergent mixed methods approach. An educational intervention was deployed on a cohort of 54 students in the second year of a 6-year undergraduate medical program as part of a single-course curriculum. The AaL intervention engaged students in generating assessments using peer collaboration, tutor facilitation, and feedback. The outcomes of the intervention were measured through quantitative and qualitative data on student perceptions, which were collected through an anonymized web-based survey and in-person focus groups, respectively. Quantitative survey data were analyzed using SPSS (IBM), and qualitative inputs underwent thematic analysis.

Results: The students' overall score of agreement with the AaL educational intervention was 84%, which was strongly correlated with scores for ease and impact on a 5-point Likert-type scale. The themes that emerged from the qualitative analysis included prominent characteristics, immediate gains, and expected long-term benefits of engagement. The prominent characteristics included individuals' engagement, effective interdependencies, novelty, and time requirements. The identified immediate gains highlighted increased motivation and acquisition of knowledge and skills. The expected long-term benefits included critical thinking, problem solving, and clinical reasoning.

Conclusions: As a form of AaL, student-generated assessments were perceived as viable, constructive, and stimulating educational exercises by the student authors. In the short term, the activity provided students with a fun and challenging opportunity to dive deeply into the content, be creative in designing questions, and improve exam-taking skills. In the long term, students expected an enhancement of critical thinking and the inculcation of student-centered attributes of self-regulated lifelong learning and peer collaboration, which are vital to the practice of medicine.

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KEYWORDS

self-regulated learning; assessment as learning; student-generated assessments; lifelong learning; medical education

Introduction

Background

Self-regulated learning (SRL) is a desirable student attribute that inculcates the habit of lifelong learning and is invaluable to budding health professionals [1]. SRL encourages adult learners to plan, implement, and evaluate their learning needs and outcomes. It works best as a supplement to traditional learning, with the adult learner increasingly taking charge of his own learning rather than passively receiving it. SRL has cognitive, metacognitive, behavioral, motivational, and emotional, or affective aspects that crosslink to make the end result either effective or not [2]. Most SRL models emphasize the development of this attribute in adult learners through preparatory, performance, and appraisal phases. In practice, SRL models can be stratified to become stage appropriate for the target student population, which, in turn, determines learning strategy and success [2].

Traditional theories and models of adult learning include instrumental learning theories, humanistic theories, transformative learning theories, social theories of learning, and motivational and reflective models [3]. In a review of their application to medical education, an Association for Medical Education in Europe guide proposes that student learners take charge of their learning through successive phases of dissonance, refinement, organization, and feedback, anchored by a learner-tutor nexus, wherein both roles are clearly defined for each phase [3]. Several teaching and learning activities can encourage the development of this quality. Flipped learning classrooms, simulation-based sessions with student-centered activities, and team-based learning are some teaching-learning formats used in preclinical medical education. In clerkship years, the learning context (eg, emergency room, inpatient bedside, or community practice) determines adult learners' increasing reliance on SRL. These adapted formats promote higher-level cognition, as determined by the Bloom taxonomy (ie, application, analysis, evaluation, and synthesis of knowledge) expected of medical graduates, and are perceived by students as beneficial to learning [4].

Relatively little attention has been paid to developing active learning in undergraduate medical education by adopting learning techniques centered on assessment [5]. Feedback on formative and summative assessments aims to bridge identified learning gaps but remains a passive process, and its success depends on student follow-through. The best practice in assessment recommends that beyond the assessment *of* learning (AoL), which is summative and determines the achievement of outcomes, assessment *for* learning (AfL) through formative feedback and assessment *as* learning (AaL), which is learner-centric, are vital to enable cognitive and skill reinforcement [6]. In a critical review of the literature on learner-oriented assessment (LOA), Zeng et al [7] discussed the evolution of the Terrace-Kink traditional assessment pyramid from the traditional AoL at the bottom, followed by AfL and

AaL at the tip of the pyramid. In this original version, AaL is at a higher level of achievement but assumes a minimal role. A rebalance of the original model shifts AaL to the base of the pyramid, thus making it foundational to and an enabler of learning, transferring AoL to the pinnacle as a definitive metric for achieving learning outcomes [7]. The authors proposed an adapted holistic framework for LOA by placing AaL, AfL, and AoL side by side with tutors and students partnering to achieve learning outcomes through innovative assessment practices. This composite framework could serve the overlapping purposes of learning, development, and certification.

The AaL framework places the contextual domain at the center of the AaL wheel for teaching and learning, supported by the societal, communication, and action domains [8]. It advocates the development of self-regulatory strategies by promoting cognition (ie, learning) and metacognition (ie, learning to learn). AaL works through student involvement in creating assessments, feed-forward on assessment results, and producing high-quality assessment tasks [9]. Student-generated assessments aim to encourage deep reading and demonstration of improved learning by creating questions that test higher-order thinking, thereby challenging students' integration of disciplinary knowledge. Students can benefit from improved examination preparedness and performance by expanding the pool of formative questions [10]. Constructive curricular alignment, which involves the use of teaching designs that transparently demonstrate learning outcomes to both the faculty and the student aligned to appropriate assessment methods, can be enhanced through student-generated assessments [11]. This exercise can have other benefits, including collaborative work through peer engagement and receiving constructive criticism [12]. Although the intention to enhance student engagement and reinforce learning abilities and styles through assessment is desirable, it is also essential to hear the student's voice by exploring their perceptions of such an educational intervention. Active student engagement and learner agency can only be ensured when they perceive the benefits of an educational intervention, both in immediate learning and in enhancing SRL [13].

Objectives

As such, this study aimed to explore, from the learners' perspective, the feasibility and perceived learning impact of student-generated formative assessments. Accordingly, the research questions of this study are as follows:

1. To what extent did the students agree that the experience of contributing to formative assessment was manageable (in terms of difficulty level) and impactful, and in what ways were the perceived ease and impact associated?
2. How do the students describe the experience of contributing to formative assessment?
3. What are the lessons learned from the firsthand experience of having students contribute to formative assessments?

Methods

Ethics Approval

The ethics approval for this study was granted by the Mohammed Bin Rashid University institutional review board (MBRU-IRB-2019-026). Informed consent was obtained from all the participants. All methods were performed in accordance with relevant guidelines and regulations. Consent for publication was not applicable as there are no individual details, images, or videos.

Research Design

This study relied on a convergent mixed methods research design [14], which is commonly used in health professions education research [15-17]. The strength of this multiphase research design lies in its potential to capture a holistic perspective of the subject matter. Instead of focusing on the generalizability of the generated results, the emphasis was on their transferability to other similar contexts. This research design is expected to generate sufficient in-depth insights [18,19]. For this purpose, a survey designed by the research team in consensus (for this study) was assembled to capture quantitative and qualitative data on undergraduate medical students' perceptions of their engagement in developing formative assessments. This unique educational intervention of student-centered assessment (ie, AaL) was implemented in a required 3-credit course entitled Pathologic Basis of Diseases. Quantitative and qualitative data were analyzed independently and then merged using a joint display analysis. As such, the integration of data is meant to raise the study's robustness and validity of the generated findings [20].

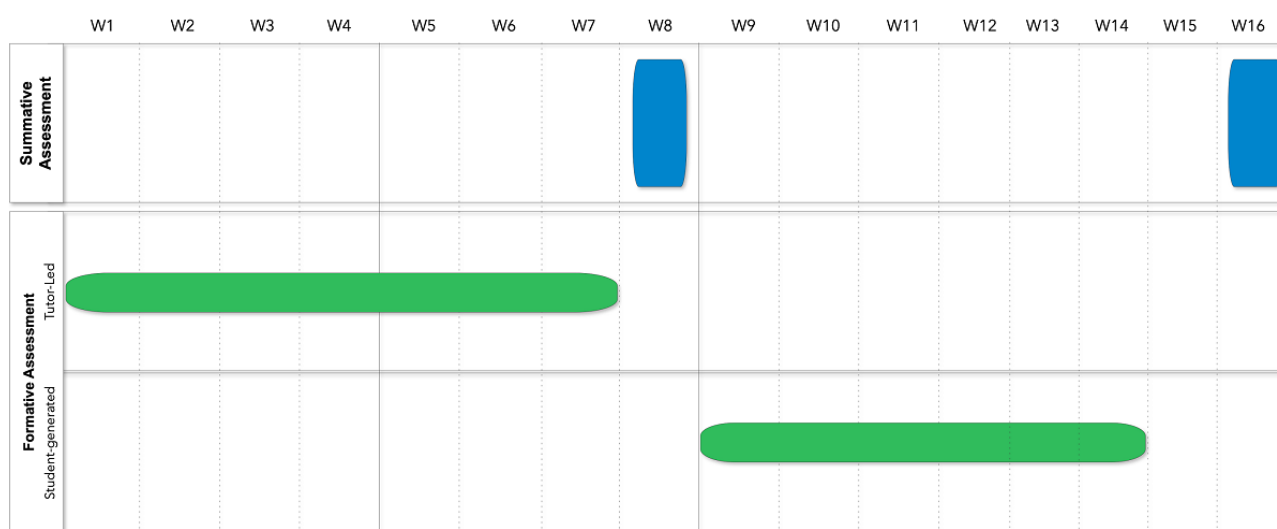
Educational Context of the Study and Participants

This study was undertaken at the Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai, United Arab Emirates, on a single cohort of students of a 6-year medical undergraduate program (MBBS) following a spiral curriculum and divided into 3 sequential phases: foundational basic sciences, preclinical sciences, and clerkship. Phase 1 takes place over the first academic year and introduces students to basic concepts in medicine, whereas phase 2 covers academic years 2 and 3, where teaching is organized around body organ systems and integrated with clinical medicine. Years 4 to 6 constitute phase 3. During the first 2 years of this phase, students undergo clinical placements or rotations, with the final academic year taking the form of an internship. The study cohort comprised 54 second-year students (academic year 2019-2020) beginning phase 2 of the undergraduate medical curriculum.

Description of the Intervention

The course under investigation was the medical students' introduction to pathology. During the first 6 weeks of the semester, the students were provided with weekly formative assessments generated by the pathology faculty teaching the course, followed by feedback sessions to reflect upon identified points of strengths and weaknesses. An in-course summative assessment (weighing 40%) was administered midsemester in week 8. The students generated formative assessments in a multiple-choice question (MCQ) format between weeks 9 and 14. The end-semester summative assessment (weighing 60%) was conducted in week 16 (Figure 1).

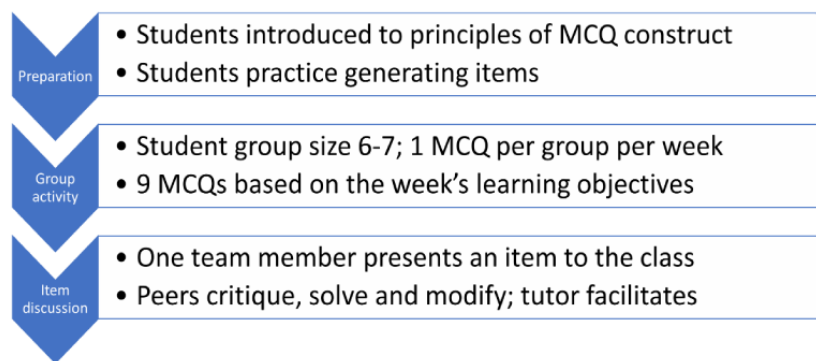
Figure 1. Study overview. Tutor-driven formative assessments in the first half of the semester were followed by a midsemester in-course summative assessment. The student-generated formative assessments in the second half of the semester were followed by the final summative assessment of the course. W: week.



Students were first guided in the principles of MCQ construction by a professor of pathology, who coordinated and taught the course and was also a chair of assessment in the college. A total of 9 groups comprising 6 students each created 1 MCQ per week on the ongoing week's learning outcomes and lesson objectives. The resultant 9 MCQs were discussed the following

week at the allotted time, supplemented by tutor-generated questions. One representative per group presented their MCQ and invited critical and constructive comments from peers. The professor tutor moderated the discussion and provided feedback on the constructs and content (Figure 2).

Figure 2. The educational intervention: assessment as learning. The educational intervention comprised weekly student-generated multiple-choice questions (MCQs) created through peer collaboration and supplemented by peer critique and review, tutor moderation, and feedback.



Data Collection

Data were collected using a survey designed specifically for this study (Textbox 1). The survey comprised 2 segments. The first segment was a 5-point Likert-type scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree) across 10 components, all of which were mandatory to respond to. Components 1 to 5 were meant to evaluate the ease of contributing to the development of formative assessments. Components 6 to 10 were designed to capture students'

perception of the impact of contributing to the development of formative assessments. It was mandatory to respond to all 10 components. The reason for which these 2 variables (ie, *ease* and *impact*) were pinpointed is that it is established (in alignment with the theories of behavioral change) that the students' perceptions of this educational intervention's barriers to its implementation (ie, *ease*) and benefits (ie, *impact*) significantly affect its effectiveness (in terms of maximizing learning) [21,22]. This link has been further reinforced in research on SRL [13].

Textbox 1. The components of the quantitative segment of the tool adapted for this study.

Ease of contributing to the development of formative assessments

1. The exercise was fairly simple (exercise fairly simple).
2. The exercise enabled me to become more competent at developing questions (competence in developing questions).
3. Effectively undergoing the exercise required that I get out of my comfort zone (out of my comfort zone).
4. I am willing to repeat this exercise for other courses (willingness to repeat the exercise in other courses).
5. Contributing to the creation of formative assessments adds value to the learning experience (adds value to learning).

Impact of contributing to the development of formative assessments

1. The exercise raised my capacity to understand the respective course material (capacity to understand course material).
2. Developing questions improved my knowledge of the subject matter (knowledge of subject matter).
3. The exercise developed my critical thinking (critical thinking).
4. The exercise raised my capacity to effectively answer relevant questions (capacity to answer relevant questions).
5. In and of themselves, the exercise and the generated in-class feedback and reflections on the created questions improved my capacity to associate the respective basic science concepts with their medical application (ie, clinical correlation skills).

The participants were given the option of qualitatively elaborating their responses to each of the 10 components. The second section of the survey entailed an open-ended question that was meant to solicit any additional reflective qualitative data using the following open-ended question: "Do you have any further remarks on your engagement with developing formative assessments? If so, please indicate them below:"

The survey was initially developed by the pathology faculty teaching the course and underwent face and content validity checks. The face validity test was conducted by a team of professionals, comprising the coordinator of the respective course, the chairperson of the College of Medicine Student

Assessment and Progression committee, an expert in medical education, and a staff member of the unit that handles the respective university's Quality Assurance and Institutional Effectiveness portfolio. They reviewed the tool to assess the clarity, comprehensibility, and readability of the questions and the flow through which they were presented. Subsequently, content validity was assessed by randomly selecting 5 students from the preceding cohort of the same program. They were invited to a classroom where they were asked to write down their interpretation of each of the components within the first segment, as well as the questions in the second segment of the survey. These responses were reviewed by the abovementioned

team. A consensus was reached that other than minor language changes, the survey was ready to be administered.

Participation in this data collection initiative was voluntary. The students' privacy and data confidentiality were protected, and no personal identifiers were recorded. The survey was assembled on the web throughout May 2020 using Microsoft Forms. Each study participant was serially assigned a unique identification number (1-27).

Data Analysis

Quantitative Analyses

Quantitative data were analyzed using SPSS (version 25.0; IBM Corp) for Windows. For each of the 10 quantitative components (measured with a 5-point Likert-type scale), the mean and SD were calculated. Subsequently, the percentage of the mean for each component was calculated by dividing the respective mean by 5 (as it is the maximum possible value) and multiplying it by 100, which determines where the 10 corresponding values lie on the predefined scale. An overall score of the agreement for all components (ie, the total of the means of all 10 components) was computed, along with an independent score for each of the 2 segments of the tool: ease and impact (ie, the total of the means for each of the 2 groups of 5 components). The mean and SD were calculated for all 3 scores.

As the scale used to capture the perception of the participants was tailor-made for this study, the validity tests of Cronbach α and the principal component analysis of the Kaiser-Meyer-Olkin and Bartlett test were performed to check the internal consistency and external variance, respectively, of the designed tool.

To select appropriate means of correlating the variables, a test of normality was conducted for each of the 10 components and for the following 3 scores: overall, ease, and impact. The data for each of the 10 components and the ease and impact scores were not normally distributed. The overall agreement score was normally distributed ($P=.38$). Accordingly, a matrix of bivariate correlations was developed using the Spearman test to assess the extent to which the 3 scores related to each other and their components.

Qualitative Analysis

Qualitative data analysis began after the conclusion of the data collection phase. The data were analyzed (based on constructivist epistemology) by 2 researchers (RL and FO) using thematic analysis following a 6-step framework [23,24]. As such, the researchers began by familiarizing themselves with

the data. Each of them reviewed the data set independently while writing down notes about key observations. They then convened to discuss their notes. The next step revolved around generating initial codes for prominent patterns identified after the initial step of examining the data set. The third step, which was the most extensive, involved searching for the themes. This required the development of several iterations of mind maps, where the manner in which the generated codes related to one another was visually presented. The fourth step included a review of themes to ensure that there was sufficient similarity between all text fragments placed within the same group while ensuring that there were enough dissimilarities across the groups to differentiate them from one another. The fifth step was defining and naming the generated themes. The last step involved reporting on the results of the qualitative analysis, which was done based on recently published standards of reporting on qualitative analysis integral to mixed methods research design [25].

Joint Display Analysis

The quantitative and qualitative data were then mapped onto each other through the iterative process of joint display analysis [18]. Integration was meant to reveal where the findings confirmed or built upon each other. It was also able to shed light on where the findings contradict each other. Therefore, meta-inferences were generated [14].

Results

Quantitative Analyses

Of the 54 students, 27 responded (ie, response rate of 50%). The reliability score of Cronbach α for the tailor-made evaluation tool that captured the students' perceptions (ie, 10 components) was .84. The percentage of the total average of the overall score of agreement was 84%, somewhere between *agree* and *strongly agree*, as per Table 1.

The sampling was determined as adequate with a Kaiser-Meyer-Olkin close to 1. In addition, according to the Bartlett test of sphericity, the null hypothesis was rejected with an identity matrix in which all diagonal elements were 1 and all off-diagonal elements were 0. As such, the principal component analysis (along with the corresponding eigenvalues) showed that 75.2% of the variance across the 10 components could be explained by the instrument as a whole. This means that the instrument was reliable and valid for measuring what it intends to measure.

Table 1. Output of descriptive quantitative analysis.

Component	Values, mean (SD)	Percentage of the mean (%)	Category
1	4.19 (0.736)	83.8	Agree to strongly agree
2	4.22 (0.641)	84.4	Agree to strongly agree
3	3.41 (1.083)	68.2	Neutral to agree
4	4.04 (1.055)	80.8	Agree
5	4.52 (0.643)	90.4	Agree to strongly agree
6	4.56 (0.577)	91.2	Agree to strongly agree
7	4.33 (0.679)	86.6	Agree to strongly agree
8	4.19 (0.736)	83.8	Agree to strongly agree
9	4.30 (0.724)	86	Agree to strongly agree
10	4.26 (0.813)	85.2	Agree to strongly agree
Score of ease	15.85 (2.231)	79.3	Agree
Score of impact	26.15 (3.45)	87.2	Agree to strongly agree
Overall score of agreement	42 (4.907)	84	Agree to strongly agree

Correlational or Inferential

As illustrated in [Table 2](#), the overall score of agreement was significantly influenced by the perception of the students regarding all components except for component 3, “Effectively

undergoing the exercise required that I get out of my comfort zone” ($P<.001$). Moreover, all 3 scores: overall, ease, and impact, correlated with each other ($P<.001$ for overall and ease, and overall and impact & $P=.01$ for ease and impact).

Table 2. Matrix of bivariate correlations.

Component	P value											Correlation
	1	2	3	4	5	6	7	8	9	10	Score	
1	.99	.44 ^a	-.23	.62 ^a	.32	.13	.42 ^a	.38 ^a	.44 ^a	.34	.59 ^a	Coefficient
	— ^b	.02 ^a	.24	.001 ^a	.11	.53	.03 ^a	.049 ^a	.02 ^a	.08	<.001 ^a	Significant
2	—	.99	.03	.33	.29	.21	.48 ^a	.48 ^a	.53 ^a	.39 ^a	.66 ^a	Coefficient
	—	—	.87	.09	.14	.30	.01 ^a	.01 ^a	.004 ^a	.046 ^a	<.001 ^a	Significant
3	—	—	.99	.11	-.13	.05	-.08	.12	.007	.02	.22	Coefficient
	—	—	—	.60	.52	.81	.69	.56	.97	.93	.28	Significant
4	—	—	—	.99	.27	.12	.48 ^a	.40 ^a	.30	.36 ^a	.63 ^a	Coefficient
	—	—	—	—	.18	.54	.01 ^a	.04 ^a	.13	.06 ^a	<.001 ^a	Significant
5	—	—	—	—	.99	.57 ^a	.58 ^a	.65 ^a	.41 ^a	.71 ^a	.64 ^a	Coefficient
	—	—	—	—	—	.002 ^a	.002 ^a	<.001 ^a	.03 ^a	<.001 ^a	<.001 ^a	Significant
6	—	—	—	—	—	.99	.71 ^a	.63 ^a	.49 ^a	.60 ^a	.60 ^a	Coefficient
	—	—	—	—	—	—	<.001 ^a	<.001 ^a	.01 ^a	.001 ^a	<.001 ^a	Significant
7	—	—	—	—	—	—	.99	.74 ^a	.60 ^a	.63 ^a	.81 ^a	Coefficient
	—	—	—	—	—	—	—	<.001 ^a	.001 ^a	<.001 ^a	<.001 ^a	Significant
8	—	—	—	—	—	—	—	.99	.63 ^a	.76 ^a	.85 ^a	Coefficient
	—	—	—	—	—	—	—	—	<.001 ^a	<.001 ^a	<.001 ^a	Significant
9	—	—	—	—	—	—	—	—	.99	.67 ^a	.75 ^a	Coefficient
	—	—	—	—	—	—	—	—	—	<.001 ^a	<.001 ^a	Significant
10	—	—	—	—	—	—	—	—	—	.99	.78 ^a	Coefficient
	—	—	—	—	—	—	—	—	—	—	<.001 ^a	Significant

^aCorrelations that revealed significance, as defined by the *P* value.

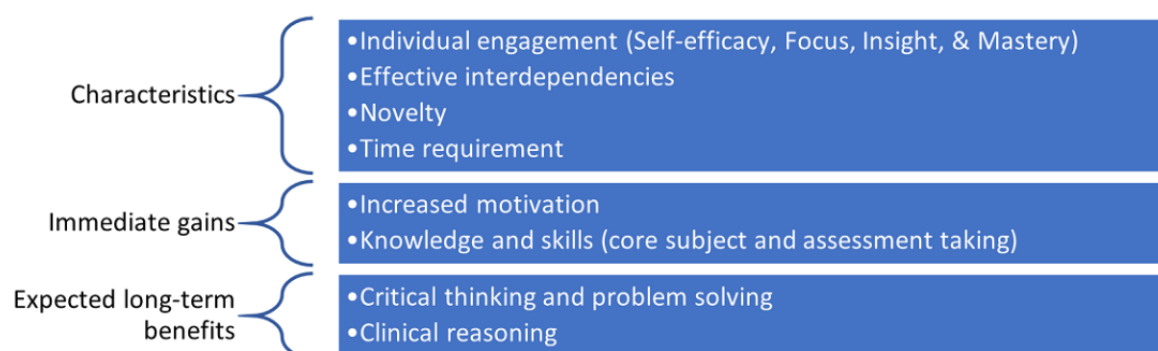
^bNot applicable.

Qualitative Analyses

The analysis of the qualitative data capturing the students' perceptions resulted in 3 interrelated themes: prominent

characteristics, immediate gains, and expected long-term benefits of their engagement in preparing the formative assessment (Figure 3).

Figure 3. The conceptual framework of the study. Prominent characteristics emerged from students' perceptions of self-generated formative assessments demonstrating immediate gains and expected long-term benefits and validating the educational intervention's utility toward assessment as learning.



Theme 1: Prominent Characteristics

This theme included text fragments that referred to how the students characterized the program and what stood out to the students as the variables upon which the activity's success relies. This included variables such as immersing oneself in the experience:

...it was not very easy since one needed to concentrate and focus a lot to develop MCQs... [Participant 23]

It was clear that the participants needed to form effective interdependencies with colleagues:

...we needed to come up with questions related to our own learning...it was a team effort...discussing the questions, among each other, enabled us to develop a better idea as to what would constitute good distractors...the variety of perspectives was useful, of course... [Participant 11]

Some students highlighted that teamwork inherent to the exercise and ensuring that all team members were equally engaged was challenging:

...the same people, within our team, kept on generating the questions. Not all the team members contributed equally; some members did not provide any input...we were able to eventually address this challenge...I needed to converse more with some of my colleagues whom I do not usually have the opportunity to speak to... [Participant 14]

...some of the group members did not bother to do their job in developing questions, which caused some frustration within the team... [Participant 22]

Students believed that engaging in the experience enabled them to develop the necessary insights and mastery or proficiency in preparing formative assessments. This belief, coupled with focusing on the exercise at hand, helped them develop their self-efficacy:

...we are expected to generate the MCQs soon after we learn a new concept. This required that we look-up key terms and additional information related to the respective concept. As part of preparing for the MCQs, we needed to come-up with distractors. We

needed to really understand the content to be able to do the task... [Participant 3]

...to develop the capacity to create our own MCQs and share them with other students... [Participant 11]

This theme also included text fragments that showed that the students were aware that the experience was novel and that they had to go through a learning curve:

...it was surely a new experience for me; we were given the opportunity to view the exam from the examiner point-of-view, from the perspective of the person forming the MCQs. It felt really good... [Participant 3]

...it was fairly simple, but developing more elaborate questions was more challenging... [Participant 4]

...it is the details that matter and that was a bit difficult, at first. Trying to discern two similar topics, while thinking of sequential order and associated elements, and formulating possible choices, among which the "best" answer, were the steps that required extra effort... [Participant 8]

...formative assessments allow us to test our understanding of concepts without the burden of having to perform well in terms of a test or a grade which gives us more opportunities to make mistakes and to learn from them... [Participant 11]

...I am not familiar with such exercise so I was getting out of my comfort zone, but I would say, in a positive way... [Participant 19]

The students also highlighted how the exercise required time investment:

...however, since we were given enough time to do it, it was good... [Participant 23]

Theme 2: Immediate Gains

This theme encapsulated all text fragments that referred to what the students gained upon completing the experience. In general, most students expressed excitement and were happy to have gone through this experience:

...finding sensible, reliable distractors became a "hobby" when forming MCQs...It was a valuable

experience, and a good exercise. Plus, it was fun...
[Participant 3]

...it was an interesting and helpful exercise...
[Participant 15]

It was evident to the students that they had gained ample knowledge and skills from their experience:

...it was both beneficial for our learning and interesting for us since we got to see how much work it actually takes to formulate proper questions...It was a very useful and interesting task... [Participant 27]

The students referred to learning that occurred in relation to the core subject (ie, pathology):

...this exercise enabled us to effectively learn the core concepts of pathology... [Participant 3]

...it allowed for additional practice on the learning material... [Participant 8]

...this exercise covered some parts that I might have missed or did not fully comprehend, at first...
[Participant 14]

...in order to structure a question, I had to gain good understanding of the topics, so it was really helpful...
[Participant 20]

Enhancing the knowledge and skills around assessment taking was also apparent to the students:

...we were required to prepare a test-like question from the preceding weeks material...we learned about the types of questions and of possible answers that are commonly used which enabled me to approach the course material in a different role... [Participant 8]

...it really enhanced how I tackle questions and how I think when answering questions... [Participant 14]

...we got to understand how the examiner thinks; this is a good skill that is useful for us to have when revising the required content prior taking any one exam... [Participant 15]

Theme 3: Long-term Benefits

This theme included text fragments that referred to the gains that the students expected to materialize over time from this experience (eg, critical thinking and clinical reasoning):

...this process gave me the opportunity to change my learning style...to create a question, one needs to approach the topic differently; this reinforces one's understanding of the topic and equips the students with transferable skills... [Participant 8]

...pathology clinical are really essential and shade huge light on the grey area that connect the aetiology/pathology to clinical manifestation...
[Participant 14]

...I learned how to figure-out what to focus on, what the important parts of any lecture is...I think it was great; it gave us insight as to what the actual assessment will be like and helped prepare us for the In-Course Assessment... [Participant 24]

...my question writing skills, which require ample of critical thinking and problem-solving skills, improved since I had to formulate questions that were advanced...this all was so beneficial to my learning...
[Participant 27]

Data Integration

The convergence of the quantitative and qualitative data resulting in the meta-inferences is shown in [Table 3](#). Quantitative inputs derived from [Textbox 1](#) and [Table 1](#) were mapped to themes 1 to 3 of the qualitative data as the perceptions of ease and impact on the individual and the group. The meta-inferences were characterized as strengths, weaknesses, challenges, and opportunities, which provide an opportunity to consolidate and build on gains and remedy weaknesses in innovation. The identified strengths of the educational intervention were well matched in the quantitative and qualitative perceptions of the students, except for the interesting qualitative description that learning through assessment was more enjoyable as the exercise had a gamification aspect. However, weaknesses were entirely identified in qualitative responses and not through quantitative scores, such as time management and disruptive peer dynamics. Among the perceived challenges and opportunities, qualitative inputs provided additional insights that enhanced available quantitative data, such as the novelty of the experience. Overall, the qualitative data lend themselves to actionable evidence, which considerably enhances the conclusions of the study.

Table 3. Joint display: output of integrating quantitative data with qualitative data.

Quantitative (Textbox 1 and Table 2 ^a)	Meta-inferences	Qualitative (themes 1-3)	
		Individual	Group
Questions 1-2, 6, and 9-10: agree to strongly agree	Strengths	<ul style="list-style-type: none"> • Simple and easy to make • Revision of content • Examination-taking skills • No stress to score 	<ul style="list-style-type: none"> • Peer reinforcement • Stratification and sequencing of learning • Gamification
The qualitative method provides insights not revealed by quantitative survey ^b	Weaknesses	<ul style="list-style-type: none"> • Time consuming (but manageable in the time provided)^b 	<ul style="list-style-type: none"> • Repeat questions in groups • Unequal participation by peers (teamwork)^b
Question 3: neutral to agree; question 4: agree to strongly agree; question 10: agree to strongly agree	Challenges	<ul style="list-style-type: none"> • Out of comfort zone • Required focus 	<ul style="list-style-type: none"> • Willingness to repeat the exercise • To create questions of higher-order thinking
The qualitative method provides insights not revealed by quantitative survey ^b (questions 6-10): agree to strongly agree	Opportunities	<ul style="list-style-type: none"> • A novel method of learning^b 	<ul style="list-style-type: none"> • Critical thinking • Problem solving

^aQuantitative analyses (Table 1).

^bAdditional insights from qualitative data.

Discussion

Principal Findings and Comparison With Prior Work

This educational intervention to promote SRL provides insights into engaging students in AaL exercises. The design of the intervention mirrored the phases of preparation, implementation, and appraisal, which were well-illustrated in an insightful meta-analysis by Panadero [2] of 6 individual SRL models proposed by Boekaerts, Efklides, Haldwin, Pintrich, Winne and Hadwin, and Zimmerman, respectively. The study focuses on *appraisal* of this form of SRL from a student's viewpoint capitalizing on the strengths of the mixed methods approach. In the process, the quantitative measurement of the ease and impact of AaL was considerably enhanced and supplemented by students' qualitative inputs. The latter provided prominent characteristics of the experience, as well as short- and long-term impacts. Integration of the mixed methods data on the ease and impact of the AaL intervention provided robust metrics (quantitative) on the strengths, weaknesses, challenges, and opportunities amplified by incisive observations (qualitative). Certain experiences could only be captured by subjective expressions in the students' own words. The positive inputs included the novelty of the experience and the gamification effect, which enhanced the enjoyment of learning. There was also a useful critique of unequal levels of peer contribution, quality of questions, or repetition in some groups. In the following paragraphs, these observations are discussed in relation to shared experiences from the published literature.

This study achieved a partnership between students and tutors, as emphasized in the holistic approach to LOA [7]. This study sheds light on how, from a constructivist perspective, assessment can be leveraged to drive students' learning. Constructivism implies the learners' central role in taking charge of their learning, gaining insights into learning gaps, and developing ways of improving learning. AfL can be a significant component of this self-regulatory mechanism but often relies on feedback

after formative assessments that remain tutor driven, focused, and directive. However, in AaL, students assume control by dominating the learning process's discourse and producing a self-regulatory and self-productive identity [6]. Students set goals, monitor progress, and reflect on learning prospectively, not retrospectively, as in formative assessments.

In this study, the design of the AaL innovation addressed the student-centered communication and action domains of the AaL wheel [8]. Evaluating students' perceptions of AaL implemented in the course of an MBBS program proved to be rewarding. In this study, students' qualitative reflections on undertaking assessment creation were characterized as short- and long-term gains. Students' scores on overall agreement of engagement with designing assessment and the related ease and impact were all considerably high, with significant correlations among all 3 scores. Similarly, in a previously assembled survey inquiring about a medical student-generated question bank at the University of Manitoba, Winnipeg, Manitoba, Canada, 91% of students reported satisfaction with their engagement in developing questions [12].

The quantitative results of this study showed that the only component that was not statistically associated with the students' overall agreement with the experience was that the exercise required them to leave their comfort zones. Qualitative inputs showed that the experienced unease was favorably perceived as an enabling challenge along the same line. The idea that leaving one's comfort zone can be of added value is well-established in the literature [26]. In a US dental undergraduate program, a study on student-generated MCQ items reported that the students were able to prepare a higher cognitive level of questions than the instructor [27]. The students perceived the intervention as contributing to their learning. Thus, student creation of assessments provides a unique opportunity for learners within a developmental framework of assessment [28].

In this study, the students specifically expressed their realization of the added value of assessment-enhanced learning toward the core content of the specific course. According to the students, this happens when tasked with preparing questions by increasing their focus on the subject matter and by the requirement of viewing it from a different perspective. They were surprised by how their efforts to create questions contributed to exam preparedness and insight into the examiner's viewpoint. One could extrapolate that this would reduce the stress of exam preparation at the end of the semester. The development of higher-order thinking is best achieved through inquiry and investigation, applying knowledge to new situations and problems, producing ideas and solutions, and collaborative problem solving [29].

The high level of agreement reported in this study was related to students' perceptions of the value of learning. This, in turn, encouraged students to invest time and effort, positively reinforcing the link to the perceived learning impact of the exercise. Students commented that creating questions weekly promoted regularity in their reading, reflecting, and revising habits. The literature on the subject matter indicates contradictory findings. In a study on undergraduate students who generated MCQs in the fourth year of the pathology course of a New Zealand medical school, students could create cognitively challenging MCQs. However, they did not find the task of educational value [30]. The students engaged well with the peer-wise platform for question creation but did not offer good peer feedback. In contrast, in another study involving second-year biomedical sciences students (n=107), perceptions of student-authored assessments in a biochemistry course demonstrated an eagerness and the generation of a large repository of relevant and good-quality MCQs [31].

An example of student-generated formative assessments specifically targeting competency-based progression was illustrated in a multicenter pilot study in German medical schools [32]. A core team of 17 students from the third to ninth semesters drawn from 17 universities was trained on MCQ generation and review, contributing 118 MCQs to a 144-item assessment based on a preagreed competency blueprint. It was administered to 469 students from 8 medical schools. The items were of high quality with higher-order thinking and generated high test reliability. However, student authors seemed to favor item generation on theoretical and practical skill competencies over scientific and communication skills competencies. The examinees perceived it more as an opportunity for feedback rather than a learning experience.

Another unexpected but beneficial aspect highlighted by students is the perceived "gamification effect" of the exercise. During moments of relaxation, tossing around distractors became a second habit to them as an intellectually entertaining tool. According to Gray [33], creativity is the basis of critical thinking and always involves a degree of playfulness: "the critical thinker plays with ideas...to see what happens and to explore consequences." The development of such instinctive and enjoyable learning through play can have a long-lasting impact, sustaining self-learning and building peer-learning habits [34]. However, there were instances of dissatisfaction when a team member did not actively participate and substantially contributed

to question creation, which reflected adversely on team output. There are contradictory findings on peer collaboration from other studies; in one study, team cooperation toward item generation was perceived as unsatisfactory [27], whereas, in another study, willingness to collaborate with peers was agreed to by 86% of students [12]. During the ongoing COVID-19 pandemic, the rapid transition to distance learning provided the impetus to students from Queen's University Belfast to create and share MCQs through Instagram to mutually enhance their learning [35]. Thus, it has been established that beneficial outcomes are a result of assessment-based peer-assisted learning.

Some students in this study perceived that the quality of the generated questions was inconsistent. They reported that some of their peers produced questions of low cognitive levels. This perceived weakness highlights the social regulation of learning, wherein the degree of achieved coregulation determines the enhancement of the ease and impact of learning on the individual and the group [2]. In contrast, in another study from a medical school in Cardiff, students were engaged in creating a question bank duly mentored and vetted by the content faculty. Within a 3-month period, 2800 tests had been attempted, indicating the popularity of the use of this learner resource [5]. The students who authored the MCQs in the Cardiff study were in their final year, which may have accounted for the higher quality of the generated questions.

The statistical reliability and validity of the survey tool provide a solid anchor for the results. A follow-up exercise based on the same framework in successive cohorts will further reinforce the tool's reproducibility and the consistency and generalizability of the findings. Investigating the effectiveness of such an intervention can be performed by comparing before and after student performance scores. In one study, the follow-up scores on single best answer summative examinations correlated well, whereas performance on clinical examinations did not [10].

Strengths, Limitations, and Future Directions

The key strength of this study lies in the integration of data derived from the mixed methods approach. This enables clarity on the aspects of building SRL that lend themselves to longitudinal replication, as well as identifies opportunities to dynamically respond to perceived challenges and weaknesses. The first limitation of this study was that the participating students were at an early stage of their medical school journey, which might have influenced their perceptions of the value of self-learning through assessment. It would be interesting to investigate in future studies whether the stage of learning plays a moderating effect on the students' understanding and perception of the exercise and its impact by collecting perceptions from students at different stages of the program. Second, future research could use additional multiple-item formats to provide students with insights into their learning techniques. Finally, this study was limited in its application to a single course of 1 cohort of students. Hence, the generalizability of the findings is limited and can be remedied by making multicohort comparisons.

Conclusions

Student-generated assessments in the form of AaL were perceived as viable, constructive, and stimulating educational exercises by the student authors. In the short term, the exercise constituted for the students a fun, challenging opportunity to

dive deep into the content, be creative in designing questions, and improve examination-taking skills. Students expected long-term effects to include enhancement of critical thinking and the inculcation of student-regulated attributes of lifelong learning and peer collaboration, all of which are vital to the practice of medicine.

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Data Availability

The data collected in this study are included in the published manuscript and are available with the corresponding author.

Authors' Contributions

RL conceptualized, designed, and executed the educational intervention and interpreted and discussed the findings. FO designed and conducted the surveys, analyzed the quantitative and qualitative data, and participated in manuscript preparation. LA and NZ critically reviewed all components of the study, anchored the manuscript review, and contributed to illustrations.

Conflicts of Interest

None declared.

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Abbreviations

AaL: assessment as learning
AfL: assessment for learning
AoL: assessment of learning
LOA: learner-oriented assessment
MCQ: multiple-choice question
SRL: self-regulated learning

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Original Paper

Implementing Remote Collaboration in a Virtual Patient Platform: Usability Study

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Abstract

Background: Learning with virtual patients is highly popular for fostering clinical reasoning in medical education. However, little learning with virtual patients is done collaboratively, despite the potential learning benefits of collaborative versus individual learning.

Objective: This paper describes the implementation of student collaboration in a virtual patient platform. Our aim was to allow pairs of students to communicate remotely with each other during virtual patient learning sessions. We hypothesized that we could provide a collaborative tool that did not impair the usability of the system compared to individual learning and that this would lead to better diagnostic accuracy for the pairs of students.

Methods: Implementing the collaboration tool had five steps: (1) searching for a suitable software library, (2) implementing the application programming interface, (3) performing technical adaptations to ensure high-quality connections for the users, (4) designing and developing the user interface, and (5) testing the usability of the tool in 270 virtual patient sessions. We compared dyad to individual diagnostic accuracy and usability with the 10-item System Usability Scale.

Results: We recruited 137 students who worked on 6 virtual patients. Out of 270 virtual patient sessions per group (45 dyads times 6 virtual patients, and 47 students working individually times 6 virtual patients minus 2 randomly selected deleted sessions) the students made successful diagnoses in 143/270 sessions (53%, SD 26%) when working alone and 192/270 sessions (71%, SD 20%) when collaborating ($P=.04$, $\eta^2=0.12$). A usability questionnaire given to the students who used the collaboration tool showed a usability score of 82.16 (SD 1.31), representing a B+ grade.

Conclusions: The collaboration tool provides a generic approach for collaboration that can be used with most virtual patient systems. The collaboration tool helped students diagnose virtual patients and had good overall usability. More broadly, the collaboration tool will provide an array of new possibilities for researchers and medical educators alike to design courses for collaborative learning with virtual patients.

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KEYWORDS

collaborative learning; clinical reasoning; webRTC; collaboration; collaborative; decision making

Introduction

Learning with virtual patients (VPs) is widely popular in medical education. It is an efficient way to give students the opportunity to learn with real-life clinical scenarios [1-3]. This popularity has led to various e-learning solutions with different conceptual backgrounds [3,4]. Some conceptualizations focus on acquiring clinical knowledge [5-8], while others concentrate on immersing the student in a virtual environment to teach medical communication skills [9-12]. Yet another learning goal is to convey the process of how a patient is diagnosed, known as clinical reasoning, which “includes the application of knowledge to synthesize and prioritize information from various sources and to develop a diagnosis and management plan for a patient” [13]. Facilitating clinical reasoning is a key goal of medical schools, yet one that is difficult to reach. Diverse e-learning innovations have attempted to foster clinical reasoning with varying degrees of success [14-18]. A review found that collaborative features enabling students to communicate within learning environments were still limited in medical education [19]. Compared to the large number of studies investigating individual clinical reasoning, only a few studies have investigated the application of collaborative learning (meaning that two or more people learn together, benefiting from one another's resources and skills) to clinical reasoning [19,20]. We understand collaborative clinical reasoning to be “the process in which two or more health care team members negotiate diagnostic, therapeutic, or prognostic issues of an individual patient resulting in an illness or treatment plan (and to reduce uncertainty)” [19].

One study implemented collaborative learning in biomedical courses via an e-learning environment, showing beneficial effects [21]. Another study investigated the collaborative learning of clinical reasoning in a face-to-face setting and found that pairs of medical students using the same computer made faster and equivalently good diagnoses compared to students learning individually [22]. The so-called ICAP (interactive, constructive, active, and passive) framework from Chi and Wylie [23] might explain these results. Chi and Wylie suggested that student engagement can be distinguished into 4 modes. In collaborative learning, students can interact, which is desirable

for deep cognitive processing and learning [23]. VP platforms are sometimes used in face-to-face settings, with groups of students working together on a case, often in problem-based learning settings [24]. However, VP platforms in medical education typically focus on the individual student and not on groups of students working together remotely to learn clinical reasoning [24].

In this paper, we describe the underlying rationale and approach to implementing a collaboration tool in the VP platform Casus (Instruct gGmbH) for learning clinical reasoning. Such a tool, being directly implemented into a VP platform, can help researchers to easily design studies and provide evidence on how to optimize collaborative learning for students. In times such as the COVID-19 pandemic, these tools can also provide learning opportunities that might otherwise be missing.

Our aim was to give pairs of students the ability to communicate remotely with each other (ie, while not in the same room) during VP learning sessions. Simultaneously, we considered that the system should be able to track the learning processes of the students. This would enable medical educators to design collaborative courses and researchers to study collaboration in VP environments. As target users of the system, we had in mind clinical educators in all fields of medicine in which collaboration plays an integral role in everyday work. We hypothesized that using a collaborative tool implemented directly within the VP platform would not impair usability of the system compared to an individual learning setting. Further, we aimed to identify whether learning with the tool led to better diagnostic accuracy for dyads of students compared to individual learners.

Methods

Technical Approach

Part of the research project FAMULUS (Fostering Diagnostic Competences in Medical Education and Teacher Training Through Adaptive, Online Case-Simulations), funded by the German Federal Ministry of Education and Research, was to enable students to work together, remotely and synchronously, in medical and teacher education. The tool was designed and developed in several steps, which will be described in the following sections and are summarized in [Table 1](#).

Table 1. Stepwise overview of the development process of the tool.

Steps	Descriptions
Step 1: Searching for suitable libraries	Identifying potential collaboration tool libraries
Step 2: Implementing the application programming interface	Defining the educational features needed and implementing (1) video communication, (2) text chat, and (3) screen sharing
Step 3: Making technical adaptations	Installing TURN (traversal using relays around network address translators) and STUN (simple traversal of user datagram protocol through network address translators) to ensure the best potential connections between users despite protective firewalls
Step 4: Designing and developing the user interface	Designing each feature (video communication, text chat, and screen sharing) so it could be turned off and on by the educator; implementing an additional onscreen window providing the collaboration functionality
Step 5: Usability testing and comparing diagnostic accuracy	Comparing the original, individual system with the collaborative tool using 6 virtual patients in a group of 45 dyads (ie, 90 students) and a group of 47 students to test for usability and compare diagnostic accuracy

Step 1: Searching for Suitable Libraries

After a search of available libraries, we decided to use the SimpleWebRTC (andYet Co) library for implementing the collaboration tool. It provided the basis for setting up a conferencing platform and could be extended to include the required features, such as video communication and screen sharing. An additional text chat function was implemented using the message protocol of the SimpleWebRTC library. We had several reasons for using SimpleWebRTC. At the time we chose it, SimpleWebRTC was an open-source library that was completely scriptable and could be used without additional credentials. This was desirable to enable tight integration into the e-learning platform. The library offered detailed documentation for integration and samples, unlike other open-source solutions. Commercial video conferencing and screen sharing tools, such as Google Hangouts (Alphabet Inc), Zoom (Zoom Video Communications Inc), Skype (Microsoft Inc), and Adobe Connect (Adobe Inc), had disadvantages. For example, Zoom usually requires one account and a dedicated administrator to initiate a call. Consequently, scripting (ie, matching two unique students) a significant number of parallel but independent video conferencing sessions would not have been possible with such tools, even though they might be more robust than WebRTC. As scripting and dynamically creating the dyads was an important part of the study setting, we decided against commercial video conferencing tools. Unfortunately, even SimpleWebRTC has now become a commercial service. Nevertheless, the original library remains open source, is self-maintained, and is regularly tested for cross-browser functionality. Comparable open-source libraries like Jitsi (8x8, Inc) [25] offered no significant advantage compared to SimpleWebRTC, although this might change in the future.

Step 2: Implementing the Application Programming Interface

To implement SimpleWebRTC independently of Casus, we set it up as an application programming interface (API). This also allowed our approach to be applied to other VP or e-learning platforms. Several features of the conferencing tool could be controlled, enabled, or disabled with the JavaScript API: (1) video and audio channels, (2) text-based chat, and (3) screen sharing. From an educational point of view, each of these features was necessary. First, the audio channel let students collaborate in a direct manner, allowing for communication without additionally transcribing speech to text. Video was helpful for establishing a feeling of proximity, despite the actual distance between the students. Reciprocal, synchronous video-based learning, in which two or more students are directly connected and work together at the same time, has been found to increase learning effectiveness [26]. Second, the text-based chat enabled educators and students to access the messages any time after a learning session and follow up on the collaborative activities. To support this aim, we added two features to the text chat: saving chats as text files and restoring the display of older

messages after a browser restart. Third, screen sharing was necessary to allow students to work together in dyads on a shared document. In order to structure the collaboration, we designed the screen sharing with a “main” user, who was able to share his or her screen, and a “secondary” user without this option. This made it possible for educators to choose to give students the same or different sets of information to create a need for collaboration.

Step 3: Making Technical Adaptations

The implemented educational features (scripting, video and audio channels, text-based chat, and screen sharing) required several technical adaptations. To be able to handle a browser reload triggered by the user or refresh the application when a problem occurred, one component of the API used the conferencing tool to save the current state at regular intervals. SimpleWebRTC includes a signaling service responsible for the exchange of metadata and coordination of the communication between connecting client browsers. Our implementation was based on the node.js signalmaster from andYet. Some adaptations were necessary to improve the monitoring options in order to track students’ logins and logouts and implement the text chat. We have detailed the adaptations in [Multimedia Appendix 1](#).

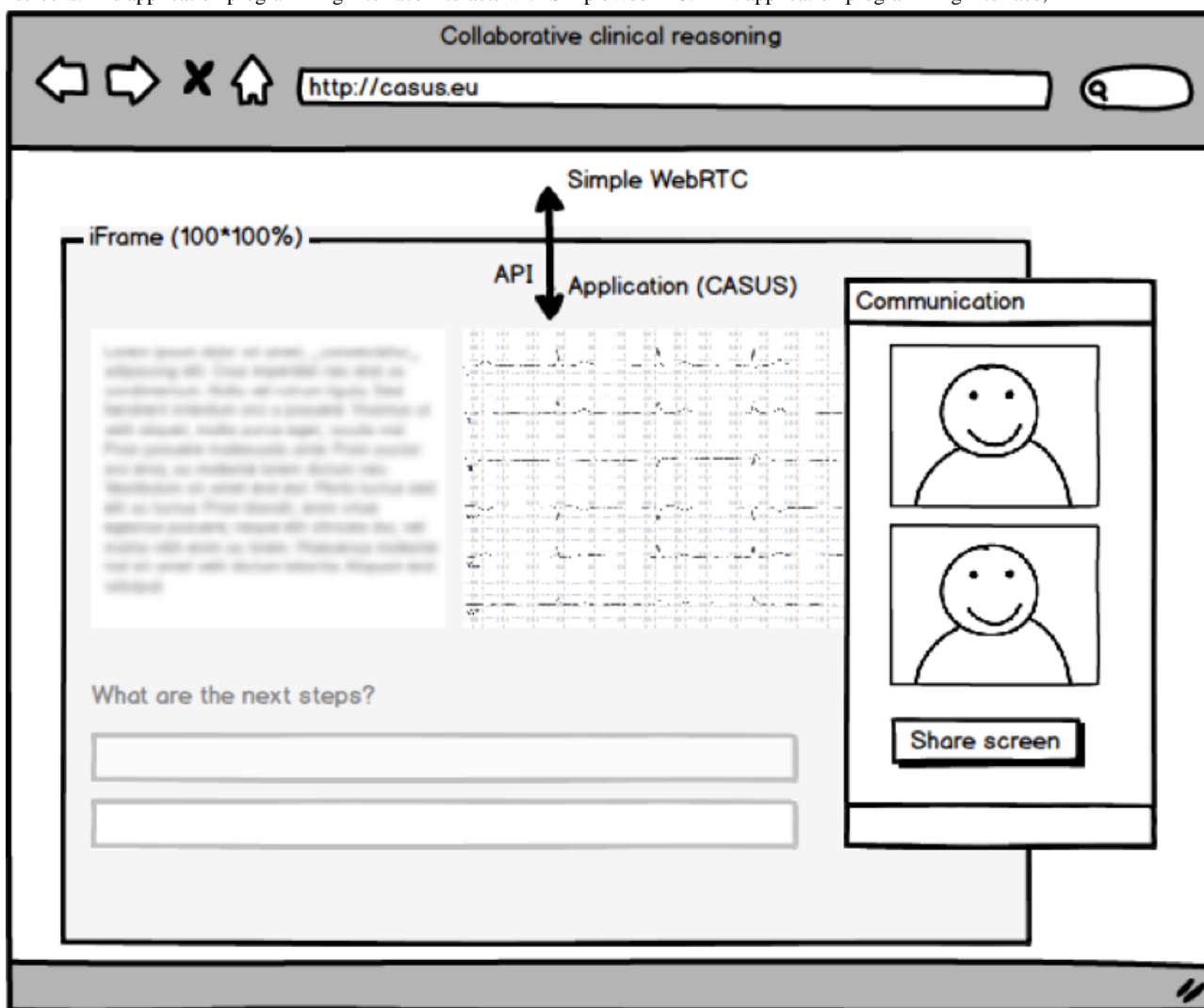
The adapted signal service, based on signalmaster from andYet, and the additions to SimpleWebRTC used the JavaScript API and were open source. They are available on request from Instruct gmbH. Detailed documentation for each component is available from the GitHub website [27], as is the documentation for STUN (simple traversal of user datagram protocol through network address translators) and TURN (traversal using relays around network address translators) with the coTurn implementation [28]. A detailed description of how the WebRTC standard manages communication can be found at various websites. A good example is the website of HTML5rocks [29]. The signalmaster from andYet was only minimally extended to provide the text chat functionality and logging for debugging.

Except text chat data, signalmaster does not currently store any data. Text chat data are stored in simple JSON (JavaScript Object Notation) text files with a room naming convention, but can be extended if needed.

Step 4: Designing and Developing the User Interface

The requirements for the user interface were generated through discussions among the authors to maximize the system’s learning and research possibilities. Students saw the usual Casus user interface with an additional window providing the collaboration functionality ([Figure 1](#) shows a wireframe model of the implementation). Students could use this window to talk to their peers and share their screens. We also implemented a user interface for educators in the Casus course administration area. The setup page enabled educators to set up and configure the collaboration ([Textbox 1](#) shows the available settings).

Figure 1. Wireframe model of the integration of Casus with WebRTC. In the foreground two people are communicating; they have the option to share their screens. The application programming interface interacts with SimpleWebRTC. API: application programming interface;



Textbox 1. Settings available to educators in the user interface.

- Turn collaboration on or off for a course (for groups of students)
- Define virtual rooms for collaboration (students in the same virtual room can communicate with each other and work on the same virtual patient)
- Enable or disable screen sharing between students (one or multiple students are allowed to share their screens with partners)

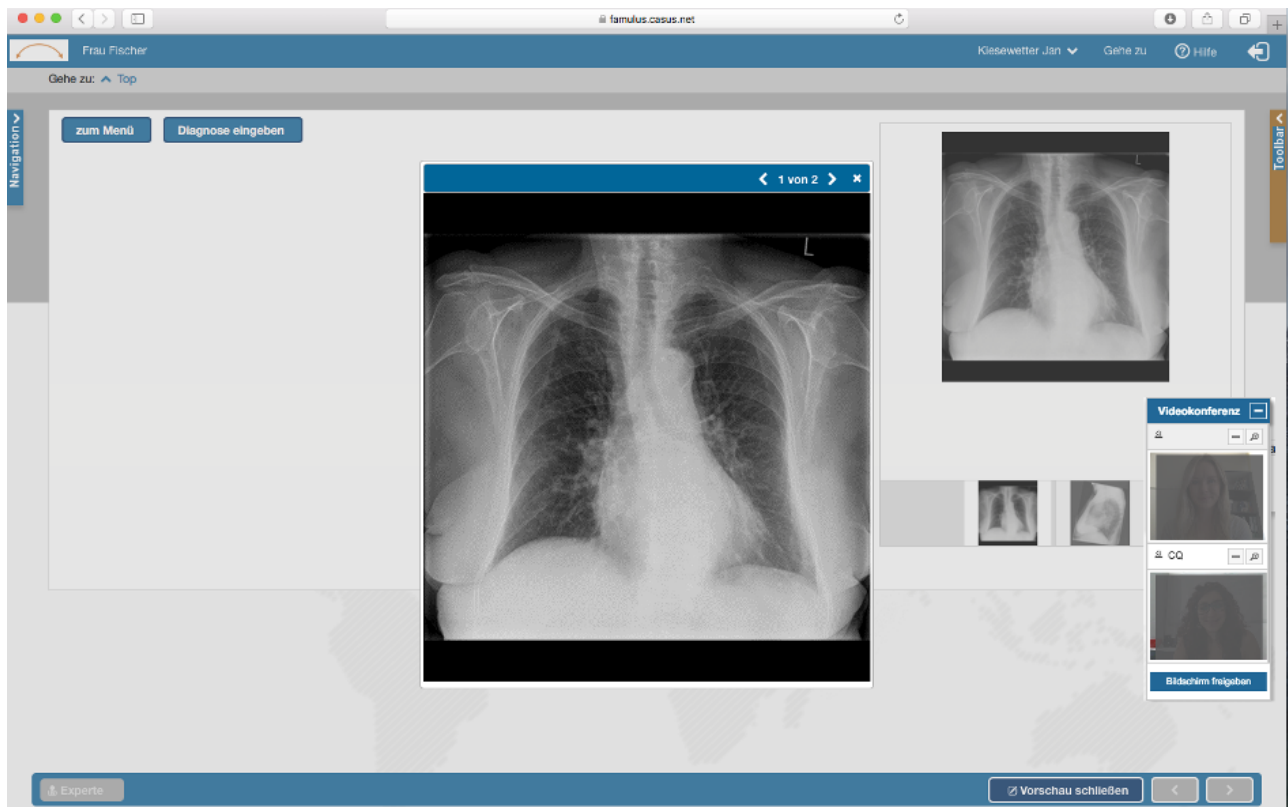
To implement the API in Casus, we only needed to implement a few code changes in Java, the main programming language of the server side of Casus. Communication between the host system (Casus in our study) and the communication framework based on SimpleWebRTC is described in detail in [Multimedia Appendix 2](#).

The HTML page for the communication framework contained the host system (again, Casus in our setting) as an iframe. This ensured that even if a user navigated through the host system to different URLs, the communication framework remained open and unchanged, making the communication more stable. Storing the actual URL (eg, in HTML5) in local storage or

cookies in order to survive a reload was possible, even though sometimes it could take a few seconds until the participants in the room were reconnected.

With the given API messages, the communication framework could be integrated into any web-based system without needing any internal knowledge of Casus, making it unnecessary to provide details in this paper. Assignment of rooms could be completely controlled and scripted by sending the API these messages: “casuswebrtcopen_*” and “casuswebrtclose_*”.

Figure 1 shows the technical implementation, including all components. The user interface is depicted in [Figure 2](#).

Figure 2. Screenshot of the user interface.

Step 5: Usability Testing and Comparing Diagnostic Accuracy

In two cohorts, we implemented the collaboration tool for students with six VPs. In the first cohort, 45 dyads diagnosed the cases together, while in the second cohort, 47 individual students diagnosed the same VPs on their own (Table 2 shows details of the two cohorts' demographic data). We invited all medical students at the Ludwig-Maximilian University of

Munich between their third and fifth year to participate via email. Allocation to dyad or individual learning was randomized according to the booking date of the participants. Overall, 270 VP sessions per group (45 dyads [ie, 90 students] times 6 VPs, and 47 students working individually times 6 VPs minus 2 randomly selected deleted sessions) were included in the analysis. Participation was voluntary and anonymous. Students received €35 (US \$36.54) for approximately 3 hours of their time.

Table 2. Descriptive statistics of the two cohorts included in the sample. All participants were between their third and fifth year of medical school.

Cohort	Number of participants, N	Mean age, years	Female, n (%)
First cohort: dyads	90 (ie, 45 dyads)	25	63 (70)
Second cohort: individual learners	47	24	33 (71)

The students in the dyads did not know each other before the study. They were allowed to exchange names but not year of medical school. The VPs were based on texts and images of clinical scenarios, with no video or audio content. We did not allow for text chat in this study, as we wanted the focus of the investigation to be on screen sharing, video, and audio collaboration. Dyads and individuals worked with the same VPs. Three of the VPs exhibited the leading symptoms of back pain (these were all male), while the other 3 exhibited the leading symptoms of fever (these included 1 male and 2 females). All cases were of medium difficulty (mean difficulty range 0.45 to 0.69; these are standard units, defined as percentage correct), as previously tested with individual students, and included all necessary visual content (eg, x-rays and computerized axial tomography scans), although no pictures of the VPs were provided. Dyads of 2 students were connected

via the collaboration tool, with each student being the main user for 3 VPs and the secondary user for the other 3 VPs, meaning that students had to balance their teamwork effort. Within the dyads, students had to settle on one final diagnosis for each VP. After reading the patient information, the teams of 2 had to choose which of the 23 available tests they wanted to look at next. They could proceed with as many tests as they wished before making a diagnosis.

Ethical Approval

Ethics approval and consent to participate were granted by the Ethics Committee of the Medical Faculty of Ludwig-Maximilian University of Munich (study 17-250). All participants gave written consent to participate in the study. We have obtained written consent by the persons identifiable in Figure 2 to publish their images.

Data Analysis

To evaluate the usability of the collaboration tool and its integration into the Casus VP platform, we used the System Usability Scale (SUS). The SUS is a reliable 10-item measure of usability, scored from 1 to 5, which in total can be extrapolated to grades from 10 to 100 [30]. The web-based questionnaire was implemented in Casus.

We analyzed the data of 137 students who completed the SUS [30] and compared the 45 dyads with the 47 individual learners. We compared usability and diagnostic accuracy using SPSS with two ANOVAs; alpha-error level was set at $P=.05$.

Results

Usability Testing

We hypothesized that using the collaboration tool, which is implemented directly within the VP platform, would not impair

usability of the system compared to an individual learning setting. The descriptive results of the original SUS scores (scored from 1-5) are presented in Table 3. As recommended by the SUS developers, we transformed the original SUS scores to percentage scores, meaning that high scores always signify good usability. There was no significant difference between the students working individually (mean score 81.28, SD 1.01), and the students working in dyads (mean score 82.51, SD 1.56). For both dyad and individual learners, the SUS score averaged a letter grade of B+ (ie, acceptable). We encountered no major technical issues during the study sessions. The students in dyads collaborated in all sessions and used the screen sharing option in both directions (ie, as both main users and secondary users). The results support the assumption that the implemented collaboration tool would not impair usability of the system compared to individual learning.

Table 3. Descriptive statistics of the System Usability Scale (N=137 respondents).

System Usability Scale item	Mean score (SD)
I think that I would like to use this system frequently.	3.72 (1.01)
I found the system unnecessarily complex.	1.93 (0.85)
I thought the system was easy to use.	4.03 (0.98)
I think that I would need the support of a technical person to be able to use this system.	1.36 (0.79)
I found the various functions in this system were well integrated.	3.74 (0.94)
I thought there was too much inconsistency in this system.	2.10 (0.93)
I would imagine that most people would learn to use this system very quickly.	4.28 (0.85)
I found the system very cumbersome to use.	1.88 (1.09)
I felt very confident using the system.	4.12 (0.90)
I needed to learn a lot of things before I could get going with this system.	1.54 (0.87)

Diagnostic Accuracy Comparison

We investigated whether learning with the collaboration tool led to better diagnostic accuracy for dyads of students compared to individual learners. Of 270 VP sessions per group (45 dyads [ie, 90 students] times 6 VPs, and 47 students working individually times 6 VPs minus 2 randomly selected deleted sessions), students made successful diagnoses in 143 cases (53%, SD 26%) when working individually and 192 (71%, SD 20%) when working in dyads. The dyads working with the collaboration tool achieved significantly higher diagnostic accuracy compared to the individual learners ($P=.04$, $\eta^2=0.12$).

Discussion

Principal Findings

We have successfully implemented a tool for remote collaboration into a VP platform, enabling students to learn together. We implemented VPs that enabled remote synchronous collaborative learning of clinical reasoning in the Casus VP system. The development of a generic API allowed the collaboration tool to be used with other e-learning platforms or learning management systems. The results of the usability

questionnaire show that there was no significant usability impairment when working with the tool. Subjectively, the usability was even slightly higher. Usability in our study was comparable to that in usability tests routinely performed with the Casus system for individual learners [31,32]. This provides initial evidence that the additional technical aspects of the collaboration tool did not decrease the usability of Casus. The Casus tool was designed some years ago for use by individual students [33,34]. With the present effort to expand the use of Casus to include collaborative learning, we provide initial evidence that working in dyads increases the diagnostic accuracy of students. This could indicate that students working in dyads engaged more in the “interactive learning mode” defined in Chi’s ICAP framework [22]. However, more in-depth research is needed to provide more evidence.

Comparison With Prior Work

We are aware that other tools for collaboration are available, including commercial online platforms and open-source platforms such as Jitsi. All of these platforms work well on their own, but have several disadvantages that limit their use in educational settings. First, the platforms require login and user identification in a separate browser window from the VP platform. These tools work well when collaboration itself is the

goal, but the VP environment provides detailed information on the patient and asks users to respond to questions and provide a diagnosis. An additional browser window complicates an already complex user interface and erects a barrier for educators seeking to incorporate collaborative clinical reasoning into their courses. Second, educators cannot monitor students' collaboration using the commercially available platforms. For example, there is no way of knowing whether the students are actually connected through a third-party platform. Third, educators do not receive any data regarding collaborative learning, which limits research when utilizing these tools.

For assessment purposes, VPs have proven more effective than standardized patients [19]. For learning purposes, a systematic review found that VPs are advantageous for learning skills, especially clinical reasoning, and comparably effective for learning knowledge [2]. For collaborative clinical reasoning, future research is still needed. For example, it remains to be determined whether and how chat-based communication can be used and how it influences collaboration. In smaller courses, however, this might distract from the task at hand. From an educational perspective, the amount of information each learner receives also needs to be explored. Users should have sufficient information for collaboration, but not be overwhelmed by the amount of information [33,34].

Limitations

We are aware that our tool has some limitations. Thus far, no courses can be guided as a whole; every user needs to be configured separately. Additionally, currently only the educator,

not the learner, can determine the roles of main and secondary user and the amount of information each user is provided with. This study included students in their third to fifth years of medical school because the VPs were designed for these years. Thus, we do not yet know whether our results are transferrable to earlier or later training, or to postgraduate training.

Conclusions

Our collaboration tool was specifically developed to support collaborative clinical reasoning education with VPs. However, the tool's design also allows for other simultaneous collaboration scenarios, including in nonmedical domains. For example, the tool could be applicable in teacher education, with two teacher education students having to determine a virtual child's reading proficiency. The tool enables video-supported communication with optional screen sharing between students and allows educators to easily activate or deactivate the collaboration feature. It also runs on all major internet browsers without any installation procedure.

Our collaboration tool helps students work together to apply content knowledge through training with VPs. The tool provides the necessary basis for using learning analytics to track students' knowledge progress and collaborative clinical reasoning skills. As a future step, we could use the tool and API to guide students through a VP curriculum designed to impart both knowledge aspects. More broadly, the tool provides new possibilities for researchers and educators alike for designing courses, sharing homework assignments, and researching questions for collaborative learning.

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Data Availability

The data sets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

JK helped to conceptualize the collaboration tool and wrote the first draft of the manuscript. IH helped to conceptualize the collaboration tool, implemented the usability test, and reviewed the manuscript. MS helped to conceptualize the collaboration tool and reviewed the manuscript. EB helped to conceptualize the collaboration tool and reviewed the manuscript. CS helped to conceptualize the collaboration tool and reviewed the manuscript. MP helped to conceptualize the collaboration tool, helped program the collaboration tool, and reviewed the manuscript. MA helped to conceptualize the collaboration tool, coordinated programming of the collaboration tool, and reviewed the manuscript. All authors have read and approved the manuscript. CS is currently working independently in London, UK.

Conflicts of Interest

Inga Hege is associate editor of BMC Medical Education. Martin Adler is head of operations of Instruct gGmbH, the developer of Casus. Manfred Platz works at Instruct gGmbH. No other authors have conflicts of interest.

Multimedia Appendix 1

Adaptions to SimpleWebRTC signalmaster from andYet and the additions to SimpleWebRTC.

[[DOCX File , 14 KB - mededu_v8i3e24306_app1.docx](#)]

Multimedia Appendix 2

The communication between the host system (in our studies CASUS) and the communication framework based on SimpleWebRTC with standard JavaScript.

[[DOCX File , 15 KB - mededu_v8i3e24306_app2.docx](#)]

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Abbreviations

API: application programming interface

FAMULUS: Fostering Diagnostic Competences in Medical Education and Teacher Training Through Adaptive, Online Case-Simulations

ICAP: interactive, constructive, active, and passive

STUN: simple traversal of user datagram protocol through network address translators

SUS: System Usability Scale

TURN: traversal using relays around network address translators

VP: virtual patient

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Original Paper

A Stroke Rehabilitation Educational Program for Occupational Therapy Students and Practitioners: Usability Study

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Abstract

Background: There are gaps in knowledge translation (KT) of current evidence-based practices regarding stroke assessment and rehabilitation delivered through teletherapy. A lack of this knowledge can prevent occupational therapy (OT) students and practitioners from implementing current research findings.

Objective: The aim of this pilot study was to create an educational program to translate knowledge into practice regarding the remote delivery of stroke assessment and rehabilitation to OT students and practitioners. Four areas of focus were addressed in the educational program, including KT, task-oriented training, stroke assessments, and telerehabilitation.

Methods: Two pilot studies were conducted to assess the knowledge gained via pretests and posttests of knowledge, followed by a System Usability Scale and general feedback questionnaire. Participants in study 1 were 5 OT practitioners and 1 OT assistant. Participants in study 2 were 9 current OT students. Four 1-hour modules were emailed weekly to participants over the course of 4 weeks, with each module covering a different topic (KT, task-oriented training, stroke assessments, and telerehabilitation). Preliminary results were reviewed using descriptive statistics.

Results: Statistically significant results were found with increased scores of knowledge for both students and practitioners. Most of the educational modules had an above-average score regarding value and positive feedback for the educational program as a whole from the participants.

Conclusions: Overall, the results of this pilot study indicate that a web-based educational program is a valuable, informational method of increasing the translation of knowledge in the remote delivery of stroke assessment and rehabilitation. OT students and practitioners found the information presented to be valuable and relevant to their future profession and current practice.

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KEYWORDS

knowledge translation; task-oriented training; stroke assessments; telerehabilitation; occupational therapy; students; practitioners; educational program

Introduction

Background

The scope of health care knowledge rapidly changes as emerging research is published about best practices; however, there is often a gap between the dissemination and implementation of research into health care practice. Unfortunately, this gap

between dissemination and implementation decreases the timely use of valuable research, limiting patients' opportunity to benefit from effective treatments [1]. Without the application of research to health care practice, patients cannot benefit from advances that will improve outcomes and reduce the amount of required medical treatment.

One way to close this gap is through knowledge translation (KT). The Canadian Institutes of Health Research defines KT as “the exchange, synthesis, and ethically sound application of knowledge within a complex system of interactions among researchers and users” that ultimately leads to “improved health, more effective services and products, and a strengthened healthcare system” [2]. Using the knowledge-to-action framework, KT is described as a 2-part cycle—the creation of knowledge and the application of knowledge into practice by relating it to specific situations [3]. The process of KT has been shown to benefit practitioners in the field of occupational therapy (OT) in practice areas such as stroke rehabilitation [4]. A stroke occurs every 40 seconds in the United States, making it a leading cause of disability that yields a multitude of functional impairments for almost 800,000 individuals each year [5-7]. Stroke rehabilitation is a significant practice area for OT because of the high prevalence of stroke and the variety of subsequent impairments that can interfere with an individual’s ability to perform activities of daily living [5-7]. Unfortunately, there are barriers that inhibit the KT process within this field.

Barriers to KT include difficulty with accessing and interpreting research, the overwhelming amount of research available, an overall focus on the validity of research rather than its applicability, and an inability to generalize research findings to nonspecific situations [2,3]. These obstacles contribute to the gap between research and clinical practice [2]. In an effort to overcome these barriers and lessen the KT gap in stroke rehabilitation, an educational program for OT practitioners and students relevant to the remote delivery of stroke rehabilitation was needed. Therefore, in this study, we selected 4 topic areas to be the focus of a web-based educational program—telerehabilitation, task-oriented training (TOT), stroke assessments, and KT. These topics were specifically chosen for this study as they address the following components of stroke rehabilitation: telerehabilitation as a practical method of rehabilitation delivery [8-11], TOT as an evidence-based intervention [12-14], stroke assessments as a feasible method to measure client performance and progress [6,15-24], and KT as a driving force behind closing the knowledge-to-action gap [2-4].

Telerehabilitation uses communication technology to provide rehabilitation services and has connected health care providers and recipients in many situations. This allows clients to receive adequate treatment from qualified providers without concern for distance and unnecessary public exposure [8]. Telerehabilitation has become more prevalent in recent years not only because of advancements in technology but also because of the advent of the COVID-19 pandemic in 2020. In addition to decreasing public exposure, this service delivery model circumvents many barriers that prevent those who have experienced a stroke from receiving OT services such as transportation issues, caregiver burden, and absence of local facilities, especially in rural areas [9]. It enhances access to services and specialists, encourages collaboration among other professionals, and prevents service delivery delays [10]. There is a misconception that at-home telerehabilitation therapy services are insufficient when compared with typical in-person services. However, a study by Tchero et al [11] found that clients

after stroke who participated in telerehabilitation services progressed at a rate similar to those receiving care as usual. In addition, another study by Simpson et al [25] found that those recovering from a stroke at home spent less time sitting and more time upright and mobile. For these positive results to persist, practitioners must be aware of best practices in the field of telerehabilitation as it pertains to clients after stroke such as the TOT intervention method.

TOT, or task-specific training, is a “repetitive and intense practice of meaningful, goal-oriented activities” [12]. Winstein and Stewart [13] measured the effectiveness of task-specific training against other intervention methods for patients, and they identified it as the most effective intervention approach for those who experienced a mild to moderate stroke [13]. This intervention approach is made up of components including guided discovery; neuroplasticity; occupational adaptation; motor learning; shaping; relevance to client and context; randomly assigned, repetitive, and involved mass practice; reconstruction of the whole task; and reinforcement of positive and timely feedback [14]. Each component works toward improving the client’s ability to complete their daily occupations independently. Understanding the tenets of TOT allows practitioners and students the opportunity of practical implementation into their everyday practice when working with clients. As recent years have given rise to telerehabilitation, carryover of a TOT program in a home environment is desirable. When deciding to use this intervention method, proper care must be taken in deciding how to assess one’s client.

Within the realm of stroke rehabilitation, assessments are used to measure functional deficits, identify client goals, guide intervention, and serve as outcome measures to track progress [6,15]. Current practitioners and students must be aware of the assessments predominantly used when treating clients who have experienced a stroke, and they must be educated on up-to-date, evidence-based research. Although numerous assessments are used in stroke rehabilitation, the following relevant assessments can be administered remotely while retaining their acceptable psychometrics: the Fugl-Meyer Assessment, the Stroke Impact Scale, the Canadian Occupational Performance Measure, the Motor Activity Log, the Confidence in Arm and Hand Movements scale, the Activities-specific Balance Confidence scale, and the brief self-efficacy rating. These assessments can be conducted through videoconferencing [16,17], structured or semistructured interviews [18-21], or self-reported questionnaires [22-24]. Consequently, these assessments are feasible for remote administration and are valuable tools for use during telerehabilitation for stroke intervention [11,26]. The findings of See et al [27] indicate that detailed training in the administration of stroke assessments leads to increased accuracy and decreased variance in assessment scores. As a result, this study seeks to implement education to improve the ability of OT practitioners and students to remotely administer stroke assessments, thereby closing the knowledge-to-action gap regarding the use of stroke assessments within telerehabilitation. KT in this way will enhance the ability of OT practitioners and students to remotely assess functional performance and track progress of clients with stroke.

Remote delivery was considered an important focus of this study as a systematic review indicated that telerehabilitation is equivalent to in-person care regarding quality of life, patient satisfaction, and caregiver burden [11]. One finding from this systematic review indicated that remotely delivered care can provide results that are not only equivalent to in-person care but are also more cost-effective [11]. On the basis of the cost efficiency and comparable results provided by telerehabilitation, the decision to base the current educational program on remote delivery was made. In addition, an observational study indicated that patients at home are generally more active than their counterparts in hospitals, providing further incentive for this study to focus on remotely delivered stroke rehabilitation [25].

Objectives

The methodology for this educational program was modeled after a feasibility study by Luconi et al [28], in which weekly emails were sent to participants to promote best practices in stroke rehabilitation. The results from this study indicated that a web-based educational program is both a feasible and successful platform to inform therapy practitioners about best practices [28]. Similarly, the pretraining and posttraining measures from a pilot evaluation study indicated that a web-based platform can be a successful method for teaching educational content to OT students [29]. On the basis of the positive results of these studies, a web-based educational program sent via email was selected for this study, which included both OT practitioners and students. To measure the value of the educational program from the perspective of the participants, this study used the System Usability Scale (SUS) because of its validity, ease of use, and reliability with small sample sizes [30].

Research has shown that practitioners have a strong desire to facilitate KT but require the material to be presented in a flexible, easily accessible, and inexpensive manner [31]. Practitioners deem free, web-based training programs to be the most feasible [31]. Therefore, this study provided a web-based educational program to inform OT students and practitioners about the topic areas of KT, telerehabilitation, TOT, and stroke assessments. The purpose of this study is two-fold: (1) to increase the knowledge of OT practitioners and students regarding stroke rehabilitation and (2) to find a valuable, user-friendly method of delivering that knowledge.

Methods

Overview

Data were collected and analyzed separately for 2 studies, referred to as study 1 and study 2. Study 1 consisted of participants who were OT practitioners, and study 2 consisted of participants who were OT students.

Ethics Approval

Institutional review board approval of Georgia State University was obtained for each study (approval number: H21592).

Study Design

Both study 1 and study 2 are pilot studies including preliminary measures to assess knowledge gained via pretests and posttests

of knowledge and program usability via the SUS, and general feedback questionnaires were included within the posttests.

Participants

Study 1

Snowball sampling of convenience over the course of a 2-week recruitment period was used to enroll 6 OT practitioners. All the recruited practitioners agreed to participate, resulting in a recruitment rate of 100% (6/6). Inclusion criteria for the study required practitioners to have a current US OT or OT assistant license and >2 years of experience working with survivors of stroke.

Study 2

Convenience sampling via email was used to enroll 10 OT graduate students over the course of a 2-week recruitment period. For inclusion in the study, students needed to be OT students within the state of Georgia in a master's or doctoral program. Students were excluded from the study if they had participated in stroke rehabilitation research to ensure a similar baseline of knowledge among the student participants. Recruitment rate of the student population was 11% (10/88).

Data Collection Process

For both studies, identical educational modules and participant instructions were administered via email. The educational program lasted 4 weeks with a new module sent out each Friday to the participants via email, allotting one week per module. The 4 modules were sent out in the following order: KT, TOT, stroke assessments, and telerehabilitation (Figure 1). The modules were created by the authors using evidence-based publications, including randomized controlled trials, meta-analyses, and systematic reviews. In addition, the modules were created in collaboration with and evaluated by an expert in stroke rehabilitation who had >25 years of experience and an extensive background in research.

The first module, "Knowledge Translation," defined KT and its importance, what is included in the KT process, how to effectively bridge the knowledge to practice gaps, and how to implement the knowledge-to-action model. This module included evidence-based articles describing KT, why it is important in the health care field, and how to use it explicitly in the OT field.

The second module, "Task-Oriented Training," included information on the definition, the different components, and how TOT is used in practice. The information from this module was obtained from evidence-based articles that studied the performance and use of TOT for patients who have experienced a stroke.

The third module, "Stroke Assessments," included information about the following 7 assessments that are commonly used within stroke rehabilitation and were deemed feasible for remote delivery: the Fugl-Meyer Assessment, Stroke Impact Scale, Canadian Occupational Performance Measure, Motor Activity Log, Confidence in Arm and Hand Movements scale, the Activities-specific Balance Confidence scale, and brief self-efficacy rating form. The information included for each

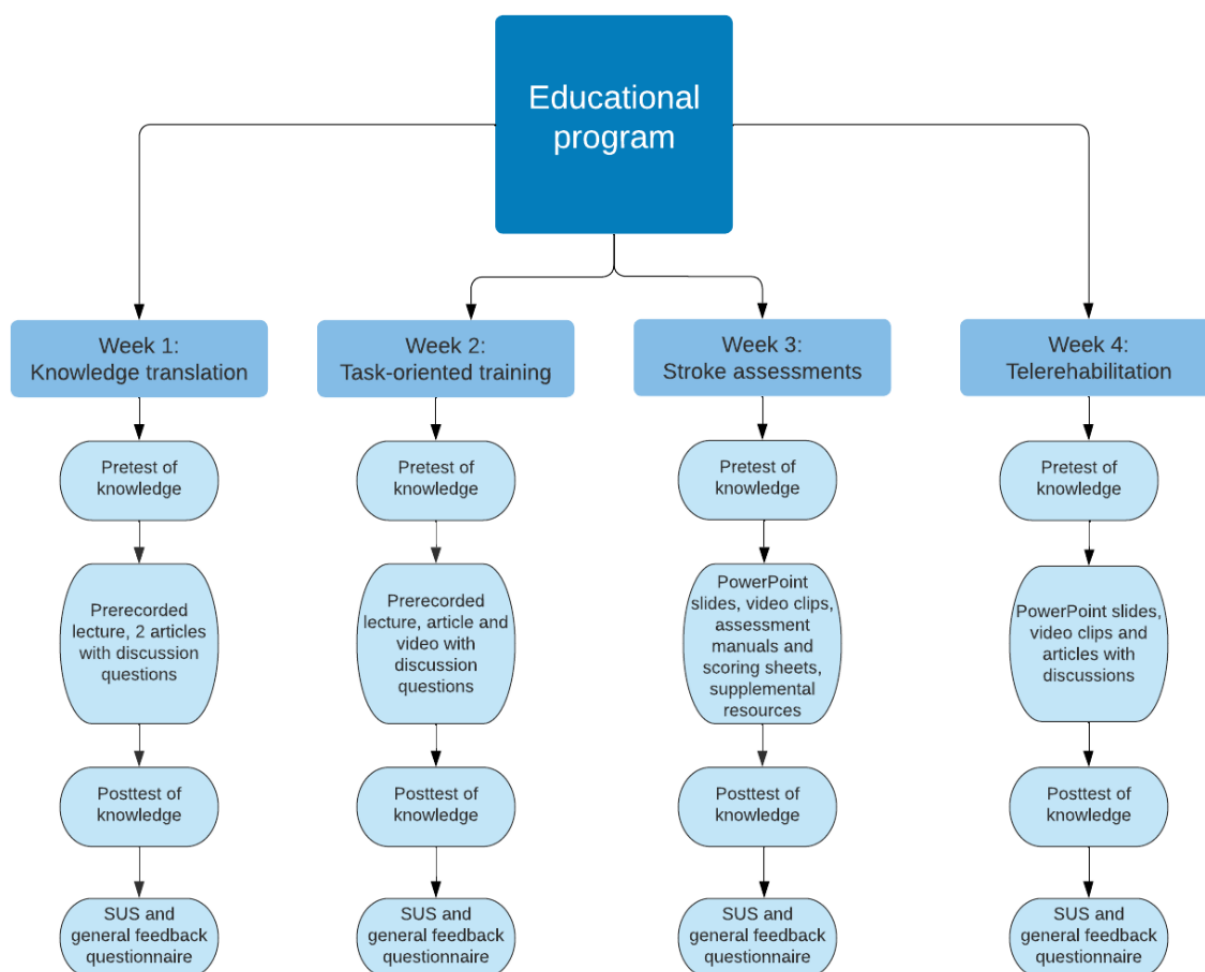
assessment detailed what the assessment measures were, how they were administered, and how they were scored.

The fourth module, “Telerehabilitation,” included information on the growing benefits of internet-based therapy sessions within the rehabilitation community, along with the advantages and disadvantages of an internet-based platform. Evidence-based research promoting the benefits of telerehabilitation was included along with strategies for conducting a smooth telerehabilitation session with minimal technical glitches while promoting therapeutic alliance.

At the start of each module, participants were prompted to take a pretest of knowledge to determine their baseline comprehension of the subject matter being presented in the module. The questions were specific to the module topic (KT, TOT, stroke assessments, and telerehabilitation). After the participants completed the pretest of knowledge, they were

instructed to complete the educational modules, which were designed to take approximately an hour to complete. Participants reviewed the modules asynchronously at convenient times of their choice, so they were permitted to pause and resume the modules throughout the week as needed. The modules included various forms of educational materials, including PowerPoint slides, discussion posts, and videos. Supplemental materials were also included in some of the modules for participants seeking additional information beyond what was required for the study, such as stroke assessment forms and journal articles. Upon completion of each module, participants took a posttest of knowledge. The posttest contained the same questions that were included in the pretest of knowledge to determine whether the participants learned the information provided through the modules. The results informed the study by showing whether the module content was presented clearly to the participants, allowing them to grasp the information.

Figure 1. A visual outline of the educational program. The program consisted of 4 educational modules with 1 module emailed to participants each week to be completed asynchronously. Included in each module was a pretest of knowledge, educational material, posttest of knowledge, System Usability Scale (SUS), and general feedback questionnaire to be completed in that order. The educational materials included in each module were Microsoft PowerPoint slides, lectures, discussion posts, evidence-based articles, and videos.



Participants' ratings and reports of the usability and value of the educational modules were collected using the SUS and general feedback questionnaire. The SUS used in this study has been determined to be both reliable and valid for determining the feasibility and ease of use for module delivery [30,32]. The SUS requires participants to rank a series of system usability statements using a 5-point Likert scale of "strongly disagree" to "strongly agree." Statements presented in the SUS included, "I found the various functions in these modules well integrated," "I thought this information was easy to use," and "I feel very confident using this information." A series of general feedback questions were administered to determine participants' overall satisfaction with the educational program, including statements such as "How relevant was this information on your education/practice?" "How likely are you to use this information?" "How likely would you be to recommend this program?"

Data Analyses

Identical data analyses were conducted for both study 1 and study 2. Qualtrics (Qualtrics International Inc) was used to collect data from the pretests and posttests of knowledge, SUS, and general feedback questions. Excel (Microsoft Corporation) and SPSS (version 27; IBM Corp) were used to analyze the descriptive results. Wilcoxon signed-rank test was used to compare the pretest and posttest scores of knowledge for each module. This test was selected because of the small sample size that did not represent a normal distribution.

After examining the studies separately, data from study 1 and study 2 were analyzed together using a Wilcoxon signed-rank test to assess the overall educational program. For both the SUS and the general feedback questionnaire, the Likert scales were converted to a corresponding number scale of 1 to 5 with number 1 corresponding to strongly disagree, 2 corresponding to

disagree, 3 corresponding to neutral, 4 corresponding to agree, and 5 corresponding to strongly agree. Finally, all participants were encouraged to provide comments about the educational program through an open response section.

Results

Participants

Overview

Study 1 enrolled a total of 6 participants and obtained responses (6/6, 100%) from all participants throughout the study. Study 1 included 5 OTs and 1 OT assistant who currently practice within the United States. Study 2 originally recruited 10 Georgia State University OT graduate students, 9 of which were second-year students and 1 was a first-year student. Before beginning the modules, 1 second-year student withdrew from the study. Throughout study 2, 9 participants had a response rate of 92% (33/36; 2 nonresponders from module 3 "Stroke Assessments" and 1 nonresponder from module 4 "Telerehabilitation").

Study 1

The participants demonstrated an increase in knowledge for 3 of the 4 modules. As seen in Table 1, the median score increased by 40% from module 2 "Task-Oriented Training" pretest to posttest of knowledge. The median scores also increased substantially for module 3 "Stroke Assessments" (median scores increased by 37.5%) and module 4 "Telerehabilitation" (median scores increased by 12.5%). Module 1 "Knowledge Translation" was an exception, with the median scores remaining the same at both the pretest and posttest of knowledge. Knowledge gained from module 3 "Stroke Assessments" was the only module that demonstrated a statistically significant difference from pretest to posttest of knowledge with the Wilcoxon signed-rank test.

Table 1. Study 1—practitioner participants: changes in knowledge for each module (N=6).

	Sample, n (%)	Values, mean (SD)	Values, median (IQR)	P value	z-score
Module 1: "Knowledge Translation"				.08	1.732
Pretest of knowledge	6 (100)	76.67 (0.15)	80 (60-85)		
Posttest of knowledge	6 (100)	86.67 (0.10)	80 (80-100)		
Module 2: "Task-Oriented Training"				.05	1.947
Pretest of knowledge	6 (100)	66.67 (0.21)	60 (55-85)		
Posttest of knowledge	6 (100)	93.33 (0.10)	100 (80-100)		
Module 3: "Stroke Assessments"				.046	2.00 ^a
Pretest of knowledge	6 (100)	56.25 (0.22)	50 (46.88-62.50)		
Posttest of knowledge	6 (100)	81.25 (0.17)	87.5 (68.75-90.63)		
Module 4: "Telerehabilitation"				.13	1.511
Pretest of knowledge	6 (100)	29.17 (0.25)	37.5 (0-50)		
Posttest of knowledge	6 (100)	54.17 (0.19)	50 (43.37-75)		

^aP<.05.

Study 2

The participants demonstrated an increase in knowledge in all 4 modules. As seen in Table 2, the median score increased by 20% from module 2 “Task-Oriented Training” pretest to posttest of knowledge. The median scores also increased substantially for module 3 “Stroke Assessments” (median scores increased by 62.5%) and module 4 “Telerehabilitation” (median scores

increased by 75%). Module 1 “Knowledge Translation” was an exception, with the median scores remaining the same at both the pretest and posttest of knowledge. A Wilcoxon signed-rank test conveyed a statistically significant difference in knowledge gained from pretest to posttest in 2 modules, as seen in Table 3 (module 3 “Stroke Assessments,” $P=.02$; module 4 “Telerehabilitation,” $P=.01$).

Table 2. Study 2—student participants: changes in knowledge for each module (N=10).

	Sample, n (%)	Values, mean (SD)	Values, median (IQR)	P value	z-score
Module 1: “Knowledge Translation”					
Pretest of knowledge	9 (90)	88.89 (0.15)	100 (80-100)	.71	0.378
Posttest of knowledge	9 (90)	91.11 (0.11)	100 (80-100)		
Module 2: “Task-Oriented Training”					
Pretest of knowledge	9 (90)	82.22 (0.21)	80 (70-100)	.06	1.890
Posttest of knowledge	9 (90)	95.56 (0.09)	100 (90-100)		
Module 3: “Stroke Assessments”					
Pretest of knowledge	7 (70)	25 (0.18)	25 (12.5-37.5)	.02	2.388 ^a
Posttest of knowledge	7 (70)	87.5 (0.14)	87.5 (75-100)		
Module 4: “Telerehabilitation”					
Pretest of knowledge	8 (80)	0 (0)	0 (0)	.01	2.539 ^a
Posttest of knowledge	8 (80)	68.75 (0.26)	75 (50-93.75)		

^a $P<.05$.

Table 3. Studies 1 and 2 combined: changes in knowledge for each module (N=16).

	Sample, n (%)	Values, mean (SD)	Values, median (IQR)	P value	z-score
Module 1—“Knowledge Translation”					
Pretest of knowledge	15 (94)	84 (0.15)	80 (80-100)	.21	1.265
Posttest of knowledge	15 (94)	89.33 (0.10)	80 (80-100)		
Module 2—“Task-Oriented Training”					
Pretest of knowledge	15 (94)	76 (0.22)	80 (60-100)	.01	2.547 ^a
Posttest of knowledge	15 (94)	94.67 (0.09)	100 (80-100)		
Module 3—“Stroke Assessments”					
Pretest of knowledge	13 (81)	39.42 (0.25)	37.5 (18.75-50)	.003	2.971 ^b
Posttest of knowledge	13 (81)	84.62 (0.15)	87.5 (75-100)		
Module 4—“Telerehabilitation”					
Pretest of knowledge	14 (88)	12.5 (0.21)	0 (0-31.25)	.002	3.028 ^b
Posttest of knowledge	14 (88)	62.5 (0.24)	62.5 (50-75)		

^a $P<.05$.

^b $P<.01$.

Combined Results for Study 1 and Study 2

The participants demonstrated an increase in knowledge for 3 of the 4 modules. As seen in Table 3, the median scores increased by 20% from module 2 “Task-Oriented Training” pretest to posttest of knowledge. The median scores also increased substantially for module 3 “Stroke Assessments” and

module 4 “Telerehabilitation.” Module 3 “Stroke Assessments” median scores increased by 50% from pretest to posttest of knowledge. The module 4 “Telerehabilitation” scores increased by 62.5% from pretest to posttest of knowledge. Module 1 “Knowledge Translation” was an exception, with the median scores remaining the same at both the pretest and posttest of knowledge. Three modules showed statistical significance with

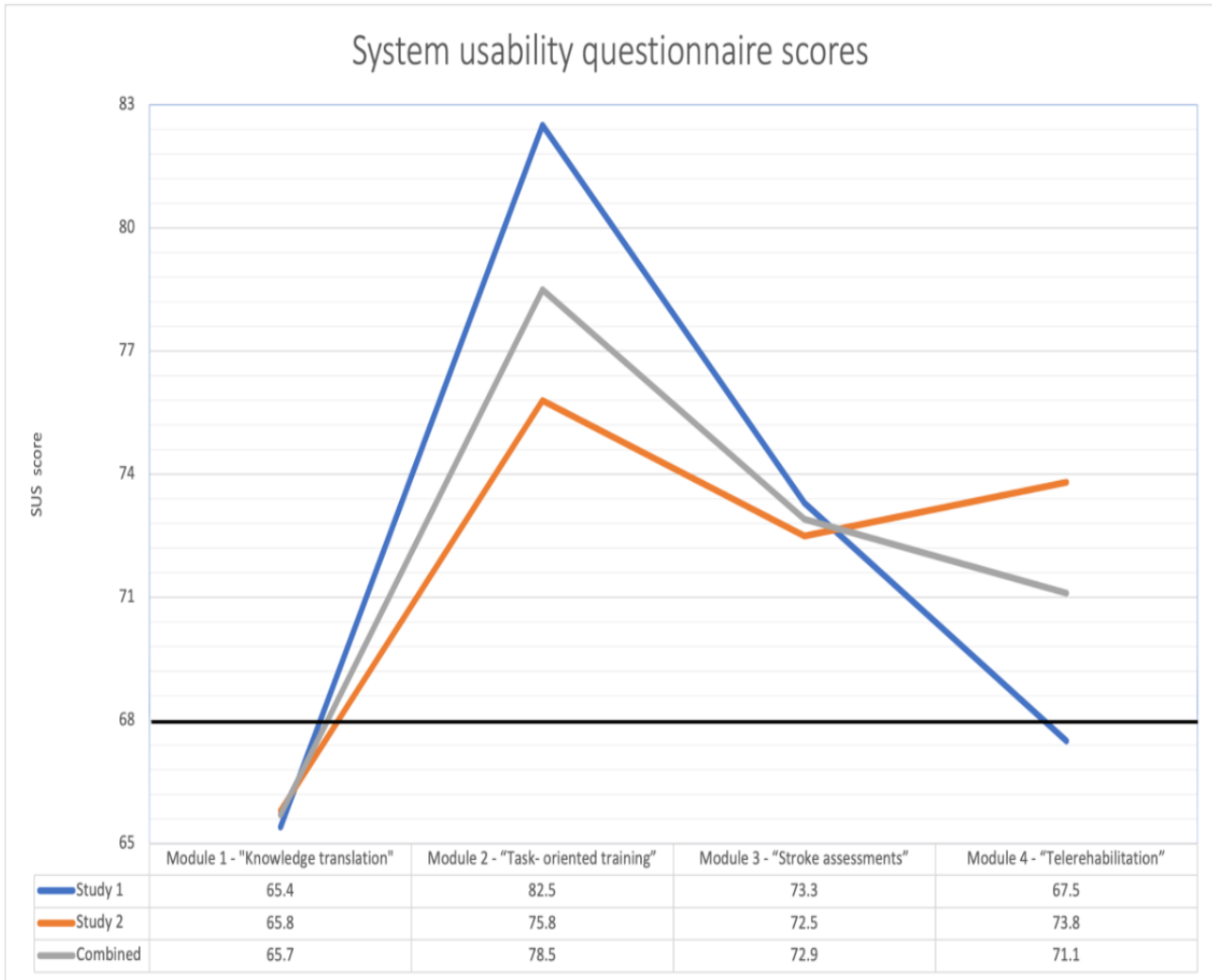
the Wilcoxon signed-rank test through knowledge gained from pretest to posttest of knowledge as seen in Table 3 (module 2 “Task-Oriented Training” $P=.01$; module 3 “Stroke Assessments” $P=.003$; module 4 “Telerehabilitation” $P=.002$).

SUS Scores

Both study 1 and study 2 results from SUS support the value of a web-based education program format. Scores >68 are

considered above average on the SUS [30]. As seen in Figure 2 for both studies individually and combined, the SUS scores were above average for module 2 “Task-Oriented Training” and module 3 “Stroke Assessments.” System usability for module 4 “Telerehabilitation” was above average only in study 2 and studies 1 and 2 combined. System usability for module 1 “Knowledge Translation” was not above average in either study 1 or study 2.

Figure 2. System Usability Questionnaire Scores for each module in Study 1, Study 2, and Combined.



General Feedback

Participants rated overall opinions on the program, and some participants voluntarily added anecdotal written comments. General feedback about the modules was positive. Study 1 reported that 85% (122/144) of the participants were likely to recommend this educational program to their peers. Furthermore, 90% (130/144) of the study 1 participants stated that they found the information to be relevant to their practice. Study 1 participants also reported 85.8% (123.5/144) satisfaction with the educational modules. One practitioner commented on module 3 “Stroke Assessments,” “I learned something new I can bring to adult neuro practice and will advocate for new assessment tools.” Other comments from practitioners focused on the “relevance of TOT” and how telehealth practices were reinforced. Another practitioner commented that module 1

“Knowledge Translation,” “reminded [them] that knowledge translation was a powerful tool for evidence-based practice.” Study 2 reported that 90.3% (149/165) of the participants were likely to recommend this program to their peers. Study 2 reported that 93.3% (154/165) of the participants were satisfied with the modules, and 89.1% (147/165) of study 2 participants reported that the information was relevant to their future practice. In study 2, some descriptive anecdotal feedback included that it was “easily understood,” “a great resource,” “very relevant,” and “beneficial.” One student stated that the information presented in these modules “made the topic of telerehabilitation less intimidating.”

Discussion

Principal Findings

This pilot study examined the value of a web-based educational program for current OT practitioners and students. Participants learned current evidence-based aspects of KT, TOT, stroke assessments, and telerehabilitation. This study was designed to bridge the gap in KT from evidence-based research to clinical practice and to assess the knowledge gained from the educational modules and the feasibility of the delivery system. On the basis of a study performed by Damarell and Tieman [31], where the practitioners found free web-based training programs to be the most feasible platform for delivery, the researchers chose a web-based delivery of the modules. The same study also found that for its population, a web-based training platform was the most accessible for both the students and practitioner groups. This was because of the flexibility of completion, delivery method, and design of the educational materials. The results from this study were examined from a sample of practitioners (study 1), from a sample of students (study 2), and from both samples combined.

Overall knowledge of participants, in both the student and practitioner groups, increased after their review of KT, TOT, stroke assessments, and telerehabilitation modules. In particular, knowledge of stroke assessments increased the most for practitioners; however, knowledge from pretest to posttest also improved with exposure to education in KT, TOT, and telerehabilitation. For the student sample, a similar statistically significant increase in knowledge was related to stroke assessment and telerehabilitation. The lack of significant differences in the knowledge gained from the KT and TOT modules may be because of the participants' prior knowledge as related to their educational curriculum or clinical experiences in these areas. Although this study included a small sample size, the results could point to increased fortification of OT programs related to stroke assessments, as this was an area of great improvement for both students and practitioners. The results of this study can provide guidance to OT educators and continuing education developers on what topics need to be focused on more in the future.

At the conclusion of each module, the participants were asked to evaluate the information presented and the program as a whole using the SUS. The usability of the overall educational program was above average. Specifically, practitioners rated the TOT and stroke assessment modules as the most usable. The student sample rated the individual modules for TOT, stroke assessments, and telerehabilitation as the most valuable modules. General feedback revealed that most participants rated an increase in confidence when using the information provided in these modules. Participants also reported that they were likely to recommend this program to their peers and were satisfied overall with the educational program. Comments from the general feedback questionnaire reflected the information provided within the modules in a positive light. The participants commented on the relevance to their current or future practice and the usefulness of the information provided. The comments provided by the participants reinforced the success of the

educational program's ability to increase knowledge regarding stroke rehabilitation and provide both students and practitioners with information that can be used to enhance their ability to treat clients.

When looking at the combined results from the 2 studies, an increase was found between the pretest and posttest scores of knowledge. Analyses found TOT, stroke assessments, and telerehabilitation modules to significantly increase knowledge for both groups of participants combined. The KT module was not found to be statistically significant; however, it demonstrated a trend toward significance. The TOT, stroke assessments, and telerehabilitation modules had above-average scores regarding usability from the SUS. Overall, the combination of SUS scores for study 1 and study 2 revealed that usability was above average.

The results, similar to those of Luconi et al [28], confirmed the effectiveness of using a web-based delivery method to disseminate educational information via email to enhance practitioners' knowledge regarding stroke rehabilitation. The results from this study are similar to those reported by Reid [29]. Reid [29] found that web-based curriculum programs can be used to increase knowledge through the use of pretests and posttests of knowledge in OT students regarding various topics. One component differing from this study and the study completed by Reid [29] was the use of informal practice exercises to increase knowledge.

Limitations identified within this study curtail the ability to generalize findings to a larger population. Practitioners were recruited within the same area of practice and reported varying years of experience. This could have influenced prior knowledge of the topics addressed in the modules and therefore increased scores between pre- and posttests for this group. In addition, all the recruited student participants were from the same university, thus limiting the generalizability to students in other geographic areas. Furthermore, the recruitment rate of the student population was low. Students who did not agree to participate verbalized their decision because of the increased academic demands during the time of year the study was conducted. Participants from both the practitioner and student populations reported some prior knowledge related to the information presented in the modules, which could impact the change in knowledge obtained. Specifically, practitioners reported prior knowledge regarding stroke assessments, as related to their current field of practice, and students reported prior knowledge regarding KT and TOT, as was previously taught in their OT curriculum. Finally, the sample size in this pilot study was relatively small, which reduces the power of this study and increases the margin of error. A larger sample size is recommended for future studies to confirm these findings.

Conclusions

Overall, the results of this pilot study indicate that a web-based educational program is a valuable and informative method of translating knowledge of current evidence-based information regarding the remote delivery of stroke assessment and rehabilitation. This study obtained preliminary results from both students and practitioners that the information presented was valuable and relevant to their future profession and current

practice, respectively. These results are valuable to consider regarding the rising prevalence of the use of telerehabilitation related to the COVID-19 pandemic and for populations who have limited access to services such as clients in rural or underserved areas.

Limitations

This study was a preliminary approach that focused on the usability of the educational modules, and thus, several lessons were learned that should be applied to future research. To preserve anonymity, participants did not have unique identifiers, which prohibited researchers from tracking each participant's specific knowledge shift and ability to follow up with participants who did not complete each module. This also kept researchers from having definitive knowledge of individually paired pretest knowledge scores to posttest knowledge scores. However, participants' test completion led to a reasonable pairing of pretests to posttests. If a form of identification would have been provided, researchers could have also identified whether years of experience or years in OT school had an influence on the knowledge gained throughout the modules.

Thus, a more accessible platform for the distribution of the educational modules would be beneficial. There were several challenges with emailing large files and additional resources to the participants. The lack of a significant change in the knowledge attained in some modules calls for the reconstruction of some modules to further increase knowledge. Participants may also benefit from having >1 week to complete each module to facilitate a more consistent response rate across modules. The students and practitioners who participated in this study

had to complete the educational modules in addition to their personal and work responsibilities. The short time frame given to the participants could have caused them to rush through the module information. Increasing the time allotted to participants to complete each module could increase the response rate and improve the overall posttest knowledge scores within the study. In addition, adding an in-person component to the educational modules could facilitate additional practice and increase the amount of knowledge retained from each module. Finally, standardizing the form of the tests of knowledge across each module would better validate knowledge changes. Various forms of questions, including the use of "check all that apply" and multiple choice were used throughout each module. Having a consistent format for questioning would increase the accuracy of reporting knowledge results.

Despite these limitations, the results of this pilot study indicate that a remotely delivered educational program is a valuable and effective method to decrease the gap between research and clinical practice regarding stroke assessment and rehabilitation for OT students and practitioners. These findings support and have implications for the use of web-based educational programs to increase knowledge and carryover from research to clinical practice. Going forward, it would be beneficial to investigate and track the impact that asynchronous learning and remote educational programs have on implementing interventions and techniques in clinical practice. Such a program has the potential to improve health care and rehabilitation treatment for patients with stroke as well as promote continued education regarding various aspects of the ever-changing rehabilitation environment.

Conflicts of Interest

None declared.

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Abbreviations**KT:** knowledge translation**OT:** occupational therapy**SUS:** System Usability Scale**TOT:** task-oriented training

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Original Paper

An Innovative Use of Twitter to Disseminate and Promote Medical Student Scholarship During the COVID-19 Pandemic: Usability Study

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Abstract

Background: Due to the emergence of the COVID-19 pandemic in March 2020, the cancellation of in-person learning activities forced every aspect of medical education and student engagement to pivot to a web-based format, including activities supporting the performance and dissemination of scholarly work. At that time, social media had been used to augment in-person conference learning, but it had not been used as the sole platform for scholarly abstract presentations.

Objective: Our aim was to assess the feasibility of using Twitter to provide a completely web-based forum for real-time dissemination of and engagement with student scholarly work as an alternative to a traditional in-person poster presentation session.

Methods: The Brody School of Medicine at East Carolina University launched an online Medical Student Scholarship Forum, using Twitter as a platform for students to present scholarly work and prepare for future web-based presentations. A single student forum participant created posts using a standardized template that incorporated student research descriptions, uniform promotional hashtags, and individual poster presentations. Tweets were released over 5 days and analytic data were collected from the Twitter platform. Outcome measures included impressions, engagements, retweets, likes, media engagements, and average daily engagement rate.

Results: During the conference, the student leader published 63 tweets promoting the work of 58 students (55 medical and 3 dental students) over 5 days. During the forum and the following week, tweets from the @BrodyDistinctly Twitter account received 63,142 impressions and 7487 engagements, including 187 retweets, 1427 likes, and 2082 media engagements. During the 5 days of the forum, the average daily engagement rate was 12.72%.

Conclusions: Using Twitter as a means of scholarly dissemination resulted in a larger viewing community compared to a traditional in-person event. Early evidence suggests that social media platforms may be an alternative to traditional scholarly presentations. Presenting via Twitter allowed students to receive instantaneous feedback and effectively network with wider academic communities. Additional research is needed to evaluate the effectiveness of knowledge uptake, feedback, and networking.

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KEYWORDS

medical education; social media; web-based learning; innovation; Twitter; dissemination; scholarship; medical student; platform; academic promotion; COVID-19

Introduction

The emergence of COVID-19 created a period of intense uncertainty for both medical students and faculty. In the spring of 2020, cancellation of all in-person learning activities forced medical education and student engagement into a web-based format, including activities in support of performance and dissemination of medical student scholarship. Prior to the pandemic, educators at the Brody School of Medicine developed 4 longitudinal, paracurricular distinction tracks through which medical students could achieve recognition in research, service learning, medical education and teaching, or health system transformation and leadership [1]. Between the first and second year of medical school, students in each track enter an 8-week summer immersion experience with the opportunity to present their results locally to faculty and students at an annual Medical Student Scholarship Forum. COVID-19-related safety restrictions prevented traditional assembly of the forum, depriving scholars of the opportunity to create a poster or oral presentation, promote their work, experience professional interactions with peers and faculty, receive real-time feedback, and celebrate project success.

To address this problem, the distinction track leadership collaborated with East Carolina University news services to develop a student-driven web-based event, leveraging the advanced features of Twitter. Social media platforms, particularly Twitter, promote discussion of key clinical and medical education topics and disseminate evidence-based medicine [2,3]. A recent review highlighted the various educational opportunities available on Twitter, including the ability to engage in Twitter-based journal clubs, web-based case conferences, and “Tweeterials,” where a user, presumably an expert, explains an important topic or concept in a series of posts [2]. Further, many professional societies are “tweeting the meeting” at academic conferences to increase visibility and distribute content to a wider audience [3-6]. Limited but still successful, examples exist of web-based-only Twitter poster sessions, such as the annual #RSCPoster event held by the Royal College of Chemistry [7]. Our objective was to assess the feasibility of using Twitter to provide a completely web-based forum for real-time dissemination of and engagement with student scholarly work as an alternative to the traditional in-person Medical Student Scholarship Forum.

Methods

Study Population

Our study population included a total of 24 medical students participating in summer distinction track programs, as well as 32 medical and 3 dental students participating in the Summer Scholars Student Research Program, a precursor to the competitively selected Research Distinction Track. Medical and dental students not participating in the programs were excluded. Academically, all medical students were between

their first and second year, whereas all dental students had yet to start their first-year curriculum.

Event Preparation

Initially, we polled scholars regarding their preference for an indefinite postponement of this in-person event or the development of a web-based event. Scholars overwhelmingly preferred the opportunity to present their projects using a web-based approach; a Twitter account (@BrodyDistinctly) already existed to promote the activities of Distinction Track Scholars. Distinction track leadership collaborated with a representative student scholar to design a web-based event using Twitter as the platform. Prior to the event, East Carolina University’s news services office provided education regarding professional “best practices” for the use of Twitter [8]. Additionally, scholars attended an educational session on the responsible use of Twitter and were encouraged to set up a professional Twitter account.

To facilitate creation of posts, we developed a standard template that included all desired elements (Figure 1). Standard template elements included the student’s preferred name, academic year, and distinction track, as well as specific university-approved hashtags used to promote the web-based event. As a final assignment, each scholar submitted additional elements needed to create their own individual post, using the template. These sections included a “hook” or headline for their individual project and their final poster, using a university-approved template. Students were then given the option to either submit a 1-minute video to describe the results and significance of their work or allow track leadership to use their professional headshot. Web links to the poster presentations stored on a file sharing service were included in each post. Finally, the standard template included the names of the research mentors and a link to a university webpage highlighting the event.

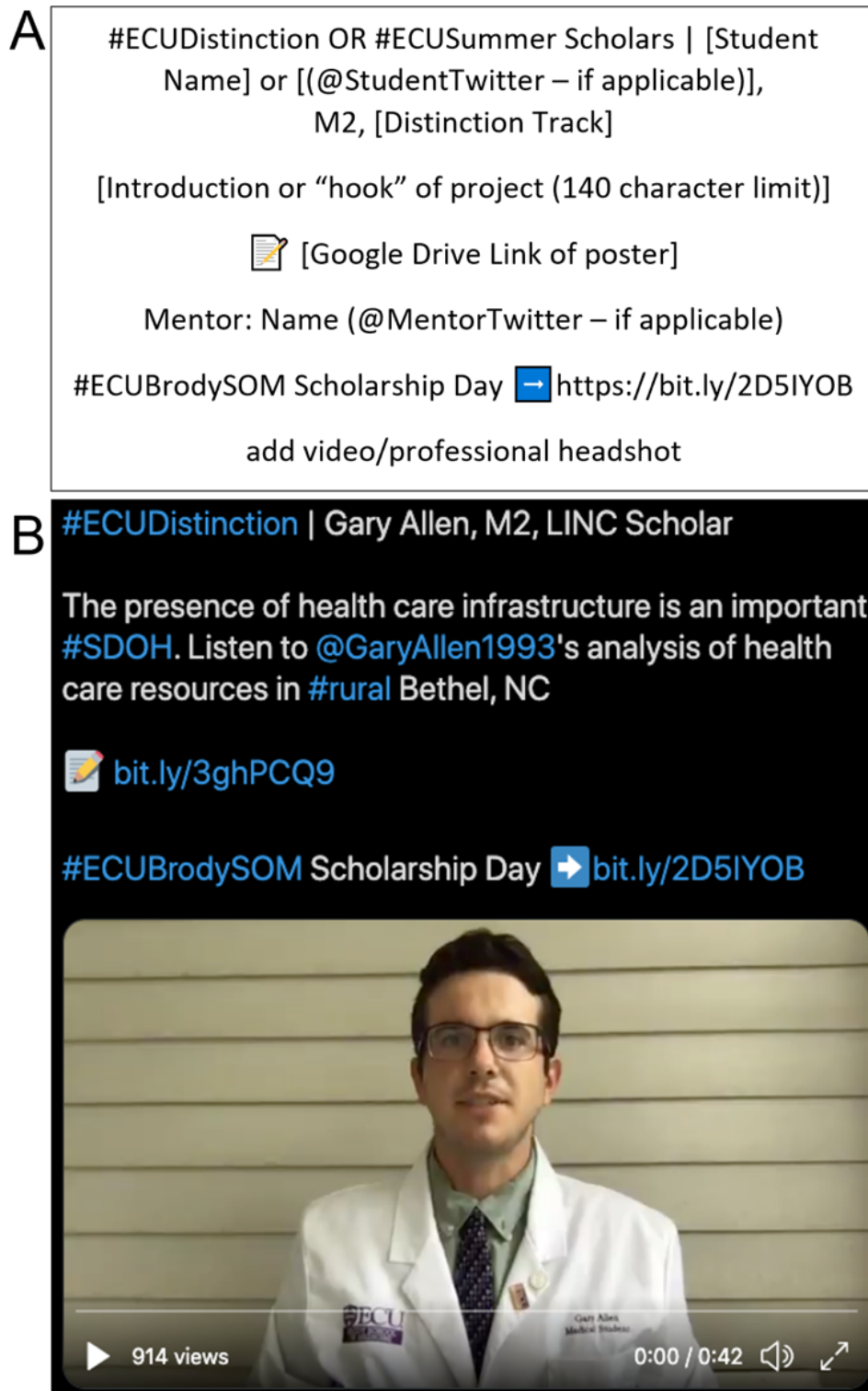
Of note, Twitter limits posts to 280 characters, so inclusion of all desired elements required innovative solutions. First, web links to poster presentations were shortened using a free URL shortening service. Additionally, electronic ideograms, commonly referred to as emojis, were used to replace words wherever possible. Lastly, students were asked to limit their research introductions to less than 140 characters. On occasion, students were asked to further shorten “hooks” to account for variations in name length among students and mentors.

Once all materials were received, the student scholar representative used TweetDeck, a free application provided by Twitter Inc, to schedule 12 posts each day, separated by 1 hour, for 5 consecutive days, from participating scholars. All content was distributed from the @BrodyDistinctly Twitter account. The distinction track leaders created this account in April 2019 to promote Distinction Track Scholars’ activities.

The event was advertised through the health sciences campuswide email listserv (with 3292 recipients) and tweeted from the Brody School of Medicine (@ECUBrodySOM; 2936

followers) and Distinction Track (@BrodyDistinctly; 172 followers) Twitter accounts. The week preceding the event, details regarding the schedule of the individual presentations were posted to the Distinction Track Twitter feed.

Figure 1. (A) Sample template with guidelines provided to students to compose their tweet; (B) example of a finalized tweet that was posted for the online Medical Student Scholarship Forum event on Twitter.



Outcome Measures

Our main outcome measures were impressions (ie, the number of times people viewed a post on Twitter), (2) engagements (ie, the number of times people interacted with a post), (3) likes (ie, the number of times people liked a post), (4) detail expands (ie,

the number of times people viewed the details of a post), and (5) retweets (ie, the number of times people retweeted a post) [9]. Lastly, we also tracked the engagement rate (ie, the number of engagements divided by the number of impressions), a common metric used by both professionals and academics to evaluate the overall performance of tweets [10,11]. These

outcomes are commonly used in professional societies as measures of successful dissemination of meeting content [11,12].

Analysis Methods

All data were obtained for free, using Twitter's basic analytics services available to all users. Date filters were used to collect data within the time frame of one week before, during, and one week after the event. Of note, analysis of the types of users (ie, students, local faculty, or outside faculty) who engaged with posts was not available for free on the Twitter platform.

Ethical Considerations

The current study was deemed not to constitute human research using the Human Research Determination Worksheet provided by the University and Medical Center Institutional Review Board of East Carolina University. This decision was confirmed by the IRB and no ethical approvals were sought.

Results

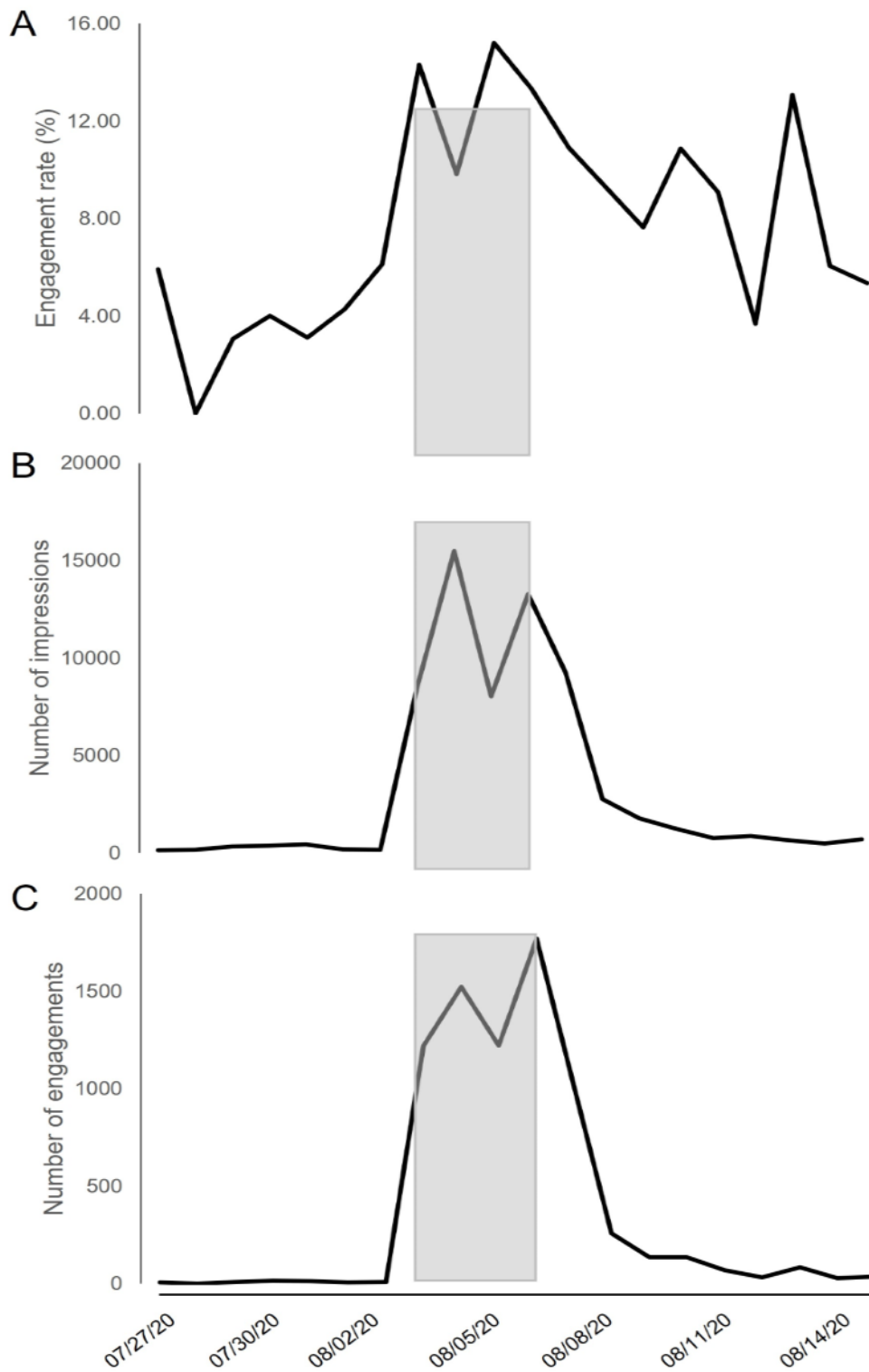
Principal Findings

The web-based Medical Student Scholarship Forum took place over 5 days (August 3-7, 2020). Data are summarized in [Figure 2](#). In the week leading up to the forum (July 27-August 2, 2020), the daily engagement rate was 3.43% (57/1662). During the forum, a total of 63 tweets promoted the work of 58 student scholars (55 medical and 3 dental students). Throughout the forum and the week following it (August 3-14, 2020), tweets from the @BrodyDistinctly Twitter account received 63,142 impressions, 7487 engagements, 1427 likes, 2082 detail expands, and 187 retweets. During the 5 days of the forum, the average daily engagement rate was 12.72% (6743/54,588)—an increase of roughly 270% from the week prior to the event. Engagement continued the week following the forum despite no additional tweets from the @BrodyDistinctly account. The postforum average daily engagement rate was 8.53% (744/8554). During

or after the forum, the highest daily engagement rate was 15.2% (1221/8025), and the lowest daily engagement rate was 3.6% (32/869). The top tweet (ie, the tweet receiving the highest number of impressions) of the event—"Drink intake is higher from 100% juice and juice-flavored drinks compared to soda and sweet tea in children with severe obesity"—earned 5855 impressions. The top media tweet (ie, the tweet with photo, video, or Vine that received the highest number of impressions)—"Outreach in diabetic and hypertensive patients serves to educate and provide necessary resources during the #COVID19 #pandemic"—earned 2705 impressions. Additionally, there were a total of 14 comments, 11 of which were generally positive (eg, "good job!"), and 3 were irrelevant. In August, the @BrodyDistinctly Twitter account acquired 49 new followers and had 2032 profile visits. Only 4 additional tweets were published from the @BrodyDistinctly account during the month of August. Prior in-person Medical Student Scholarship Forums have included approximately 65 student poster presentations and an estimated 70 faculty and student attendees. Strict in-person counts of nonpresenting attendees have not been recorded in previous years.

A total of 5 medical students from all distinction tracks were individually asked to identify the strengths and weaknesses of the web-based-only forum. They cited early exposure to web-based medical communities, convenience to create materials and participate in the conference, and distribution of their work to a wider audience as strengths of the web-based-only conference. Additionally, many recognized the importance of understanding how to create posts to promote their work in the future. Weaknesses identified included lack of prolonged discussions, critical feedback, and questions regarding their work. Additionally, some students lacked a Twitter account and chose not to make one for the event. Lastly, the design of the tweets, with research "hooks" in the tweet and posters being embedded as hyperlinks, may have decreased the total number of posters thoroughly reviewed by each participant.

Figure 2. Twitter analytics of the (A) engagement rate, (B) number of impressions, and (C) engagements with the @BrodyDistinctly account before (July 27-August 2, 2020), during (August 3-7, 2020), and after (August 8-14, 2020) the web-based Medical Student Scholarship Forum. The gray shaded area represents the 5 days of the web-based event.



Discussion

In response to unanticipated limitations for in-person gatherings due to the COVID-19 pandemic, our Twitter-based celebration of scholarship served as a successful substitute to a traditional in-person poster presentation session. Our results show that the event allowed dissemination of student scholarship to a wider

audience than previously possible. Prior in-person Medical Student Scholarship Forums have included around 65 student poster presentations and approximately 70 faculty and student attendees. During the web-based forum, the number of engagements (7487) exceeded the number of faculty and students at the School of Medicine (approximately 343 students and 445 full-time faculty). Additionally, analysis indicates that

the content of student posts, which included our standard template, a research “hook,” and various hashtags, was crafted in a way to capture the attention of users who viewed them, otherwise referred to as “engagement rate.” Multiple sources report that a “good” Twitter engagement rate ranges from 0.2% to 0.9%, with the August 2020 rate reported to be 0.18% [13]. In academia, studies have suggested that a rate of roughly 7% is considered “high engagement” [12]. Our average daily engagement rate during the 5 days of the web-based forum was 12.72%, and the average daily rate remained elevated at 8.53% for 7 days afterward. Furthermore, our report may still underestimate the overall scope of impressions and engagements due to the variability in the ways that students promoted themselves. Most notably “quoted retweets,” in which the tweet is reposted by someone with an added comment of their own, are not included in the engagement or impressions analytics of the @BrodyDistinctly Twitter account. Lastly, scholars learned how to use social media for professional self-promotion and engagement [14].

The combination of our initial survey, where students chose to have a web-based-only scholarship forum rather than no event, and focus group themes indicated general student satisfaction with the event. Students cited early introduction to #MedTwitter, a popular Twitter thread for medical professionals, as well as practicing promoting themselves on social media as advantages to the web-based event. Disadvantages mentioned included less critical feedback and interaction with poster presentations than would have been likely in an in-person poster session.

A growing body of evidence describes the incorporation of concurrent Twitter use into in-person academic conferences,

and examples exist of successful web-based-only academic poster presentations [3-6,9]. Our analysis suggests that an entirely web-based forum displaying the scholar’s projects can be an effective means to disseminate the outcomes of summer immersion programs and promote scholarly work. Considering the evidence base and the advantages identified in this analysis, we plan to continue to use Twitter to advertise and complement future in-person and web-based events. Moving forward, we will institute a dated, event-specific hashtag that can be updated annually (ie, #BSOMScholars21). We will also work to grow our Twitter followers so that the scholars’ presentations can reach a wider audience. As others seek to implement novel strategies to disseminate knowledge and network, development of best practices and approaches for social media use are necessary to effectively harness its educational and professional development potential. Future research will need to examine the relationship of reader engagement with learning and determine whether student participation in such events enhances their visibility within residency programs of interest.

Limitations of our analysis include inability to identify demographic trends of individuals who interacted with the posts. For instance, the current analytics cannot differentiate the interaction of medical school faculty who can provide career opportunities from the interaction of a supportive family member or one of the authors. Additionally, although the @BrodyDistinctly Twitter account gained 49 new followers in August, many of these were likely students who created a profile to participate in the event. Finally, as quoted retweets and any activity they generate are not measured in our program analytics, we may be underestimating the reach of our Twitter forum.

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Conflicts of Interest

None declared.

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Original Paper

Defining Potentially Unprofessional Behavior on Social Media for Health Care Professionals: Mixed Methods Study

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Abstract

Background: Social media presence among health care professionals is ubiquitous and largely beneficial for their personal and professional lives. New standards are forming in the context of e-professionalism, which are loosening the predefined older and offline terms. With these benefits also come dangers, with exposure to evaluation on all levels from peers, superiors, and the public, as witnessed in the #medbikini movement.

Objective: The objectives of this study were to develop an improved coding scheme (SMePROF coding scheme) for the assessment of unprofessional behavior on Facebook of medical or dental students and faculty, compare reliability between coding schemes used in previous research and SMePROF coding scheme, compare gender-based differences for the assessment of the professional content on Facebook, validate the SMePROF coding scheme, and assess the level of and to characterize web-based professionalism on publicly available Facebook profiles of medical or dental students and faculty.

Methods: A search was performed via a new Facebook account using a systematic probabilistic sample of students and faculty in the University of Zagreb School of Medicine and School of Dental Medicine. Each profile was subsequently assessed with regard to professionalism based on previously published criteria and compared using the SMePROF coding scheme developed for this study.

Results: Intercoder reliability increased when the SMePROF coding scheme was used for the comparison of gender-based coding results. Results showed an increase in the gender-based agreement of the final codes for the category professionalism, from 85% in the first phase to 96.2% in the second phase. Final results of the second phase showed that there was almost no difference between female and male coders for coding potentially unprofessional content for students (7/240, 2.9% vs 5/203, 2.5%) or for coding unprofessional content for students (11/240, 4.6% vs 11/203, 5.4%). Comparison of definitive results between the first and second phases indicated an understanding of web-based professionalism, with unprofessional content being very low, both for students (9/222, 4.1% vs 12/206, 5.8%) and faculty (1/25, 4% vs 0/23, 0%). For assessment of the potentially unprofessional content, we observed a 4-fold decrease, using the SMePROF rubric, for students (26/222, 11.7% to 6/206, 2.9%) and a 5-fold decrease for faculty (6/25, 24% to 1/23, 4%).

Conclusions: SMePROF coding scheme for assessing professionalism of health-care professionals on Facebook is a validated and more objective instrument. This research emphasizes the role that context plays in the perception of unprofessional and potentially unprofessional content and provides insight into the existence of different sets of rules for web-based and offline interaction that marks behavior as unprofessional. The level of e-professionalism on Facebook profiles of medical or dental students and faculty available for public viewing has shown a high level of understanding of e-professionalism.

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KEYWORDS

professionalism; e-professionalism; internet; social media; social networking; medicine; dental medicine; health care professionals; students; faculty

Introduction

Background

Social media (SM) use has long become mainstream, and both our private and professional lives are daily influenced by events, changes, and developments occurring on these web-based services. Private and professional life is interchanging, and navigating this can pose a challenge, especially for health care professionals (HCPs). New standards are forming, which are possibly loosening older and predefined terms.

Professionalism is broadly defined as behavior in accordance with professional and ethical standards of the profession and can be evaluated through ten components: professional competence, honesty in a physician-patient relationship, health professional-patient privacy, maintaining a proper relationship with the patient, improving the quality of health care, improving the availability of health care, fair distribution of resources, evidence-based knowledge, maintaining patient confidence (prevention of conflict of interest), and professional responsibility [1].

e-Professionalism is a form of professionalism that can be defined as the implementation of traditional principles of professionalism during web-based activities. It is a commitment to carry out professional tasks while adhering to ethical principles and care for the patient's well-being while using SM [2]. Cain et al [3] were the first authors who defined e-professionalism in a more concise way that can ease the operationalization of the concept as "attitudes and behaviors [some of which may occur in private settings] reflecting traditional professionalism paradigms that are manifested through digital media." When using sociological approach, through terms of norms and sanctions that define socialization in the medical profession [4], even though e-professionalism is traditionally defined as both *attitude* and *behavior*, the behavioral part of e-professionalism is more of a concern to the medical profession, because it represents a violation of the professional norms and can be susceptible to sanctions. Other terms used in the literature for the intersection between medical professionalism and SM are online professionalism or digital professionalism [5].

A large number of medical and educational institutions [6-10] have implemented guidelines for e-professional behavior. This effort to implement, teach, and adhere to e-professional behavior emphasizes how important this concept is to the medical profession.

HCPs are increasingly encountering board disciplinary proceedings, monetary fines, and even license restrictions and suspensions due to heightened awareness of rigorous ethical and legal boundaries for web-based professional behavior [11,12]. This has also been influenced by the positive shift in patient's attitudes toward educating themselves about their health on the web and gathering information about their

physicians [12]. In addition, a new problem arises, as web-based actions and events are no longer temporary. The digital footprint is everlasting and unprofessional activity can re-emerge from past events and remains ineradicable [13].

Even though research about HCPs' professionalism issues on SM and social networking sites (SNSs) began in 2010 [14,15], researchers still name a gray area between clearly professional content and unprofessional content with various terms as questionable content [14,16], potentially or questionably unprofessional content [17-19], or potentially objectionable content [20,21]. In addition to the lack of consistent terminology, there is also no consensus on the criteria needed to define or explain what these terms constitute, nor has a validated instrument been developed to assess those types of content on SM or SNSs of HCPs.

In December 2019, a paper by Hardouin et al [22] was published in the *Journal of Vascular Surgery* investigating publicly available Facebook (FB), Twitter, and Instagram profiles of young vascular surgeons for unprofessional posts. The study screened SM profiles for prespecified material categories as either clearly unprofessional or potentially unprofessional, which was based on previously published studies of unprofessional SM content among general surgery and urology residents [17,20]. A total of 3 male researchers created new anonymous SM profiles and screened the publicly available content of the SM profiles. Clearly unprofessional content was defined as *Health Insurance Portability and Accountability Act* (HIPAA) violations, intoxicated appearance, unlawful behavior, possession of drugs or drug paraphernalia, and uncensored profanity or offensive comments about colleagues or patients. Potentially unprofessional content was defined as holding or consuming alcohol, inappropriate attire, censored profanity, controversial political or religious comments, and controversial social topics. Examples of inappropriate attire cited in the publication were provocative Halloween costumes and provocative posing in bikinis or swimwear [22].

This sparked controversy, primarily on Twitter, and the #medbikini movement started on July 23, 2020, with the tweet by Dr Londyn Robinson: "Article says photos of vascular surgeons in a 'provocative pose wearing a bikini' is unprofessional. I'll say it: I wear bikinis. I am going to be a doctor. I also have a belly button ring. I am a professional person" [23]. This carried over to other SM sites and mainstream media, which criticized the lack of objectivity and bias of researchers, reviewers, and editors and created the hashtag #medbikini for the movement [24]. A great number of HCPs participated in the outrage against branding posting of such images or videos in bikinis as a possible sign of unprofessional behavior. As a revolt, they posted exactly such content with the #medbikini, showing their disapproval of such a label and referring to the gender bias of the researchers, questioning possibly outdated norms of behavior for HCPs [25]. In a month after Dr Robinson posted the original tweet [23], by the end of

August 2020, the #medbikini movement gained >55,000 tweets with 40,000 contributors ([Multimedia Appendix 1](#)). Screenshots of publicly available SM reactions to #medbikini movement are presented in [Multimedia Appendix 2](#) [23,26-30].

This has ultimately led to the retraction of the paper, invited commentary [31], and the publication of a retraction notice by the editors of the *Journal of Vascular Surgery* [22,32]. Official notice from the journal [32] was very methodologically oriented, stating the reasons for the retraction: “study did not have permission to use the list of vascular trainees, the methodology, analysis and conclusions of this article were based on published but not validated criteria, the study had significant conscious and unconscious biases caused by predominantly male authorship that supervised the assessments made by junior, male students and trainees.”

Until January 16, 2022, the #medbikini movement had reached 60,002 tweets with 40,863 contributors ([Multimedia Appendix 1](#)), 27,911 posts on Instagram, and >10,000 posts on FB ([Multimedia Appendix 2](#)). The attention that the #medbikini movement gained on SM, with numbers of an engaged audience, emphasizes the importance of e-professionalism of HCPs. It is important to raise awareness about ways that e-professionalism affects the digital footprint of all HCPs and investigate the difference between the unquestionably unprofessional posted content and very questionable potentially unprofessional content. When the #medbikini movement erupted, prior preconceptions of professionalism have started to be considered as outdated or are criticized and have potentially become dismissed. Initiatives for a new definition or at least a better understanding of the term began. In the same journal, the *Journal of Vascular Surgery*, a year after the paper by Hardouin et al [22] was published and retracted [32], Drudi et al [33] gave a historical overview of professionalism in surgery in an attempt to present a new general direction for the definition of the term professionalism. They suggested a much more inclusive definition based on diversity and equity, with responsibilities toward professionalism explained on the level of the individual, the organization, and society at large. HIPAA violations and legal transgressions remain in the realm of unprofessional behavior on SM; however, individual rights to self-expression and self-realization are loosely given priority over professionalism.

As a part of a long-term research project funded by the Croatian Science Foundation *Dangers and benefits of social networks: E-Professionalism of healthcare professionals – SMePROF* [34], the female authors of this paper engaged in content analysis of FB profiles of students and faculty of medical and dental schools in April 2020, before the #medbikini movement started.

Objectives

The primary objective of the study was to compare professionalism on FB of medical or dental students and faculty of 2 schools in Croatia with previous research, using the rubric for assessment of unprofessional content on FB as described in the papers by Koo et al [20,21].

When the #medbikini movement happened, the gender of the coders was brought up as one of the main reasons for the bias of the study, because all the coders were young men. Besides the gender of the coders, the methodology was questionable, emphasizing that the analysis and conclusions of the study were based on published but not validated criteria. So the question raised was, how and to what extent could the imprecisely defined or explained subcategories of potentially unprofessional content in the studies by Langenfeld et al [17,18] and Koo et al [20,21] be accounted for the #medbikini reaction, as they were used as a basis for the coding criteria in the retracted paper by Hardouin et al [22].

With the unique position of having an objective, nonbiased data from the pre-#medbikini era and from female coders, we decided to extend and enhance the primary objective and to set new objectives for a more complex study. Objectives of this study were to (1) develop an improved coding scheme (SMePROF coding scheme) for the assessment of unprofessional behavior on FB of medical or dental students and faculty, (2) compare reliability between coding schemes used in previous research and SMePROF coding schemes, (3) compare gender-based differences for the assessment of the professional content on FB, (4) validate the SMePROF coding scheme, and (5) assess the level of and to characterize web-based professionalism on publicly available FB profiles of medical or dental students and faculty.

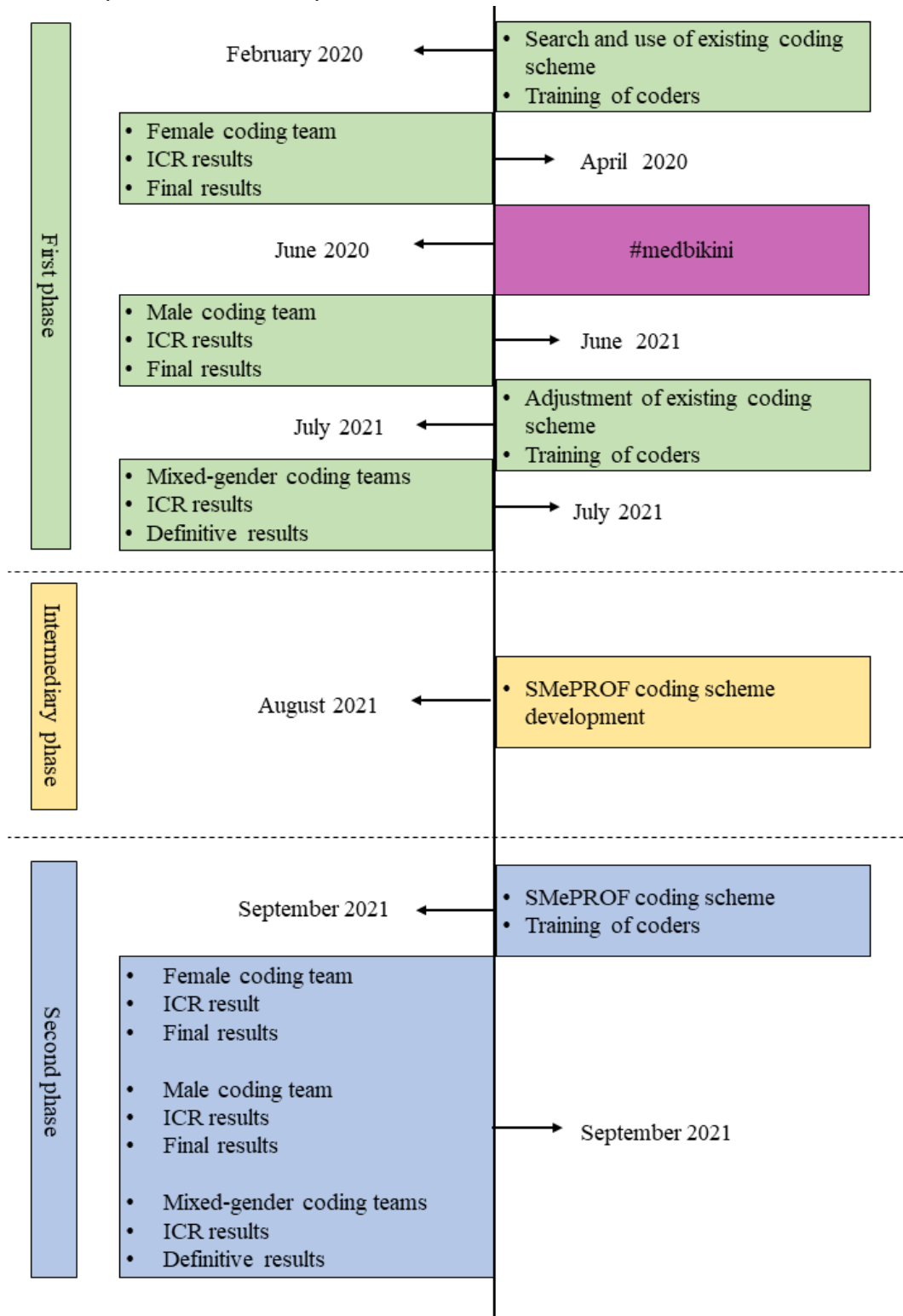
Methods

Chronology and Research Design

The study was conducted in 3 phases, the first phase, the intermediary phase, and the second phase ([Figure 1](#)). The first phase included three rounds of coding: female coding team, male coding team, and mixed-gender coding team, using the coding scheme for assessment of unprofessional behavior on FB, developed for this study based on previous research (Nason-Koo coding scheme), presented in [Multimedia Appendix 3](#) [16,20,21]. After the initial part of the first phase (female coding), the #medbikini movement occurred which influenced the rest of the research design.

The intermediate phase was the development of the new rubric for assessment of unprofessional content on FB (SMePROF rubric), which included corrections of the rubric for assessment of unprofessional content (Koo rubric) by Koo et al [20,21] based on findings from the previous steps and insights from the #medbikini movement [22,31,32,35-38], resulting in the new SMePROF coding scheme, especially in the category for assessment of unprofessional content (SMePROF rubric). Finally, the second phase included three rounds of coding: female coding team, male coding team, and mixed-gender coding team, using the SMePROF coding scheme that includes the SMePROF rubric.

Figure 1. Phases of the study. ICR: intercoder reliability.



Ethics Approval

Following approval from the ethical committees of the School of Medicine University of Zagreb (UZSM) and the School of Dental Medicine University of Zagreb (UZSDM), UZSM (641-01/18-02/01) and UZSDM (05-PA-24-2/2018), students' class lists were obtained from the schools' secretarial staff for all years. Lists of all faculty were also obtained for both schools.

Authors were blinded to the individual student identification numbers.

To view individual student or faculty FB profiles, coders used a neutral, newly created FB account in each coding round. This account was intended to mimic potential search queries from patients, employers, or members of the public and capture publicly available content. Because these neutral accounts had no connections to other accounts of the inspected profiles, it was ensured that the content considered was accessible to any

member of the public. The only data that were analyzed was the information that students or faculty made publicly available; hence, the posts that anyone, regardless of the friendship status with them on FB, could see were analyzed. The final samples of UZSM and UZSDM students and faculty were searched on FB, individually by name from the lists, by each author using the newly created FB account.

Instruments Used in the Study

In the first phase of the study, profiles were reviewed for 6 categories according to the coding scheme developed for this study based on previous research (Nason-Koo coding scheme) [16,20,21]. The Nason-Koo coding scheme consists of six categories previously used in the study by Nason et al [16]: (1) existence of identifiable FB profile, (2) sex, (3) privacy settings, (4) relationship status revealed, (5) affiliation with the school

revealed, and (6) professionalism. Category professionalism was coded according to the rubric for assessment of unprofessional content on Facebook (Koo rubric) by Koo et al [20,21]. The Nason-Koo coding scheme and Koo rubric are presented in [Multimedia Appendix 3](#).

Because one of the objectives of the study is to explore how and to what extent could the imprecisely defined or explained subcategories of potentially unprofessional behavior in previous studies [17-21] be accounted for the #medbikini reaction, as they were used as a basis for the coding criteria in the retracted paper by Hardouin et al [22], we have developed a SMePROF rubric for assessment of unprofessional content on FB during the intermediate phase of the study ([Figure 1](#)). Changes were made during August 2021, resulting in a SMePROF coding scheme that differs from the Nason-Koo coding scheme based on the changes made in the SMePROF rubric ([Textbox 1](#)).

Textbox 1. SMePROF rubric for assessment of unprofessional content on Facebook.

Unprofessional content

- Image
 - Protected health information
 - Engaging in unlawful behavior
 - Offensive attire (photo or video content of an attire that includes offensive elements; for example, wearing a T-shirt with profanity or Nazi symbols [work or nonwork related])
 - Possession of drugs or appearance thereof
 - Displaying drug paraphernalia
 - Appearing intoxicated
 - Offensive content of a political, religious, or racial nature
- Text
 - Protected health information
 - References to specific instances of unlawful behavior
 - References to possession of drugs
 - References to drug paraphernalia
 - References to specific instances of alcohol intoxication
 - Uncensored profanity
 - Offensive comments about colleagues at own hospitals
 - Offensive comments about colleagues at other hospitals
 - Offensive comments about a specific patient
 - Offensive comments of a political, religious, or racial nature
- Page, link, or other posted content
 - Advocating or supporting the use of drugs
 - Advocating or supporting unlawful behavior
 - Offensive content of a political, religious, or racial nature

Potentially unprofessional content

- Image
 - Holding or consuming alcohol in a clinical or work-related setting (excluding conferences or other work-related dinners or parties)
 - Inappropriate attire (clinical or work-related setting: photo or video content in a clinical or work environment in which an individual is wearing physicians' attire [laboratory coat, scrubs, surgical gowns, etc] and also partially revealing skin [sleeveless, deep cleavage, abdomen, back, short pants, or skirts high above the knee] or underwear inappropriate for clinical or work environment)
 - Sexualization—sexually suggestive or provocative posing regardless of the attire or revealing clothing (sexualization focuses on sexual suggestive or provocative posing [in a professional or private setting], regardless of the attire or revealing clothing, excluding nonsexual suggestive posing in swim or beachwear)
- Text
 - Reference to sexually provocative or sexually disturbing content
 - Censored profanity
- Page, link, or other posted content
 - Advocating or supporting alcohol intoxication
 - Sexually provocative or sexually disturbing content

Main differences comparing the Koo rubric and the SMePROF rubric for assessment of unprofessional content on FB are presented in [Multimedia Appendix 4](#) [17,18,20-22,33,36,37,39,40].

In the second phase of the study, profiles were reviewed for six categories (existence of identifiable FB profile, sex, privacy settings, relationship status revealed, affiliation with the school revealed, and professionalism) according to SMePROF coding scheme. Category professionalism was coded according to the SMePROF rubric. Profiles were categorized as (1) unprofessional content if at least one element of unprofessional content was found, (2) potentially unprofessional content if at least one element of potentially unprofessional content was found or, (3) professional content if none of the elements of unprofessional nor potentially unprofessional content were found ([Textbox 1](#)).

Coders and Coding Process

In each step of the coding processes, assessments were first conducted by the two independent coders (either members of female or male coding teams). The female coders were LMP and M Majer. LMP, aged 37 years, was at that time a Master of Library and Information Science; M Majer, aged 45 years, was at that time a doctor of medicine (MD), a school and adolescent medicine specialist, and an assistant professor in public health. The male coders were DR and JV. DR, aged 33 years, was at that time an MD and a family medicine resident, and JV, aged 36 years, was at that time a doctor of dental medicine (DMD), a prosthodontics specialist, and an assistant professor of dental medicine.

Intercoder reliability (ICR) was determined for subjective category professionalism for female and male coding teams in both phases of the study. ICR was determined using the following indices: *Average Pair-Wise Percent Agreement* and *Krippendorff α* [41]. For differences between 2 coders, the first consensus among coders was tried to be established; if not able to reach a consensus, a third reviewer was consulted and differences were resolved (the third reviewer, TVR, was always the same: woman; aged 46 years; an MD, a psychiatrist, and an assistant professor in public health). This process produced the final results for the female and male coding teams in the first and second phases of coding ([Figure 1](#)).

The final results of the female and male coders from the first and second phases of coding were compared, and the ICR was determined for the categories as in the previous steps. If there were differences in the final results between the 2 teams, an attempt was first made to reach a consensus between the teams. If this was not possible, a third reviewer (TVR) was consulted, and the differences were resolved. This led to definitive results produced for both genders in both phases of coding ([Figure 1](#)).

Statistical Analysis

ICR during both phases of coding was determined for the subjective category professionalism using the indices *Average*

Pair-Wise Percent Agreement and *Krippendorff α* [41]. ICR was calculated with the ReCal (*Reliability Calculator*), an online utility that computes ICR coefficients [42].

Descriptive statistics were used to present all data obtained in both phases. Differences between coders' variable categories within the same coding team and phase were assessed using the chi-square test or Fisher test, if >20% of cells had an expected count of <five. Differences among ordinal variables conducted between the first and the second phases were tested using the Wilcoxon signed-rank test. *P* values of <.05 were considered statistically significant. All statistical analyses were carried out using the SPSS Statistics (version 26; IBM) software.

Results

Overview

The final samples for the content analysis of student's and faculty's FB profiles were made by a method of systematic sampling, therefore allowing us to create probabilistic samples that represent populations better than random sampling [43]. The sample of students' FB profiles included 16.7% of all registered students at the UZSM (325/1951) and 16.6% of students at the UZSDM (94/566), equally distributed according to study year and gender (n=419). The final sample for the content analysis of faculties' FB profiles was made by systematic sampling of 16.7% of all registered faculty at the UZSM (86/516) and 16.9% at the UZSDM (28/166), equally distributed according to the academic position and gender (n=114). In total, there were 533 names for analysis (n=419, 79% students and n=114, 21% faculty).

In the first phase of coding, the female coding team found 255 (60.9%) students and 42 (36.8%) faculty with identifiable FB accounts. The male coding team found 222 (53%) students and 24 (21.1%) faculty with identifiable FB accounts. Definitive results (mixed-gender coding team) for the first phase of coding found 222 (53%) students and 25 (21.9%) faculty with identifiable FB accounts ($\chi^2_2=63.7$; $P<.001$). In the second phase of coding, the female coding team found 240 (57.3%) students and 41 (36%) faculty with identifiable FB accounts. The male coding team found 203 (48.4%) students and 24 (21.1%) faculty with identifiable FB accounts. Definitive results (mixed-gender coding team) for the second phase of coding found 206 (49.2%) students and 23 (20.2%) faculty with identifiable FB accounts ($\chi^2_2=30.7$; $P<.001$).

ICR Results

ICR results for female coding team, male coding team, and final female versus final male coding teams in the category professionalism, for the first (Koo rubric) and the second (SMePROF rubric) phases are presented in [Table 1](#).

ICR shows an increase when the SMePROF rubric was used for gender-based coding and for comparison of final results.

Table 1. Intercooder reliability for the total sample.

	Category (professionalism)			
	Koo rubric		SMePROF rubric	
	APPA ^a	Krippendorff α	APPA	Krippendorff α
Female coding team	79.40	.64	81.10	.71
Male coding team	79.20	.61	82.40	.67
Final female versus final male coding teams	76.90	.60	82.00	.67

^aAPPA: Average Pair-wise Percent Agreement.

Comparison of the Gender-Based Differences Among Coder Teams for the Category Professionalism (First and Second Phases of Coding)

Comparison of the gender-based difference among coder teams for the category professionalism according to the Koo and SMePROF rubric is presented in [Table 2](#).

Final results show that while using the Koo rubric, the female coding team, more often than the male coding team, reported potentially unprofessional content (54/297, 18.2% vs 29/246, 11.8%) but almost 2.5 times less than the male coding team, reported unprofessional content (5/297, 1.7% vs 10/246, 4.1%).

Final results show that in the second phase (SMePROF rubric), there was almost no difference between female and male coding teams for coding potentially unprofessional content (8/281, 2.9% vs 6/227, 2.6%) or for coding unprofessional content (13/281, 4.6% vs 11/227, 4.9%).

When we compared the final female coding with the final male coding (for accounts that both teams coded as identifiable FB accounts, n=227), the gender-based agreement using the Koo rubric was 85% for the reviewed profiles ([Table 3](#)). In the second phase of coding, for the comparison of final female coding and final male coding (for accounts that both teams coded as identifiable FB accounts, n=210), gender-based agreement using the SMePROF rubric was 96.2% for the profiles reviewed ([Table 3](#)).

Table 2. Gender-based differences for the category professionalism (Koo rubric vs SMePROF rubric).

Difference	Koo rubric		SMePROF rubric (N=508)	
	Female (n=297), n (%)	Male (n=246), n (%)	Female (n=281), n (%)	Male (n=227), n (%)
None	238 (80.1)	207 (84.1)	260 (92.5)	210 (92.5)
Potentially unprofessional	54 (18.2)	29 (11.8)	8 (2.9)	6 (2.6)
Unprofessional	5 (1.7)	10 (4.1)	13 (4.6)	11 (4.9)

Table 3. Gender-based agreement of the final codes for the category professionalism (Koo rubric vs SMePROF rubric).

Agreement	Comparison (Koo rubric) of final female coding with final male coding (n=227), n (%)	Comparison (SMePROF rubric) of final female coding with final male coding (n=210), n (%)
Unprofessional↔none	1 (0.4)	2 (1)
Unprofessional↔potentially unprofessional	4 (1.8)	4 (1.9)
Unprofessional↔unprofessional	4 (1.8)	9 (4.3)
Potentially unprofessional↔potentially unprofessional	17 (7.5)	4 (1.9)
Potentially unprofessional↔none	29 (12.8)	2 (1)
None↔none	172 (75.8)	189 (90)
Subtotal disagreement	34 (15)	8 (3.8)
Subtotal agreement	193 (85)	202 (96.2)

Comparison of Definitive Results Between the First and the Second Phases

Comparison of the Koo and SMePROF Rubric Results for the Category Professionalism, Female Coding Versus

Male Coding Versus Definitive Coding

Table 4 displays a comparison of the definitive results for the category professionalism (Koo vs SMePROF rubric), divided between students and faculty, for the total sample (N=533).

Table 4. Comparison of the Koo and SMePROF rubric coding results for the category professionalism, final female coding versus final male coding versus definitive coding (N=533).

Group and professionalism	Final female coding		Final male coding		Definitive coding	
	Koo rubric, n (%)	SMePROF rubric, n (%)	Koo rubric, n (%)	SMePROF rubric, n (%)	Koo rubric, n (%)	SMePROF rubric, n (%)
Students (n=419)						
No unprofessional content	208 (81.6)	222 (92.5)	188 (84.7)	187 (91.7)	187 (84.2)	188 (91.3)
Potentially unprofessional content	43 (16.9)	7 (2.9)	25 (11.3)	5 (2.5)	26 (11.7)	6 (2.9)
Unprofessional content	4 (1.6)	11 (4.6)	9 (4.1)	11 (5.4)	9 (4.1)	12 (5.8)
No profile or impossible to determine	164 (39.1)	179 (42.7)	197 (47)	216 (51.6)	197 (47)	213 (50.8)
Faculty (n=114)						
No unprofessional content	30 (71.4)	38 (92.7)	19 (79.2)	23 (95.8)	18 (72)	22 (95.7)
Potentially unprofessional content	11 (26.2)	1 (2.4)	4 (16.7)	1 (4.2)	6 (24)	1 (4.3)
Unprofessional content	1 (2.4)	2 (4.9)	1 (4.2)	0 (0)	1 (4)	0 (0)
No profile or impossible to determine	72 (63.2)	74 (64.9)	90 (78.9)	90 (78.9)	89 (78.1)	91 (79)

In a sample of students, a comparison of the Koo and SMePROF rubric results showed a decrease in potentially unprofessional content for final female coding (from 43/255, 16.9% to 7/240, 2.9%), final male coding (from 25/222, 11.3% to 5/203, 2.5%), and definitive coding (from 26/222, 11.7% to 6/206, 2.9%). Decrease in potentially unprofessional content was also observed in the sample of faculty for final female coding (from 11/42, 26.2% to 1/41, 2.4%), final male coding (from 4/24, 17% to 1/24, 4%), and definitive coding (from 6/25, 24% to 1/23, 4%). On the contrary, when comparing students' sample Koo and SMePROF rubric results, an increase in unprofessional content was shown for final female coding (from 4/255, 1.6% to 11/240, 4.6%), final male coding (from 9/222, 4.1% to 11/203, 5.4%), and definitive results (from 9/222, 4.1% to 12/206, 5.8%).

Similar decrease in potentially unprofessional content was observed in the faculty's sample for final female coding (from 11/42, 26% to 1/41, 2%), final male coding (from 4/24, 17% to

1/24, 4%), and for definitive coding (from 6/25, 24% to 1/23, 4%). When comparing the faculty's sample Koo and SMePROF rubric results, an increase in unprofessional content was shown only for final female coding (from 1/42, 2% to 2/41, 5%), but final male coding (from 1/24, 4% to 0/24, 0%) and definitive coding (from 1/25, 4% to 0/23, 0%) showed a decrease in unprofessional content.

Unprofessional or Potentially Unprofessional Content on Students' and Faculty's Public Facebook Accounts

The categories and frequencies of unprofessional or potentially unprofessional content using the Koo rubric are summarized in Table 5.

The categories and frequencies of unprofessional or potentially unprofessional content using the SMePROF rubric are summarized in Table 6.

Table 5. Unprofessional or potentially unprofessional content on the students' and faculty's public Facebook accounts (Koo rubric).

Content type and content	Final female coding		Final male coding		Definitive coding	
	Students (n=255), n (%)	Faculty (n=42), n (%)	Students (n=222), n (%)	Faculty (n=24), n (%)	Students (n=222), n (%)	Faculty (n=25), n (%)
Unprofessional content	4 (1.6)	1 (2.4)	9 (4.1)	1 (4.2)	9 (4.1)	1 (4)
Uncensored profanity (T ^a)	1 (0.4)	0 (0)	4 (1.8)	0 (0)	5 (2.3)	0 (0)
Appearing intoxicated (I ^b)	1 (0.4)	0 (0)	1 (0.5)	0 (0)	2 (0.9)	0 (0)
Advocating or supporting the use of drugs (P ^c)	1 (0.4)	0 (0)	2 (0.9)	0 (0)	1 (0.5)	0 (0)
Protected health information (I or T)	0 (0)	0 (0)	1 (0.5)	0 (0)	1 (0.5)	0 (0)
Offensive attire (I)	1 (0.4)	1 (2.4)	0 (0)	0 (0)	0 (0)	0 (0)
References to alcohol intoxication (T)	0 (0)	0 (0)	1 (0.5)	0 (0)	1 (0.5)	1 (4)
Potentially unprofessional content	43 (16.9)	11 (26.2)	25 (11.3)	4 (16.7)	26 (11.7)	6 (24)
Holding alcohol (I)	8 (3.1)	2 (4.8)	5 (2.3)	1 (4.2)	8 (3.6)	0 (0)
Appearing in sexually suggestive attire or circumstances (I)	13 (5.1)	1 (2.4)	3 (1.4)	1 (4.2)	6 (2.7)	2 (8)
Inappropriate attire (I)	13 (5.1)	3 (7.1)	7 (3.2)	1 (4.2)	5 (2.3)	0 (0)
Censored profanity (T)	2 (0.8)	0 (0)	4 (1.8)	0 (0)	2 (0.9)	0 (0)
References to sex or sexual behavior (T)	2 (0.8)	1 (2.4)	1 (0.5)	0 (0)	1 (0.5)	0 (0)
References to alcohol intoxication (T)	2 (0.8)	0 (0)	1 (0.5)	0 (0)	1 (0.5)	0 (0)
Politics or content of a political nature (P)	1 (0.4)	2 (4.8)	1 (0.5)	1 (4.2)	1 (0.5)	1 (4)
Consuming alcohol (I)	2 (0.8)	1 (2.4)	3 (1.4)	0 (0)	1 (0.5)	3 (12)
Controversial of polarizing topic (P)	0 (0)	1 (2.4)	0 (0)	0 (0)	0 (0)	0 (0)

^aT: text.^bI: image.^cP: post, link, or other posted content.

Table 6. Unprofessional or potentially unprofessional content on the students' and faculty's public Facebook accounts (SMePROF rubric).

Content type and content	Final female coding		Final male coding		Definitive coding	
	Students (n=240), n (%)	Faculty (n=41), n (%)	Students (n=203), n (%)	Faculty (n=24), n (%)	Students (n=206), n (%)	Faculty (n=23), n (%)
Unprofessional content	11 (4.6)	2 (4.9)	11 (5.4)	0 (0)	12 (5.8)	0 (0)
Possession of drugs or appearance thereof (I ^a)	2 (0.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Appearing intoxicated (I)	2 (0.8)	0 (0)	2 (1.0)	0 (0)	2 (1)	0 (0)
Uncensored profanity (I or T ^b)	5 (2.1)	1 (2.4)	5 (2.5)	0 (0)	5 (2.4)	0 (0)
Offensive attire (I)	2 (0.8)	0 (0)	1 (0.5)	0 (0)	2 (1)	0 (0)
Offensive comments of a political, religious, or racial nature (T)	0 (0)	1 (2.4)	0 (0)	0 (0)	0 (0)	0 (0)
Advocating or supporting the use of drugs (T or P ^c)	0 (0)	0 (0)	1 (0.5)	0 (0)	1 (0.5)	0 (0.0)
Offensive content of a political, religious, or racial nature (T or I)	0 (0)	0 (0)	2 (1.0)	0 (0)	2 (1.0)	0 (0)
Potentially unprofessional content	7 (2.9)	1 (2.4)	5 (2.5)	1 (4)	6 (2.9)	1 (4)
Inappropriate or offensive attire (nonsexual; I)	1 (0.4)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)
Sexualization—appearing in sexually suggestive posture (I)	3 (1.3)	1 (2.4)	3 (1.5)	1 (4)	4 (1.9)	1 (4)
Advocating or supporting alcohol intoxication (T or P)	1 (0.4)	0 (0)	1 (0.5)	0 (0.0)	2 (1)	0 (0)
Sexually provocative or sexually disturbing content (I)	2 (0.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

^aI: image.

^bT: text.

^cP: post, link, or other posted content.

Definitive Results

For the definitive results, significant differences between students and faculty were identified regarding the existence of identifiable FB accounts (206/419, 49.2% vs 23/114, 20.2%; $\chi^2_1=30.7$; $P<.001$), affiliation of the school revealed (193/206, 93.7% vs 15/23, 65%; $\chi^2_1=20.1$; $P<.001$), and relationship status revealed (11/206, 5.3% vs 4/23, 17%; $\chi^2_1=4.9$; $P=.03$). There were no significant differences between students and faculty for closed privacy settings (202/206, 98.1% vs 21/23, 91%; $\chi^2_2=3.7$; $P=.11$) or for the category professionalism ($\chi^2_2=1.5$; $P=.47$). Although there were no statistically significant differences between students and faculty in definitive results of professionalism variable, students had less potentially unprofessional content than faculty (6/206, 2.9% vs 1/23, 4%); however, they had more unprofessional content (12/206, 5.8% vs 0/23, 0%).

Discussion

Comparison With Previous Research

The consensus about what constitutes unprofessional behavior has still not been reached since the original definition by Chretien et al [15] in 2010. There are numerous studies with

examples of definitions of unprofessional behavior on SM [44-48].

From the first study in 2013 by Ponce et al [14] to the latest study in 2021 by Pronk et al [49], various attempts were made to define the gray area of e-professionalism. This has brought a great deal of variety to the field, possibly even causing one of the biggest medical affairs on SM—#medbikini. Understanding the evolution and difficulty of defining this problem, defining the linguistic terms and nuances, and the ramifications of ill-fated attempts to do so are crucial to our research; therefore, a review of previous research descriptions of potentially unprofessional content is provided in [Multimedia Appendix 5](#) [6,14,17,18,20-22,49-52].

The #medbikini movement has raised important questions, besides professional questionability of posting pictures in bikinis for our female colleagues, also regarding the possibility to present ourselves as humans on SM or to be able to express an opinion about important social topics. HCPs have realized that SM is not just a platform to post vacation photos and interact with followers [53]. As Drudi et al [33] emphasized, there is a need to re-examine current definitions and philosophies surrounding professionalism in medicine that may be discriminatory and exclusive. The term professionalism has no standard definition [54]; however, resolving problems of

unprofessional posting with repression is an unsustainable model of managing e-professionalism.

Principal Findings

The #medbikini affair and the subsequent movement that followed rattled the foundations of how professional behavior is understood and valued in modern and emerging environments. With a broader understanding of the problem at hand, this paper is the first to address issues not previously reported in the literature.

We have developed the SMePROF coding scheme for the assessment of unprofessional behavior on FB by medical or dental students and faculty. The first 5 categories of the coding scheme are objective (Multimedia Appendix 3) and have remained the same in the SMePROF coding scheme, but the category professionalism has provoked many controversies so far.

Our SMePROF rubric for assessment of unprofessional content on FB was developed with the intention to improve previous instruments and rubrics, to have more precise criteria or explanations for previously ambiguous or vaguely defined categories of unprofessional or potentially unprofessional content to have fewer possibilities for subjective interpretation, and to have a more updated comprehension of e-professionalism.

The SMePROF rubric differentiates *offensive attire* versus *inappropriate attire*, inappropriate attire being defined for clinical or work-related settings. General guidance to the medical community regarding physician's attire outside the operating room exists. The review by Bearman et al [55] showed that overall, patients express preferences for certain types of attire, with most surveys indicating a preference for formal attire, including a preference for a white coat. However, patient comfort, satisfaction, trust, and confidence in their physicians are unlikely to be affected by the practitioner's attire choice. Petrilli et al [56] explored whether physician attire can affect patient experiences. Their findings include the fact that attire preferences vary by geographic location, patient age, and context of care. Although physician attire cannot replace excellent clinical care, data from this study suggest that it may influence how patients perceive care and perhaps how willing they are to trust their physicians. Xun et al [57] recently investigated how the public perceives casual physician attire compared with white coats and whether there are differences by gender of the physician. Their findings suggest that individuals prefer that physicians wear white coats and that gender biases in the perception of professional physician attire exist. Physician attire is only a small aspect of the practice of medicine and does not embody the wearer's qualifications, nor does it necessarily affect their performance, practice, and contributions.

We propose a new subcategory *sexualization* in the potentially unprofessional behavior, with an explanation that sexualization focuses on sexually suggestive or provocative posing (in a professional or private setting), regardless of the attire or revealing clothing, excluding nonsexual suggestive posing in swim or beachwear. Previous researches [17,18,20-22] have not clearly defined it, which led to broad possibilities for

interpretation of this category, also resulting in the #medbikini movement.

Sexualization can be envisioned as the combination of a multitude of sexualized attributes—body position, the extent of nudity, textual cues, and more—the cumulative effect of which is to narrow the possible interpretations of the image to just the sex. Sexually suggestive posture is a potentially important aspect of sexualization, because it represents open body language that appears to invite sexual activity. It can be illustrated in subtle ways such as placing a hand on one's hips and not-so-subtle ways such as sitting with one's legs spread wide open [58].

Although suggestive postures and revealing clothing often go hand in hand, it may be possible to decouple these elements in the media and interpersonal interactions. Bernard et al [59] have deconstructed sexualization and shown that posture suggestiveness causes objectification and exerts a more powerful influence on objectification than the skin-to-clothing ratio. For example, images of underwear and swimsuits may show people in a way that would reduce the risk of objectification by presenting them in revealing clothing but with nonsuggestive posture, so that there is no element of sexualization.

ICR results showed an increase in the Krippendorff α coefficient when the SMePROF rubric was used, both for gender-based coding (for male coders from .61 to .67; for female coders from .64 to .71) and for the comparison of final results (from .60 to .67). Although these are acceptable levels for reliability, none of these results can be classified as highly reliable [41]. Compared with the results of Ponce et al [14] for their professionalism, interrater reliability scores (Cohen $\kappa=0.43$), our results indicate a more reliable coding method. Langenfeld et al [17] were not able to calculate ICR owing to a collaborative approach and authors' discussion of the analyzed content, but in the second paper [18], they report that κ coefficient was used to calculate interrater reliability, with no mention of the obtained results for the κ coefficient. Koo et al [20,21] in both studies reported excellent results for interreviewer concordance ($\kappa>0.90$) in all content categories. Because their description of the coding process was minimal, it is hard to speculate how these excellent interrater concordance results were obtained.

Krippendorff [41] and Potter and Levine - Donnerstein [60] define three types of reliability: *stability*, *reproducibility*, and *accuracy* [41,60]. The first goal of this paper was to develop an improved coding scheme for the assessment of unprofessional behavior on FB, so using any of the previous instruments [17,18,20-22] as a standard for accuracy is simply impermissible and violates the purpose of this research. The stability of the instrument used in this research is on an acceptable level, because repeated measures are performed by the same coders at 2 time points and similar results are provided. However, because of the circumstances that had arisen around the #medbikini movement and necessary changes in the coding scheme, the demonstration of stability must be taken with caution. Therefore, the reliability of this instrument is mainly demonstrated through its reproducibility, with carefully selected independent coders, and further substantiated using the reliability coefficient.

This research is the first assessment of unprofessional behavior on FB comparing gender differences in the coding process itself. Besides the study by Hardouin et al [22], previous studies have not identified explicitly who among the authors were coders, according to their gender, age, academic status, or position. In the first phase of this study, coding done by the female coding team was conducted before the #medbikini movement, and it was to our knowledge the first analysis in literature done by women-only coding team before the #medbikini movement and the potential male bias emphasized as a reason for the retraction of the paper [22].

The final results of the first phase show that while using the Koo rubric, female coders more often than male coders reported potentially unprofessional content (54/297, 18.2% vs 29/246, 11.8%) but almost 2.5 times less than male coders reported unprofessional content (5/297, 1.7% vs 10/246, 4.1%). Our finding that female coders have recognized more potentially unprofessional content contradicts arguments from the retraction notice [32] and public reaction that the study by Hardouin et al had significant conscious and unconscious biases caused by predominantly male authorship that supervised the assessments made by junior male students and trainees [22,39]. Especially when our results show that results for the subcategories *inappropriate attire* or *sexually suggestive attire* final female versus final male coding (for students) were 10.2% (26/255) versus 4.5% (10/222). The lower results of unprofessional and potentially unprofessional content of male coders can be explained with a bias connected to the #medbikini movement. As the first male coding occurred after the #medbikini movement and with the knowledge (conscious or unconscious) of the new trend in understanding the boundaries of professional behavior, the results could be skewed to the lower levels. It can be argued that this also boosts the idea that there is no difference in male versus female coding as the first phase female coding results (before and unaffected by #medbikini) show a stricter approach to professionalism rooted perhaps more in outdated professionalism norms (before #medbikini) and use of an imprecise coding instrument rather than in gender differences.

During the intermediate phase and the process of the development of the SMePROF rubric, the main conclusions from coding experience in the first phase, from both female and male coders, were that coders were confused about the difference between these 2 categories and whether photographs in bikini or swimwear should be categorized as one of them. The final results of the second phase show that there was almost no difference between female and male coders for coding potentially unprofessional content for students (7/240, 2.9% vs 5/203, 2.5%) or for coding unprofessional content for students (11/240, 4.6% vs 11/203, 5.4%). Thus, we conclude that the SMePROF rubric is a more objective instrument. This is also confirmed by the increase in the gender-based agreement of the final codes for the category professionalism, from 85% (193/227) in the first phase to 96.2% (202/210) in the second phase. Gender-based differences were almost neutralized using the SMePROF rubric. A comparison of gender-based agreement of final codes in the first phase shows that majority of disagreements were detected when coders disagreed on whether the profile was potentially unprofessional or professional. This

also proves that the previously defined subcategory of potentially unprofessional content [20,21] was subjective for interpretation.

The original objective of this study was to assess the level of web-based professionalism on FB profiles of medical or dental students and faculty available for public viewing. In previous studies that made a distinction between unprofessional and potentially unprofessional content [16-18,20-22], unprofessional content ranged from 2% to 12% and potentially unprofessional content, from 10.3% to 34%. Our definitive results of the first phase, using the Koo rubric, for unprofessional content (9/222, 4.1% students; 1/25, 4% faculty) are similar to the study by Nason et al [16] for students (3%) and to the study by Langenfeld et al [18] for faculty. For potentially unprofessional content, our definitive results of the first phase (26/222, 11.7% students; 6/25, 24% faculty) are lower compared with 34% of students in the study by Nason et al [16] and similar to 14.1% residents in the study by Langenfeld et al [17]. Langenfeld et al [18] determined lower rates of faculty with potentially unprofessional content (10.3%) compared with ours (6/25, 24%). The findings of Koo et al of potentially unprofessional content among urologist graduates and residents (26.9% and 25.3%, respectively) [20,21] are similar to our results for faculty (6/25, 24%).

Karveleas et al [61], in a recent study (2021) about the relationship between FB behavior and e-professionalism among Greek dental students, did not differentiate unprofessional from potentially unprofessional content. In the study, unprofessional content, defined according to previously published studies [44-47,62,63], had been posted by most participants and depicted as 71.7% posted pictures from holidays; 41.5%, moments in nightclubs; and 26.2%, photographs wearing swimwear or underwear. Still, this publication did not gain so much attention.

Comparison of definitive results between the first and second phases, indicate an understanding of web-based professionalism, with unprofessional content being very low, both for students (9/222, 4.1% to 12/206, 5.8%) and faculty (1/25, 4% to 0/23, 0%). For assessment of the potentially unprofessional content, we observed a 4-fold decrease using the SMePROF rubric for students (26/222, 11.7% to 6/206, 2.9%) and a 5-fold decrease for faculty (6/25, 24% to 1/23, 4.3%). This can be explained by a more precise definition of subcategories of the potentially unprofessional category (inappropriate attire and appearing in sexually suggestive attire or circumstances) and decreased numbers of subcategories (such as not having holding or consuming alcohol) described in the SMePROF rubric.

During the coding process of the first phase, coders themselves were confused what are the differences between inappropriate attire and appearing in sexually suggestive attire or circumstances, especially considering photographs in swimwear. Questioning whether they belong to this category or not sparked many disagreements among coders. These types of images, inappropriate attire, and appearing in sexually suggestive attire or circumstances, were observed in 5% (11/222) of the students and 8% (2/25) of the faculty, being the second most frequent potentially unprofessional content. Since we have introduced sexualization as a subcategory with a clear distinction from

inappropriate attire in the SMePROF rubric, sexualization was observed for 1.94% (4/206) of the students and 4% (1/24) of the faculty. There were no examples for the subcategory inappropriate attire.

Of the profiles that we were able to access publicly in the second phase of coding (using the SMePROF rubric), although there were no statistically significant differences between students and faculty in definitive results of the professionalism variable ($\chi^2_2=1.5$; $P=.47$), students had less potentially unprofessional content than faculty (6/206, 2.9% vs 1/23, 4%); however, they had more unprofessional content (12/206, 5.8% vs 0/23, 0%). The most frequent unprofessional content for students was uncensored profanity (5/206, 2.4%), and the faculty did not have any profile with unprofessional content. In the potentially unprofessional content, faculty had 4% (1/23) of sexualization (but this is owing to only one sexually suggestive photograph and small numbers of faculty with identifiable FB accounts, $n=23$). Sexualization was found in just 1.9% (4/206) of students. Images of inappropriate attire were not found within students' or faculty profiles.

Besides more precise criteria in the SMePROF rubric, a decrease in unprofessional and potentially objectionable content in the second phase of coding could also be explained by the development of guidelines for e-professionalism for medical and dental students in UZSM and UZSDM that became publicly available in November 2020 [64]. Also, both schools have implemented in their curriculum themes e-professionalism as part of the obligatory subjects. Also, elective subjects, completely focused on e-professionalism in medicine and dental medicine have been developed and implemented in the curricula.

Although it has passed almost 20 years since the advent of SM, little evidence exists to inform about the interplay between personal web-based disclosures and professional trust and credibility from patients' or public perspectives. Jain et al [65] measured the perception of unprofessional content of HCPs on SNSs among medical students, faculty members, and the public. The most significant result they found is that faculty members, medical students, and the public have different thresholds of what is acceptable on SM or SNS. Medical students were more likely to post comments, images, and photographs that medical school faculty members and the public would consider inappropriate or unprofessional [65]. The study by Weijs et al [66] provided the first evidence of the impact of HCPs' web-based disclosures on credibility and healthy patient-physician relationship. Their study also emphasizes specifics of SM in a different context, suggesting that the public has expectations of web-based professionalism that warrant further exploration across a range of health professions to broaden our understanding of credibility evaluations in this relation.

The recommendation that HCPs maintain a separate account with a different name, a *dual citizen approach*, which maintains web-based professional and private identities by creating separate web-based profiles was introduced in 2011 [67]. Surprisingly, this issue is still so prevalent [48]. Patients search on the web for their physicians and their impressions about professionalism are based on the publicly available web-based

SM content [68,69], but patients also use SM as the most influential web-based method in selecting a physician [69,70]. Besides patients, publicly available content on SM is also screened by future or current employers [48]. This screening is not only performed to make hiring decisions but also to evaluate current employees and assess their behavior and professional competency. Examples exist of unprofessional SM posts as a reason [71] or an alleged reason [72] for firing.

Clear legal violations (HIPAA violations or similar legal transgressions) should and are categorized as unprofessional, but when it comes to potentially unprofessional behavior on SM, it should be judged through the *simulacrum of the professional* only when the context is clearly linked to clinical or work-related settings and to the ability of the individual to practice for the benefit of the patients. This leaves enough room for diversity, self-expression, inclusivity, and equity of the individual.

When the paper by Hardouin et al [22] was retracted with justifications, it has started the #medbikini movement [33,36,37,39,40]. Numerous media articles presented the paper by Hardouin et al [22] as an example of *creepy stalking* [25,73-75], but viewing publicly available information about physicians or HCPs at SM is done by patients or employers, with benefits or consequences, either to their image or their careers. To #medbikini is not potentially unprofessional, yet we should all be aware of publicly available presentations of ourselves we post on SM and how they may affect our professional credibility and integrity, as perception can vary among different groups [65,66].

Strengths

The sampling method used in this research is one of the main strengths that directly contributes to the quality of obtained data. Systematic sampling creates representative data for a population of interest and reduces the nonresponse bias that other nonprobabilistic sampling (such as a convenient sample) would create. In addition, it has better dispersion control than a random sample.

The SMePROF rubric for assessment of unprofessional content on FB was developed with improved rubric and criteria for unprofessional or potentially unprofessional content, therefore reducing possibilities for subjective interpretation. Through the implementation of these changes, comprehension of e-professionalism was reassessed and updated.

This research is the first assessment of unprofessional behavior on FB that controls for gender bias among coders. In the final results of the second phase (using the SMePROF rubric), there was almost no difference between female and male coders in the coding of potentially unprofessional content or for coding unprofessional content. Thus, we conclude that the SMePROF rubric is a more objective instrument. This is also confirmed by an increase in the gender-based agreement of the final codes for the category professionalism, from 85% (193/227) in the first phase to 96.2% (202/210) in the second phase. Gender-based differences were almost neutralized using the SMePROF rubric.

The reliability of this instrument is mainly demonstrated through reproducibility, with carefully selected independent coders, and further substantiated using a reliability coefficient that increased from Krippendorff α of .61 in the first phase to Krippendorff α of .67 in the second phase. Nonexistence of validated criteria or instruments to assess unprofessional content on FB was emphasized by previous e-professionalism studies [17,19,32]. In content analysis, obeying the translation rules is equivalent to validity [76]. Validity of the coding process is ensured when the researcher is consistent and coherent in their codes, meaning that they follow their translation rules. The SMePROF rubric has face and content validity established through a lengthy development process, containing categories and subcategories identified through a search of the literature and review by interdisciplinary experts followed by further revisions to establish more precise criteria for coding [77].

This research emphasizes the role that context plays in the perception of unprofessional and potentially unprofessional content and provides insight into the existence of a different set of rules for web-based and offline (face-to-face) interactions, which marks behavior as unprofessional.

Limitations and Future Research

There are several limitations to this study. In the first phase of coding, female coding was conducted before the #medbikini movement, and male coding and mixed-gender coding were conducted after it. This may affect their unconscious and conscious bias during the coding process when analyzing the unprofessional content and potentially unprofessional content. As the #medbikini movement was changing the sensibility of the public and professionals to repressive standards of judging e-professionalism, it could have changed the sensibility of our coders too, resulting in less content coded as potentially unprofessional or unprofessional. The timing of the #medbikini movement that forced us to improve the instrument between the 2 phases also made it difficult to directly demonstrate stability between the 2 repeated measurements.

Secondly, our sample consisted of both phases of the same lists of students and faculty. Students who were sixth year students in the first phase, meantime, finished their education and became MDs or DMDs when the second phase coding was performed. This might affect changes in their privacy settings or affiliation with the school. Our sample has a small total number of faculty representatives from the UZSDM, as it is a much smaller institution than the UZSM, having a total of 166 faculty. Content analysis of faculty's FB profiles was made by a method of probabilistic systematic sampling of 16.7% of registered faculty, equally distributed according to the academic position and gender, therefore only 28 faculty from the UZSDM entered the final sample for the content analysis versus 86 faculty from the UZSM. Although used systematic sampling offers a nonbiased probabilistic sample, as only 21% (24/114) of the faculty had identifiable FB accounts, conclusions were made based on these results.

For definitive results, if reaching a consensus was not possible between the female or the male coding teams, a third reviewer was consulted, and differences were resolved. The third reviewer was always the same (woman, TVR).

Even though the SMePROF coding scheme demonstrates face and content validity, the construct validity is asserted to be the most valuable indicator of the validity of an instrument established through a practical application over time, demonstrating the instrument's replicability [77]. As our efforts to enhance the construct validity of the SMePROF coding scheme move forward, we believe that our work on reliability may facilitate the future assessment of the construct validity of this instrument.

The Nason-Koo coding scheme was developed for this study based on previous research [16,20]. Both methodological principles, for the studies by Nason et al [16] and Koo et al [20], were created by MDs or DMDs. The SMePROF coding scheme, especially the criteria for the SMePROF rubric, were developed after the #medbikini movement, with an interdisciplinary team of authors (MDs, DMDs, sociologists, and informational professionals), but we do not have insights from the public or patients about what they consider to be unprofessional or potentially unprofessional behavior. As suggested in previous research [19,65,66], public perceptions about professionalism and credibility are integral to developing the evidence base for e-professionalism assessment, e-professionalism guidelines, and encouraging best practices in SM use. These interventional processes would require multidisciplinary and cross-sectoral input from patients, academic and physician leaders, SM experts, and interprofessional stakeholders [78] that future research should address. The recent systematic review by Guraya et al [79] also calls for assistance and guidance in training the digitally enhanced learning in preparation for their future digitally driven clinical practice. They also emphasize the problem of the multidimensional construct of professionalism, making it hard to assess all domains in the medical field. To add to its complexity, the assessment of e-professionalism is still in its infancy.

We did not include in the coding scheme or assess other SM platforms, such as Instagram, which is highly used among the UZSM and UZSDM students [64]. With the rapid evolution of SM, future insights should be more oriented toward new and emerging SM sites and how different professions among HCPs use them. Kerr et al [80] have explored the characteristics and behaviors of nurses who have attained microcelebrity status on Instagram, but other HCPs show similar tendencies in SM self-promotion, which should be explored more. Instagram has gained enormous popularity by introducing new features such as Stories and Reels, which are completely scientifically unexplored [48]. YouTube as an example of an old SM site, is also unexplored in the context of HCP's professional behavior, with the study by Lee et al [81], published in 2021, being the first study on digital professionalism behavior on medical students' YouTube videos. Research shows that students' perceptions and reports of their Twitter experiences offer insights into behavior on the web and the evolving role of cyberspace, and potentially problematic posts provide opportunities for teaching digital professionalism [82]. Twitter was not included for assessment in our study, as it is not prevalently used by students of medicine or dental medicine in Croatia [64].

The COVID-19 pandemic has caused much of the world's population to isolate itself and many of us to shift our lives to digital tech platforms, especially SM and SNSs, all experiencing strong growth. Previous research has shown that more people are relying on SM to find and share health information during times of crisis [48]. We are experiencing an unprecedented time in health care and education owing to the COVID-19 pandemic [83], so the use of SM in patient-HCP communication and student education should also be explored in more detail. Examples of sensationalist SM use by MDs and DMDs during the COVID-19 pandemic have been described [84], providing a partial insight as to the likely motivations of physicians and dentists to use SM in a manner that may not necessarily lend well to the professional standards expected. The question of how the pandemic affected our e-professional behavior needs to be explored further.

Conclusions

Because of this study, the development of a SMePROF coding scheme, a part of which is the SMePROF rubric for the professionalism of HCPs on SM, has reduced the influence of

subjective interpretation. Assessment of potentially unprofessional behavior is very subjective. Differences in that assessment may be the result of age, gender, different professional background or level, and other cultural or context related variables. New, more defined evaluation criteria were developed and validated, providing a better instrument for future research. According to the results of this study, the gender of coders did not affect the results for coding unprofessional or potentially unprofessional content using the same methodology and available criteria. This research emphasizes the role that context plays in the perception of unprofessional and potentially unprofessional content and provides insight into the existence of a different set of rules for web-based and offline (face-to-face) interactions that marks behavior as unprofessional.

Finally, the level of web-based professionalism on FB profiles of medical or dental students and faculty available for public viewing has shown a high level of understanding of e-professionalism, with unprofessional content being very low. This is indicative of the new more open view of professionalism on SM that will continue to evolve in the years to come.

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Authors' Contributions

TVR and M Marelić conceptualized and designed the study, and TVR coordinated it. M Majer, LMP, DR, and JV conducted the data searches on Facebook and coding. M Marelić and TVR analyzed and interpreted the data. TVR drafted the manuscript. All authors reviewed and approved the final version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Twitter Binder report: #medbikini historical search for the period from September 9, 2013 to January 16, 2022.

[PDF File (Adobe PDF File), 1267 KB - [mededu_v8i3e35585_app1.pdf](#)]

Multimedia Appendix 2

Health care professionals' social media engagement related to the #medbikini movement.

[PDF File (Adobe PDF File), 522 KB - [mededu_v8i3e35585_app2.pdf](#)]

Multimedia Appendix 3

Instruments used in the first phase of the study.

[PDF File (Adobe PDF File), 109 KB - [mededu_v8i3e35585_app3.pdf](#)]

Multimedia Appendix 4

Main differences comparing the Koo rubric and SMePROF rubric for assessment of unprofessional content on Facebook.

[PDF File (Adobe PDF File), 108 KB - [mededu_v8i3e35585_app4.pdf](#)]

Multimedia Appendix 5

Overview of previous research descriptions of potentially questionable, unprofessional, or objectionable behavior on social media.

[PDF File (Adobe PDF File), 113 KB - [mededu_v8i3e35585_app5.pdf](#)]

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Abbreviations

- DMD:** doctor of dental medicine
- FB:** Facebook
- HCP:** health care professional
- HIPAA:** Health Insurance Portability and Accountability Act
- ICR:** intercoder reliability
- MD:** doctor of medicine
- ReCal:** Reliability Calculator
- SM:** social media
- SNS:** social networking site
- UZSDM:** School of Dental Medicine University of Zagreb
- UZSM:** School of Medicine University of Zagreb

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Original Paper

The Use of Telegram in Surgical Education: Exploratory Study

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Abstract

Background: The COVID-19 pandemic has disrupted medical education, shifting learning online. Social media platforms, including messaging apps, are well integrated into medical education. However, Telegram's role in medical education remains relatively unexplored.

Objective: This study aims to explore the perceptions of medical students regarding the role of messaging apps in medical education and their experience of using Telegram for surgical education.

Methods: A Telegram channel "Telegram Education for Surgery Learning and Application (TESLA)" was created to supplement medical students' learning. We invited 13 medical students who joined the TESLA channel for at least a month to participate in individual semistructured interviews. Interviews were conducted via videoconferencing using an interview guide and were then transcribed and analyzed by 2 researchers using inductive thematic content analysis.

Results: Two themes were identified: (1) learning as a medical student and (2) the role of mobile learning (mLearning) in medical education. Students shared that pandemic-related safety measures, such as reduced clinic allocations and the inability to cross between wards, led to a decrease in clinical exposure. Mobile apps, which included proprietary study apps and messaging apps, were increasingly used by students to aid their learning. Students favored Telegram over other messaging apps and reported the development of TESLA as beneficial, particularly for revision and increasing knowledge.

Conclusions: The use of apps for medical education increased during the COVID-19 pandemic. Medical students commonly used apps to consolidate their learning and revise examination topics. They found TESLA useful, relevant, and trustworthy.

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KEYWORDS

COVID-19; undergraduate medical education; distance education; social media; Telegram; general surgery; messaging apps

Introduction

COVID-19 was declared a global health emergency on January 30, 2020 [1]. Consequently, medical education was disrupted due to the social distancing efforts to contain disease spread and transmission [2-4]. Clinical-year students were particularly affected as clinical rotations were suspended or altered [2] or the students were deployed to perform clinical tasks [5]. To

compensate for the lack of face-to-face interactions, medical schools increasingly leveraged the use of digital technologies [2] as students and educators were required to quickly adapt to virtual learning environments, such as videoconferencing and social media platforms, websites, blogs, or other educational materials available online [4]. The use of digital technologies in education has increased steadily over the past decade, including podcasts and videos with flipped classrooms, mobile

devices with apps, video games, simulations (part-time trainers, integrated simulators, virtual reality), and wearable devices [6].

Digital education, defined as “the act of teaching and learning by means of digital technologies” [7], is an encompassing term including a wide variety of teaching methods from digital books to complex technology, such as virtual reality. Mobile learning, or mLearning, constitutes 1 of several digital education modalities, and it is defined as “learning across multiple contexts, through social and content interactions, using personal electronic devices” [8] and appears effective in improving the knowledge and skills of students and professionals in health care [9].

Social media refers to websites or apps that “allow for the creation and exchange of content generated by users” [10]. These include collaborative projects or wikis, blogs, content-sharing sites, networking platforms, social games [10], and, often, messaging apps. Social media platforms have long been well integrated into medical education [11-17], and they may be especially appealing to younger students [16] as they are readily accessible from smartphones [17], easy to use [16], and affordable [12,16,17]. The use of social media platforms in medical education has been associated with improved knowledge (examination scores), attitudes (empathy), and skills (reflective writing) [18]. They also promote student collaboration [10,12,16-18], learner engagement [16,18], feedback [16,18], and professional development [18] and are generally well accepted by students [19,20].

Messaging apps, particularly WhatsApp, are being increasingly used in medical education [21-23]. Alternatively, the use of Telegram, a free, cross-platform, cloud-based messaging app [24] popular with younger individuals, remains relatively unexplored [11]. Several Telegram features, such as large group chats, broadcast channels to reach large audiences, and polls, may facilitate access to educational resources and offer unlimited sharing capacity and collaborative peer learning, while providing heightened security [11].

The increased digitalization of medical education, greatly enhanced during the heightened social distancing measures to contain COVID-19, supports further evaluation of the use of

Telegram to assist learning in medical schools. Therefore, in this study, a Telegram channel “Telegram Education for Surgery Learning and Application (TESLA)” was developed to support general surgery learning by offering regular access to multiple-choice questions (MCQs). The acceptability of the Telegram channel among students was subsequently assessed by conducting in-depth interviews to explore student’ views of the channel and, more generally, of the use of mobile messaging apps to support learning in medical schools. This study aims to explore the perceptions of medical students regarding the role of messaging apps in medical education and their experience of using TESLA for surgical education.

Methods

Study Design and Setting

This qualitative study, including semistructured interviews, was a collaboration between the Department of General Surgery in Khoo Teck Puat Hospital and the Lee Kong Chian School of Medicine (LKCMedicine) in Singapore. The study was conducted between August and September 2021.

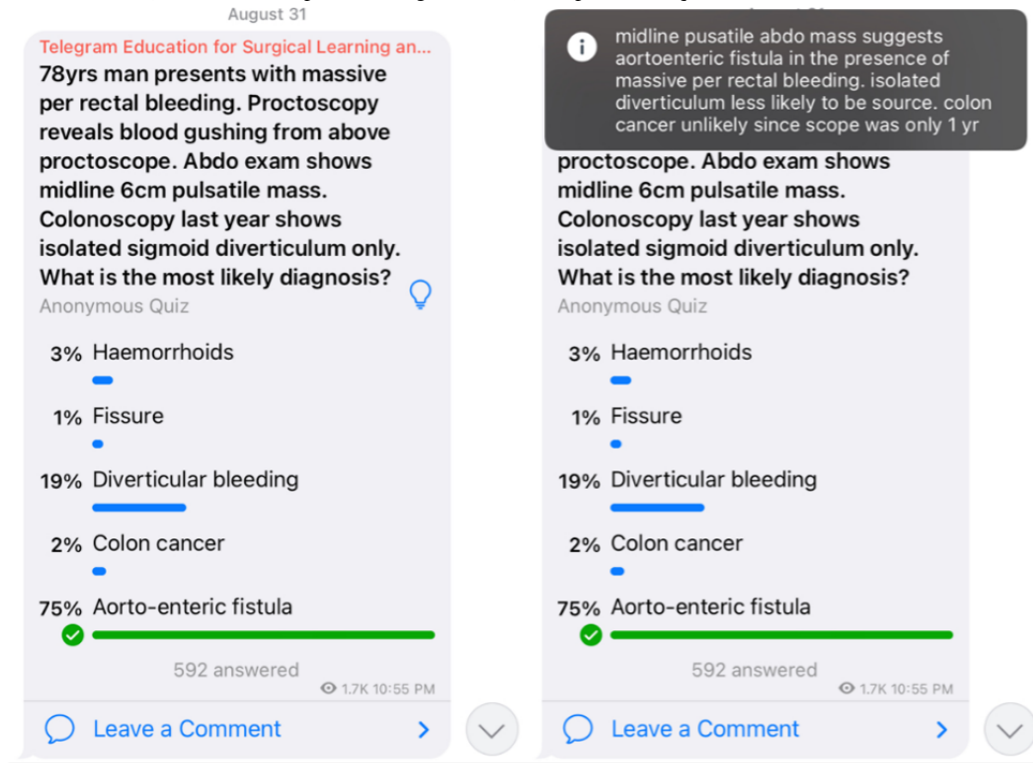
Ethical Considerations

Ethical approval was obtained from the Nanyang Technological University Institutional Review Board (#IRB-2021-377).

Telegram Channel to Support Surgical Education

TESLA was developed in October 2020 to support students’ learning of general surgery during the COVID-19 pandemic. The questions were constructed using clinical scenarios encountered during clinical practice by a practicing general surgeon (author CLK). The channel consisted of weekly MCQs, succinct explanations of the correct responses aligned with Telegram word limit restrictions, and supplemental learning resources, such as illustrations and relevant published papers (Figure 1). Students answered the questions anonymously and were encouraged to leave comments or request clarifications via a group chat function. This format appears to benefit students by promoting learning and enabling information retention [25,26].

Figure 1. Screenshot of an MCQ (left) with its explanation (right). MCQ: multiple-choice question.



Participants and Recruitment

Medical students attending clinical years 4 and 5 in LKCMedicine who had completed their general surgery module and had used TESLA for at least 1 month were invited to participate in this study. Per the qualitative research methodology, the sample size was expected to be 10-12 participants [27], according to reaching data saturation, defined as no new themes emerging in 3 consecutive interviews [28]. All participants read a study information sheet and signed the informed consent form before data collection began. After completing the interviews, participants were compensated with a digital voucher of SG \$20 (US \$14.22).

Development of the Interview Topic Guide

A thorough literature review was conducted to develop an inventory of open- and closed-ended questions. The initial interview topic guide was pilot-tested on 3 LKCMedicine students and reviewed to improve the clarity and flow of the interview (Multimedia Appendix 1). The interview included questions about the impact of COVID-19 on medical education, the use of apps to support learning, and the use of the TESLA channel.

Data Collection and Analysis

Individual, online semistructured interviews were conducted by a male undergraduate year 4 medical student (author MS) using Zoom, a videoconferencing app. MS took part in qualitative research training before conducting the interviews.

Interviews lasted around 30 minutes and were audio-recorded using Zoom. The audio recordings were transcribed and proofread (MS) to ensure accuracy. Participants remained anonymous in the transcription and data analysis. The data were analyzed following Burnard's thematic analysis method [29], comprising familiarization with the transcripts by reading them multiple times, creation of initial codes, and subsequent development of themes from the codes by 2 independent researchers. The codes were subsequently compared and discussed by the researchers to reach a consensus on the final list of codes (Multimedia Appendix 2). We used NVivo (QSR International), a computer-assisted qualitative data analysis software package, to analyze the data. The study was reported according to the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Multimedia Appendix 3) [30].

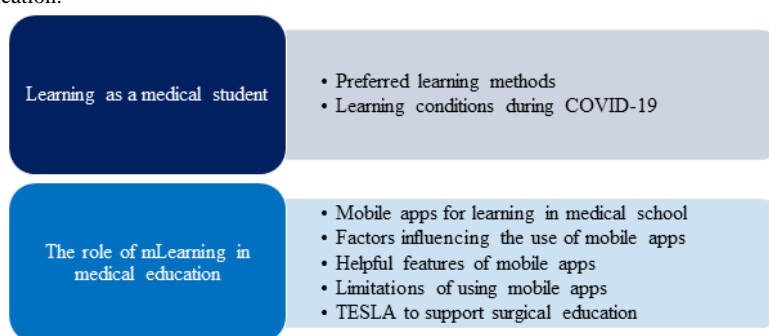
Results

Participants and Themes

We interviewed 13 students for this study, of which 11 (85%) were in year 4 and 2 (15%) were in year 5. Their participation in the surgical education support channel ranged from 1.5 to 18 months.

Two main themes were identified: (1) learning as a medical student (2) the role of mLearning in medical education (Figure 2). We present each theme, along with its subthemes and relevant participants' quotes, next.

Figure 2. Themes and subthemes arising from thematic analysis of the interview transcripts. mLearning: mobile learning; TESLA: Telegram Education for Surgery Learning and Application.



Theme 1: Learning as a Medical Student

Preferred Learning Methods

Students valued hands-on, experiential learning as they felt that seeing actual patients is more conducive to learning.

Real learning comes from seeing the real signs and how the patients present, as well as talking to patients in the wards. [Participant 3 (P3)]

I think it is a little bit different between digital and physical, in a sense that you do not get to feel it or ask questions immediately if you do not understand. [P4]

Particularly, students considered that the learning of skills should always occur in a face-to-face setting that allows students to practice the skills while receiving real-time feedback from mentors.

...The best way to learn these skills will be with a clinical mentor who can see and give you personalized feedback. [P2]

...Skills need to be practiced and seen in person... [P5]

Learning Conditions During COVID-19

The social distancing measures associated with COVID-19 impacted traditional learning practices, particularly the interaction with patients. All students reported increased restrictions in the hospitals, such as reduced clinic allocations and the inability to visit wards.

We could not really go around the wards as freely anymore. We also could not see a lot of patients, so the patient load was decreased as well. Yeah, we had restrictions in the OT, and we cannot have too many people around when having bedside tutorials. [P1]

What I lost in the pandemic due to the restrictions is not the knowledge, but the practical skills and the experiences of being immersed in the different situations. [P11]

This resulted in decreased exposure to patients and a shift of a significant portion of learning online.

I think it was affected because our postings were cut short and a lot of lessons were moved online. [P5]

...You cannot go to the hospital anymore, and then you have to attend lectures online,...you do not get to see the clinical presentations. [P13]

Given these changes during the pandemic, most students found their clinical and surgical rotations substantially shorten.

...Since ward time has been reduced, I think there has also been a reduction in content delivery, like bedside tutorials. [P4]

I think a lot of like opportunities were reduced and there were a lot more restrictions. So, it was more difficult to get practical hands-on learning. [P11]

Theme 2: The Role of mLearning in Medical Education

Mobile Apps for Learning in Medical School

Many students used apps to aid their learning, including proprietary study apps and messaging apps. The study apps consisted of question banks and flashcards (Amboss, Anki, Qstream, Capsule, and Osmosis) and an evidence-based clinical resource tool (UpToDate). These apps allowed students to review previously learned topics leveraging study techniques such as spaced repetition and active recall.

For educational videos, I use the internet, YouTube, Osmosis, and Amboss. For knowledge and practice questions, I use the internet, Telegram, and also other educational apps, such as the flashcard app Anki. [P3]

My school uses Qstream, which also prompts questions for [you] to answer...There are also other applications that I use, such as Amboss, which also does the same. I also use Anki. [P9]

Students also used messaging apps for their learning, particularly Telegram, WhatsApp, and Instagram. Students were generally familiar with these apps as they used them for social communications with family and friends. These apps were often used to communicate with tutors and peers, as well as to join specific channels offering study support tools.

I use the Telegram channels as well as polls on Instagram stories. [P9]

This Telegram group, some Instagram pages that our batchmates created, online notes and also YouTube. [P12]

Messaging apps were also used for communication with friends and family members. Among these apps, Telegram was favored for its friendlier user interface and multifunctionality.

Telegram is good because it has more features and has more stickers as well. [P5]

I prefer Telegram because I think it is more user-friendly than WhatsApp and it is easier to navigate. [P13]

Students were aware that the use of mobile apps would not replace more traditional ways of learning, for example, textbooks, lectures, and, particularly, patient interactions.

...It works to complement the main learning from, like, textbooks or seniors notes, etc, and to reinforce whatever I have already learnt... [P2]

Because it is virtual, there is a lack of face-to-face interaction and the ability to perform physical examination or take a proper face-to-face history. I think that is a big issue that people feel with regards to personnel competency in medicine...I think it is something that no amount of virtual learning can replace. [P4]

...Mobile-based education is more for contents, while clinical skills have to come through the clinical context. [P9]

Factors Influencing the Use of Mobile Apps

In general, students considered using apps that were free of charge or affordable.

For some mobile apps like Amboss, our school actually helped to pay for their subscription fees and so made it available for all of us to use. [P2]

They also favored apps if they were considered useful or entertaining.

If I think I learnt quite a lot from it or I feel that their way of teaching is effective, then I will use it more. [P2]

Students also considered using apps if they were recommended by their peers or seniors.

Even my seniors who went through the rotations without the pandemic were already using them and recommended them to me. [P1]

It's more of a recommendation by word of mouth, like whether this particular app is good or not. [P2]

Students appreciated the convenience of accessing mobile apps at any time and place.

These apps make learning accessible and convenient since we can study anytime and anywhere, even when queueing up for food or when traveling between places. [P1]

The greatest pull factor is how convenient it is to use the phone. I can easily use these apps when I am on public transport. [P3]

Helpful Features of Mobile Apps

The apps offered a wealth of resources and information that motivated students to learn.

The number of questions available on these question banks online is really a lot. [P5]

Another pro is that it stimulates active recall. [P6]

Furthermore, messaging apps facilitated 2-way communication with tutors and peers.

I think in my school, there are, like, a few groups that me and my friends created, just to, like, practice taking histories from each other or, like, trying to identify what is an important topic and what is high yield to learn. [P2]

I also use it to communicate with friends during postings and to receive posting information from official sources. [P11]

Limitations of Using Mobile Apps

Barriers to the use of study apps included high subscription costs and hardware limitations, such as small phone screens, battery drainage, and an inflexible typing keyboard.

If I use my phone too much, the battery will also run out very quickly. [P1]

Some apps require subscriptions or a one-time payment for use. So, such costs are like a barrier if you do not like to or do not wish to pay for these apps. [P2]

It is harder for me to edit things because the phone keyboard is less versatile. [P3]

Other limitations were associated with accessing apps using a phone. These included limited content on display, the information presented in an unorganized manner, and greater difficulty taking notes.

...It is very difficult to search for the different files because they will be, like, mixed with other non-work or [non]-education-related chats, which is very messy. [P1]

It is also harder to take notes...It is harder to refer to notes or huge chunks of texts on the train as compared to when at home. [P10]

An issue that I encounter with mobile learning, which also exists for hard-copy learning, is that explanations may not be complete. [P11]

When using study apps, students felt that the information was sometimes irrelevant to the local context:

The conditions and presenting complaints are very localized to their countries. For example, in America, they have certain diseases that are more prevalent and, to them, they are a must-know. But then to us, it is something that we were taught not to pay so much attention to. [P13]

Alternatively, the use of messaging apps could potentially be intrusive with notification alerts and blurring of lines between personal use as a communication tool versus a tool for learning.

I don't like it, because questions and work messages get mixed together in one app and then it kind of distracts the learning. [P1]

TESLA to Support Surgical Education

In general, students expressed positive feedback toward the development of the mLearning platform, which they considered useful to consolidate and maybe augment their learning and review before tests.

I think it is quite useful because of the case-based style of questions. The question difficulty is appropriate... [P3]

The Telegram group is definitely a very useful tool to augment learning. Any form of revision questions will definitely help students in clarifying questions. [P10]

Particularly, students appreciated that the resources were developed by the teaching staff of the Department of Surgery.

The information in the group is provided by doctors, and so, the information is more credible. Compared to the other groups, I would be more inclined to trust the information from this group. [P2]

Since it is a channel created by a doctor, it makes the questions more legitimate as compared to if being made by students. [P10]

Students considered that the questions, and the associated supplementary material, were clinically relevant, of appropriate difficulty, and relevant to the local context. They also valued that responses to the channel questions were anonymous, an aspect that allowed students to attempt the task without the stress of being wrong.

...The content posted is very relevant to the Singapore medical student, and it is the important stuff that you cannot miss. [P3]

Some of the pictures are what students might not get the opportunity to see. So, I think that is good. [P5]

When it is an anonymous poll, it takes away any shame in answering the questions wrongly. Even if I do not know, I can just give it a shot and see how I am doing. [P9]

Alternatively, the associated discussion forum required the students' identities to be disclosed, and this feature was a major deterrent to students clarifying their doubts.

I think it is weird that everyone in the group will be reading your question. So, I guess, maybe one thing that I would prefer is to ask questions anonymously. [P1]

It seems that no one uses the comment feature. Probably it is because it is not anonymous, and people are shy to use it even if they have questions. [P10]

Students reported that the questions were presented without following specific themes or surgical specialties. Some questions lacked explanations, or if present, they were brief and difficult to comprehend. Students were aware that this may be an inherent Telegram limitation, and they suggested that providing links to

extra information, as well as categorizing the content, would improve the channel.

I feel that the Telegram group is a bit messy as the questions are random...Telegram is not able to provide such clear classification of the questions, and a new learner might feel that their learning would be all over the place...The explanations are very short since there is a word limit to the questions and explanations. Hence sometimes, I do not fully understand the explanation, because it's not complete. [P1]

I think the explanations to the questions are quite short. Hence, I think there is room to expand on that, for instance, providing resources for students on where to find articles or guidelines. Maybe, the doctors can also explain their approach to solving the questions. It would help lead to a more comprehensive understanding of the explanations. [P12]

Discussion

Principal Findings

This study explored medical students' perceptions of learning during the COVID-19 pandemic, the role of mLearning in medical education, and the use of a Telegram channel to support surgical education. Students experienced important changes in their learning during the COVID-19 pandemic, particularly the substantial decrease in clinical, hands-on, and experiential learning, leading to a rise in virtual learning. The use of mobile apps to support learning, although already in use prepandemic, increased. Students found these apps useful as a refresher or to consolidate learning and valued the development of the TESLA, as they found it relevant and trustworthy.

Medical students consistently reported disruptions in learning due to the pandemic, particularly the substantial decrease in face-to-face, experiential learning in health care institutions. Digital learning tools, including mobile apps, were increasingly used to compensate for the lack of face-to-face learning. This shift to digital-based learning was not unique to our student population but was consistently reported in medical schools worldwide [5,31,32]. Digital tools were an adequate substitute for theoretical learning and revisions ahead of examinations, although they could not substitute face-to-face patient interactions in the learning of clinical skills. The use of digital technologies in medical education has steadily increased for over a decade, although their adoption was not consistent. However, only with the onset of the COVID-19 pandemic was widespread adoption of digital learning seen in medical schools worldwide. This educational shift was accompanied by added flexibility and increased emphasis on individual learning preferences, which are valued by students and educators alike. At the same time, the wide differences in digital readiness observed in high- and low- and middle-income countries translated to inadequate training for students unable to access educational materials [32,33], while the lack of access to health care institutions also impacted the acquisition of critical clinical skills [33].

Mobile apps to support medical education were widely used by students. They selected a combination of proprietary study apps, consisting mostly of question banks and other revision tools, and study groups created in popular messaging apps, such as the Telegram group presented in this paper. A recent systematic review on the use of mobile apps in education in health care professions reported these tools as effective to enhance knowledge and skills in a range of topics, including anatomy, dermatology, and surgery [34], but it did not provide information about the type of mobile apps described in the included studies. Furthermore, another review on the use of social media in medical education in the context of the COVID-19 pandemic highlighted the use of messaging apps, such as Facebook, Twitter, Instagram, and WhatsApp [35], to organize groups to post revision topics or questions and share articles and as communication tools to inform students of changes in schedules, important deadlines, or administrative tasks [15,18]. None of these studies presented compelling evidence that the use of proprietary study apps or messaging apps would be advantageous. Furthermore, the students interviewed for this study appear to use a combination of both types of apps, each of which may provide specific advantages or disadvantages. For example, study apps may offer students a trustworthy source of information, particularly if recommended by instructors or peers, but their content may not be relevant to the local context and the associated cost might be a deterrent for some students. In contrast, messaging apps are readily available, usually free of charge, and students may already be familiar with their functionalities, but their content may not be adequately verified.

The students interviewed in our study consistently reported a preference for Telegram over other messaging apps, referring to the flexibility and enhanced functionalities the app offers. The evidence for the use of social media and messaging apps

has focused particularly on the use of WhatsApp, Facebook, and Instagram compared to Telegram, whose role in medical education remains relatively unexplored [11]. Telegram may offer key advantages, such as a poll function that allows for the development of MCQs, the possibility of creating large groups of up to 200,000 members, and enhanced data security safeguards, which may increase its appeal in educational settings [11,24]. Further studies on the use of Telegram for medical education are required.

Strengths and Limitations

Our study was undertaken in 1 medical school in Singapore, a city-state with a high penetration of smartphones, and as such, our findings and recommendations may not be generalizable to other contexts. Although our findings were more focused on the use of Telegram channels, the findings may apply to the use of other messaging apps to support medical education.

We used a stringent qualitative methodology in this study. The number of students recruited was aligned with sample size guidelines for qualitative studies, and they had varied experiences with the use of mobile apps to support medical education. Data analysis was performed by 2 independent researchers and reviewed by other members of the research team to increase the validity of our findings.

Implications for Future Work

The findings of this qualitative evaluation of medical students' perceptions of the use of messaging apps appear to support their use in medical education. Table 1 presents a series of suggestions to implement when creating study groups using messaging apps, based on our experience deploying TESLA and students' feedback. Nevertheless, experimental clinical trials evaluating the effectiveness of mLearning compared to other learning approaches are urgently needed.

Table 1. Suggested features to include when creating messaging app groups to support medical students' learning.

Suggested features	Recommendations
Delivery	
Recognizable	<ul style="list-style-type: none"> • A catchy channel name
Accessible	<ul style="list-style-type: none"> • Clear guidance for users on how to join the study group
Anonymity	<ul style="list-style-type: none"> • Participants to be allowed to answer questions anonymously
Timely	<ul style="list-style-type: none"> • Questions to be posted during the academic year and not during holidays
Regular	<ul style="list-style-type: none"> • Questions to be posted at regular, predictable intervals
Content	
Credible and trustworthy	<ul style="list-style-type: none"> • Created by health professionals or reference to trusted information sources
Organized	<ul style="list-style-type: none"> • Study group content clearly organized, with adequate signposting to study topics, etc
Clear and unambiguous	<ul style="list-style-type: none"> • Indication of the difficulty level of each question • Explanations provided for all options and all questions • Links provided to learning resources, such as peer-reviewed papers, book articles, pictures/photos, short videos
Relevant to the target population	<ul style="list-style-type: none"> • Appropriate question difficulty • Real-life clinical cases • Contextualized to the local setting
Format	
Type of questions	<ul style="list-style-type: none"> • Variety of question formats, including MCQs^a, open-ended questions, etc
Engaging	<ul style="list-style-type: none"> • Bite-sized information • Case-based questions • Variation of question difficulty • Use of visuals
Instant feedback	<ul style="list-style-type: none"> • Immediate response after participant's response • Showing participant option selection rates

^aMCQ: multiple-choice question.

Conclusion

The use of apps and other digital tools to support medical education increased during the COVID-19 pandemic. mLearning was commonly used among medical students to consolidate their learning and revise examination topics. In general,

Telegram was preferred over other messaging apps for its user interface and multifunctionality, and TESLA was evaluated as useful, relevant, and trustworthy. Experimental clinical trials on the use of mobile apps to support medical education are urgently needed.

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Authors CLKC and LTC are both senior authors of the paper.

Authors' Contributions

LTC and CLKC conceptualized the study and provided supervision at all steps of the research. MKSS conducted and transcribed the interviews. MKSS and JL conducted the data analysis. MKSS and LM wrote the manuscript. JL, CLKC, and LTC provided a critical review of the manuscript. All authors approved the final version of the manuscript and take accountability for all aspects of the work.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Interview guide.

[\[DOCX File , 14 KB - mededu_v8i3e35983_app1.docx \]](#)

Multimedia Appendix 2

Codebook.

[\[DOCX File , 34 KB - mededu_v8i3e35983_app2.docx \]](#)

Multimedia Appendix 3

COREQ 32-item checklist.

[\[DOCX File , 21 KB - mededu_v8i3e35983_app3.docx \]](#)**References**

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Abbreviations

LKCMedicine: Lee Kong Chian School of Medicine

MCQ: multiple-choice question

mLearning: mobile learning

TESLA: Telegram Education for Surgical Learning and Application

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Original Paper

The Role of Metacognitive Beliefs in Predicting Academic Procrastination Among Students in Iran: Cross-sectional Study

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Abstract

Background: Academic procrastination is a challenge that many students face. Metacognitive beliefs are the main cause of academic procrastination because they are one of the main reasons for students' academic failure or progress.

Objective: This study aimed to determine whether and to what extent academic procrastination could be predicted based on students' metacognitive beliefs.

Methods: This descriptive cross-sectional study involved 300 students selected via stratified random sampling. Data were collected using the Procrastination Assessment Scale for Students and the Metacognition Questionnaire-30. The data analysis was done using the Pearson correlation coefficient and regression analysis to estimate the correlation coefficient and predictability of academic procrastination based on metacognitive beliefs.

Results: A significant negative correlation was observed between the subscale of positive beliefs of concern and academic procrastination ($r=-0.16$; $P<.001$). In addition, the metacognitive beliefs of the participants predicted 10% of academic procrastination. The component of positive metacognitive beliefs with the β value of 0.45 negatively and significantly predicted the students' academic procrastination ($P<.001$), whereas the component of negative metacognitive beliefs with the β value of .39 positively and significantly predicted the students' academic procrastination ($P<.001$).

Conclusions: Metacognitive beliefs can predict students' academic procrastination. Therefore, the modification of metacognitive beliefs to reduce procrastination is suggested.

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KEYWORDS

procrastination; metacognitive awareness; medical students; academic training

Introduction

Academic procrastination is a challenge faced by many individuals and organizations [1], and it is a major cause of learners' failure to attain academic achievement [2]. A study conducted by Kagan et al [3] involving 265 students from different universities, departments, and classes showed that among students with individual characteristics of perfectionism and compulsive obsession, 67 (25%) showed some a degree of

academic procrastination, which disrupted their ability to learn [3]. *Academic procrastination* could be defined as a student delaying their studies until the night before an exam, which affects the student's academic achievement. In academic settings, students have specific tasks to perform, such as writing term papers; studying for exams; reading assignments; and performing academic, administrative, and attendance tasks. However, for one reason or another, the completion of these tasks is often postponed. The general propensity to engage in such dilatory behavior is called *academic procrastination* [4].

The main consequences of academic procrastination are poor educational performance and the feeling of negative emotions, such as guilt and shame. Notably, procrastination is not always an issue, since not completing a task is in some cases better than doing it incompletely [5]. Academic procrastination emerges as a deliberate delay in a practical course of study and tasks such as reading, article writing, and preparing for an exam. Academic procrastination is an irrational desire to delay the completion of a homework assignment or other academic tasks. Under such circumstances, students lack the motivation for academic activities at certain times despite the intention to complete them. Consequently, they fail to complete assignments to their desired level of quality within the expected time frame, which adversely affects their mental health [6].

Dysfunctional cognitive and metacognitive beliefs are considered to be the main causes of academic procrastination [7]. In general, cognitive approaches emphasize the impact of negative attitudes and beliefs on procrastination, though they fail to explain the efficacy of such beliefs through different mechanisms. Nonetheless, the metacognitive perspective of procrastination could accurately explain these processes [8]. According to Flavell, metacognition is the cognitive knowledge or process that cooperates in the assessment, review, and control of cognition, thereby tuning cognitive performance [9]. Moreover, it could be used to link and combine new information with previously learned data that are to be stored in long-term memory [10].

Most theorists believe there are 2 distinct aspects of metacognition. The first aspect is metacognitive knowledge, which refers to the knowledge one has about their cognitive processes and strategies for learning [11]. The second aspect is metacognitive regulation, which refers to different types of executive actions, such as attention, review, planning, and the identification of performance errors in terms of their impact on cognitive activity [11,12]. Therefore, procrastination is related to metacognition from 2 perspectives. First, procrastination is considered a strategy for regulating cognition. Second, procrastination is associated with negative emotions and is considered a strategy adopted by individuals to avoid and regulate negative emotions [13].

With regard to the performance of students on academic assignments, some researchers have considered cognitive elements to be the strongest predictors of learning, while others have highlighted the role of metacognitive components in this regard [14]. Studies have shown a positive correlation between procrastination and difficulties in emotional regulation [15]. Furthermore, a positive association has been reported between improper emotional regulation strategies (eg, blaming others) and procrastination. Therefore, training on emotional regulation skills could reduce procrastination [16]. Nonetheless, some studies have identified academic procrastination in 80%-90% of students [17].

In a study on this topic, Özer et al [18] reported procrastination in the process of article writing, preparation for exams, and the completion of weekly assignments in 46%, 27%, and 30% of students, respectively. According to Özer and Sackes [19], 38% of students were severe procrastinators, although Walters [11]

reported a reverse correlation between adopting certain metacognitive beliefs and procrastination. Furthermore, results obtained by Howell and Watson [20] indicated a reverse correlation between certain metacognitive beliefs and academic procrastination.

Given the previously mentioned findings and the high prevalence of procrastination among students, authorities, educational planners, and those involved in the academic system must adopt strategies for the management and reduction of procrastination in students. This could be a step toward solving the educational problems of learners at different levels of study. This study aimed to determine the role of metacognitive beliefs in the prediction of academic procrastination. The main question of the study is the following: to what extent do metacognitive beliefs predict academic procrastination?

Methods

Ethics Approval

This study was approved by the ethics committee of Kermanshah University of Medical Sciences (IR.KUMS.REC.1396.446), and participants provided written informed consent for participation in this study.

Participants and Setting

This descriptive-analytical cross-sectional study focused on students at Kermanshah University of Medical Sciences (N=4200) from July to August 2020. All students at Kermanshah University of Medical Sciences, including students in the School of Health (n=50), the School of Paramedical Sciences (n=70), the School of Nursing (n=50), the School of Medicine (n=60), the School of Pharmacy (n=40), and the School of Dentistry (n=30) participated in the study. The sample size was estimated to be 300 students via the Morgan table. Participants were selected via stratified random sampling; students were selected from all educational disciplines.

Data Collection and Descriptive Analysis

Data were collected using the Persian version of the Procrastination Assessment Scale for Students (PASS) by Solomon and Rothblum [21] and the Metacognition Questionnaire-30 (MCQ-30) by Wells and Cartwright-Hatton [22]. The PASS was first developed and used by Solomon and Rothblum in 1984. In this 27-item tool, items 2, 4, 6, 11, 15, 16, 21, 23, and 25 are scored reversely. The scale evaluates procrastination in the following three areas: preparing for an exam (items 1-6), completing assignments (items 9-17), and writing papers at the end of a semester (items 20-25). This scale has been used and validated in previous studies, and its reliability has been confirmed with a Cronbach α of .73 [21]. In this study, its internal consistency was estimated to be 0.84, and its reliability was confirmed with a Cronbach α of .64 [22]. This questionnaire was reviewed and approved in a study by Mortazavi et al [23] in Iran, who conducted a confirmatory factor analysis on an ethnically diverse sample of 345 participants. The MCQ-30 is a 30-item self-report tool consisting of 5 subscales, in which items 2, 4, 6, 11, 15, 16, 21, 23, and 25 are scored reversely. The five factors are cognitive confidence, positive beliefs about worry, cognitive

self-consciousness, negative beliefs about the uncontrollability of thoughts and danger, and beliefs about the need to control thoughts. The MCQ-30 showed good internal consistency and convergent validity and acceptable to good test-retest reliability [22].

The data analysis was performed in SPSS (version 20; IBM Corporation) using the Pearson correlation coefficient and regression analysis. The Pearson correlation coefficient was used to estimate the relationships between the study variables. The regression coefficient was used to calculate the predictability of academic procrastination based on metacognitive beliefs.

Results

The mean age of the students was 21.86 (SD 2.70) years. In terms of sex, 150 (50%) of the 300 students were female. The mean total score of procrastination was 63.67 (SD 4.88), and the mean scores of procrastination in the dimensions of preparation for an exam, completing assignments, and completing homework during the semester were found to be 18.53 (SD 3.05), 25.79 (SD 4.08), and 18.62 (SD 1.99), respectively. Table 1 shows the mean scores of the metacognition variable and its dimensions.

Tables 2 and 3 show the correlation coefficients of academic procrastination, metacognitive beliefs, and their subscales. The results indicated a significant negative correlation between the subscale of positive beliefs of concern and academic procrastination ($r=-0.16$; $P<.001$). In other words, a higher score for academic procrastination was associated with a lower score for the subscale positive beliefs of concern (Tables 2 and 3).

Table 1. Means and SDs of the total scores for academic procrastination.

Components of procrastination	Score, mean (SD)	Minimum score	Maximum score
Total negligence score	63.67 (4.88)	55	75
Preparation for an exam	18.53 (3.05)	13	23
Completing homework	25.79 (4.08)	18	33
Writing end-of-term papers	18.62 (1.99)	15	25

Table 2. Means and SDs of the total scores for metacognitive beliefs.

Dimensions of metacognitive beliefs	Score, mean (SD)	Minimum score	Maximum score
Positive concerns	18.47 (4.43)	10	29
Negative metacognitive beliefs	19.44 (4.57)	9	28
Low cognitive efficiency	18.80 (4.00)	12	27
Negative metacognitive beliefs about thoughts	18.47 (3.60)	12	26
Cognitive self-awareness	22.68 (4.45)	15	33
Total score	94.47 (4.45)	58	136

In this study, a simultaneous multiple regression analysis was applied to determine the share of each component of metacognitive beliefs in determining the variance in academic procrastination. As shown in model 1, approximately 10% of the variance in academic procrastination could be predicted based on metacognitive beliefs (model 1: $R=0.309$; $R^2=0.095$; justified $R=0.089$; $F_{298}=15.63$; $P=.001$). The F ratio also indicated that academic procrastination could be predicted based on the variable of metacognitive beliefs—something that was statistically significant ($P=.001$; Table 4).

The F ratio demonstrated that the regression of the criterion variable (ie, academic procrastination) was significant based on the predictive variables ($P=.001$); in other words, the components of metacognitive beliefs were considered significant. Among the dimensions of the metacognitive beliefs variable, the elements of positive and negative metacognitive beliefs affected the students' academic procrastination, predicting 10% of their academic procrastination (model 2: $R=0.324$; $R^2=0.105$; justified $R=0.090$; $F_{298}=6.89$; $P=.001$). On the other hand, the component of positive metacognitive beliefs with the β value of $-.45$ negatively and significantly predicted the students' academic procrastination ($P<.001$), while the component of negative metacognitive beliefs with the β value of $.39$ positively and significantly predicted the students' academic procrastination ($P<.001$).

According to the obtained β coefficients, the component of positive metacognitive beliefs had the most significant contribution in explaining the variance in the students' academic procrastination ($P<.001$). In terms of predictive power, the components of positive and negative metacognitive beliefs had the highest and lowest ability to predict procrastination, respectively (Table 5).

Table 3. Correlation analysis (Pearson r and 2-tailed P value) among procrastination variables and dimensions of metacognitive beliefs. Correlation is significant at the .01 level.

Variables	Negligence	The total score of metacognitive beliefs	Positive concerns	Negative metacognitive beliefs	Low cognitive efficiency	Negative metacognitive beliefs about thoughts	Cognitive self-awareness
Negligence							
r	1	-0.40	-0.16	0.10	-0.03	-0.03	-0.05
P value	— ^a	.001	.006	.10	.51	.66	.42
The total score of metacognitive beliefs							
r	-0.40	1	0.85	0.84	0.74	0.78	0.79
P value	.001	—	.001	.001	.001	.001	.001
Positive concerns							
r	-0.16	0.85	1	0.63	0.66	0.45	0.59
P value	.006	.001	—	.001	.001	.001	.001
Negative metacognitive beliefs							
r	0.10	0.84	0.63	1	0.45	0.65	0.62
P value	.10	.001	.001	—	.001	.001	.001
Low cognitive efficiency							
r	-0.03	0.74	0.66	0.45	1	0.45	0.44
P value	.51	.001	.001	.001	—	.001	.001
Negative metacognitive beliefs about thoughts							
r	-0.03	0.78	0.45	0.65	0.45	1	0.49
P value	.66	.001	.001	.001	.001	—	.001
Cognitive self-awareness							
r	-0.05	0.79	0.59	0.62	0.44	0.49	1
P value	.42	.001	.001	.001	.001	.001	—

^aNot applicable.**Table 4.** β coefficients and t test values for academic procrastination.

Criterion variable and predictive variable	B ^a (SD)	β ^b	t test (df)	P value
Academic procrastination				
Constant	55.70 (2.27)	N/A ^c	24.49 (298)	.001
Metacognitive beliefs	-0.024 (0.017)	.079	-1.42 (298)	.16

^aUnstandardized β coefficient.^bStandardized beta coefficient.^cN/A: not applicable.

Table 5. β coefficients and t test values for metacognitive beliefs.

Criterion variable and predictive variable	B ^a (SD)	β^b	t test (df)	P value
Metacognitive beliefs				
Constant	64.52 (1.72)	N/A ^c	37.63 (298)	.001
Positive concerns	0.454 (0.098)	.412	-4.63 (298)	.001
Negative metacognitive beliefs	0.416 (0.092)	.389	4.54 (298)	.001
Low cognitive efficiency	0.169 (0.091)	.138	1.86 (298)	.06
Negative metacognitive beliefs about thoughts	-0.118 (0.104)	-.087	-1.14 (298)	.25
Cognitive self-awareness	-0.068 (0.0082)	-.062	-0.83 (298)	.41

^aUnstandardized β coefficient.

^bStandardized beta coefficient.

^cN/A: not applicable.

Discussion

Principal Findings

This study aimed to determine the predictability of academic procrastination based on metacognitive beliefs among students in Iran. A significant negative correlation was observed between the subscale of positive beliefs of concern and academic procrastination ($r=-0.16$; $P<.001$). The metacognitive beliefs of the participants predicted academic procrastination. The component of positive metacognitive beliefs with the β value of $-.45$ negatively and significantly predicted the students' academic procrastination ($P<.001$), whereas the component of negative metacognitive beliefs with the β value of $.39$ positively and significantly predicted the students' academic procrastination ($P<.001$).

Our results showed that a significant negative correlation was observed between the subscale of positive beliefs of concern and academic procrastination ($r=-0.16$; $P<.001$). The results of this study are consistent with the findings of Hayat et al [24], who reported that 28.85% of students have a high level of academic procrastination and that academic procrastination among postgraduate students is very common and has a negative impact on their mental health. Academic self-efficacy positively correlated with academic self-control and negatively correlated with academic procrastination, and academic self-control negatively correlated with academic procrastination. Academic self-control had a completely mediating effect on the influence of academic self-efficacy on academic procrastination. Sex variables moderated the influence of academic self-efficacy on academic self-control and thus significantly moderated the mediating effect of academic self-control. Specifically, academic self-control had a stronger mediating effect on the influence of academic self-efficacy on academic procrastination for female postgraduate students [25].

In addition, the metacognitive beliefs of the participants predicted 10% of academic procrastination. The component of positive metacognitive beliefs with the β value of $-.45$ negatively and significantly predicted the students' academic procrastination ($P<.001$), whereas the component of negative metacognitive beliefs with the β value of $.42$ positively and significantly predicted the students' academic procrastination

($P<.001$). Among the dimensions of the metacognitive beliefs variable, the components of positive and negative metacognitive beliefs affected the prediction of the students' academic procrastination. Since obtaining a higher score on this scale was interpreted as having more negative metacognitive beliefs, a positive correlation was denoted between the 2 variables, indicating that the students with more negative metacognitive beliefs procrastinated more often. Based on the correlation coefficients, a reverse association was also shown, suggesting that those who procrastinated more often had more negative beliefs. In this regard, our findings are in line with the results obtained by studies showing a positive correlation between academic procrastination and metacognitive beliefs [26,27].

According to Özer, PhD (unpublished data, 2010), learning new study skills could reduce procrastination, which might be due to the fact that procrastination is a defect in metacognitive strategies. Throughout the literature, procrastination has been perceived as a failure in self-regulation (ie, metacognitive beliefs) by various researchers [28-30].

Considering the theoretical research background and the results of this study, it could be inferred that the high prevalence of procrastination among students necessitates the attention of education officials and planners toward reducing or correcting academic procrastination. Overall, procrastination is a maladaptive behavior and an inefficient with negative consequences. These findings have implications for the better understanding of academic procrastination and the use of academic interventions to correct this issue.

Based on the findings of this study, the following recommendations could be employed to improve learning and reduce academic procrastination. Given the multidimensional nature of metacognitive variables, the dimensions of procrastination should be evaluated along with these variables. Extensive educational programs could be implemented regarding learning positive and beneficial metacognitive beliefs and avoiding negative and harmful metacognitive beliefs. Special attention should be paid to preventive strategies for procrastination by education authorities, planners, and policy makers. Similar studies should be conducted on students in other educational levels, but such studies should use experimental study designs to increase the generalizability of

the results and determine causal relationships. The concept of academic procrastination should also be assessed at lower levels of education to take proper measures for reducing procrastination and preventing its negative outcomes in the education and future careers of younger students.

Limitations

This study compiles the results of a questionnaire and has its own limitations; there is a possibility of bias, exaggeration in estimating features, or memory errors when responding to a questionnaire. Therefore, measuring each of the variables while performing tasks that are closely related to the real-world situation can provide a more realistic view of the relationships being studied. However, we attempted to gather reliable information. Due to the analysis of correlations between variables, there are limitations in explaining variable relationships causally; therefore, conducting research with an experimental design that examines the interventional effect of metacognitive beliefs about procrastination on reducing

academic procrastination to confirm and complete the results of this study would be helpful.

Strengths

We tried to gather and analyze reliable data. A strength of this study was the completion of questionnaires with the presence of the researcher. Furthermore, this topic has not been studied before in Iran.

Conclusions

A significant negative correlation was observed between the subscale of positive beliefs of concern with academic procrastination ($r=-0.16$; $P<.001$). The metacognitive beliefs of the participants predicted academic procrastination. The component of positive metacognitive beliefs negatively and significantly predicted the students' academic procrastination ($P<.001$), whereas the component of negative metacognitive beliefs positively and significantly predicted the students' academic procrastination ($P<.001$). Due to the predictability of procrastination based on metacognitive beliefs, the modification of metacognitive beliefs to reduce procrastination is suggested.

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Conflicts of Interest

None declared.

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Abbreviations

MCQ-30: Metacognition Questionnaire-30

PASS: Procrastination Assessment Scale for Students

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Original Paper

Using Mobile Virtual Reality Simulation to Prepare for In-Person Helping Babies Breathe Training: Secondary Analysis of a Randomized Controlled Trial (the eHBB/mHBS Trial)

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Abstract

Background: Neonatal mortality accounts for approximately 46% of global under-5 child mortality. The widespread access to mobile devices in low- and middle-income countries has enabled innovations, such as mobile virtual reality (VR), to be leveraged in simulation education for health care workers.

Objective: This study explores the feasibility and educational efficacy of using mobile VR for the precourse preparation of health care professionals in neonatal resuscitation training.

Methods: Health care professionals in obstetrics and newborn care units at 20 secondary and tertiary health care facilities in Lagos, Nigeria, and Busia, Western Kenya, who had not received training in Helping Babies Breathe (HBB) within the past 1 year were randomized to access the electronic HBB VR simulation and digitized HBB Provider's Guide (VR group) or the digitized HBB Provider's Guide only (control group). A sample size of 91 participants per group was calculated based on the main study protocol that was previously published. Participants were directed to use the electronic HBB VR simulation and digitized HBB Provider's Guide or the digitized HBB Provider's Guide alone for a minimum of 20 minutes. HBB knowledge and skills assessments were then conducted, which were immediately followed by a standard, in-person HBB training course that was led by study staff and used standard HBB evaluation tools and the Neonatalie Live manikin (Laerdal Medical).

Results: A total of 179 nurses and midwives participated (VR group: n=91; control group: n=88). The overall performance scores on the knowledge check ($P=.29$), bag and mask ventilation skills check ($P=.34$), and Objective Structured Clinical Examination A checklist ($P=.43$) were similar between groups, with low overall pass rates (6/178, 3.4% of participants). During the Objective Structured Clinical Examination A test, participants in the VR group performed better on the critical step of positioning the head and clearing the airway (VR group: 77/90, 86%; control group: 57/88, 65%; $P=.002$). The median percentage

of ventilations that were performed via head tilt, as recorded by the Neonatalie Live manikin, was also numerically higher in the VR group (75%, IQR 9%-98%) than in the control group (62%, IQR 13%-97%), though not statistically significantly different ($P=.35$). Participants in the control group performed better on the *identifying a helper and reviewing the emergency plan* step (VR group: 7/90, 8%; control group: 16/88, 18%; $P=.045$) and the *washing hands* step (VR group: 20/90, 22%; control group: 32/88, 36%; $P=.048$).

Conclusions: The use of digital interventions, such as mobile VR simulations, may be a viable approach to precourse preparation in neonatal resuscitation training for health care professionals in low- and middle-income countries.

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KEYWORDS

virtual reality; mobile learning; Helping Babies Breathe; neonatal resuscitation; mobile Helping Babies Survive powered by District Health Information Software 2; neonatal mortality; digital education; health care education; health care worker; medical education; digital intervention

Introduction

Intrapartum asphyxia—the failure to breathe at birth—is a common medical emergency that occurs in the newborn period, and newborns with this condition require neonatal resuscitation to survive. The outcome of neonatal resuscitation depends on the availability of equipment and appropriately trained personnel [1]. The periodic in-service training of health care professionals, such as physicians, nurses, and midwives, on newborn resuscitation has significantly decreased neonatal mortality, which accounts for 46% of under-5 mortality globally [2-7]. Neonatal resuscitation training has largely depended on in-person, daylong workshops and manikin-based simulation exercises that are time-consuming and cost-intensive, resulting in widely spaced intervals for refresher training [4].

Newer models of neonatal resuscitation training involving the use of emerging technologies have been described [8,9]. Virtual reality (VR) is a new technology that has been described as “the learning aid of the 21st century,” as the feasibility and applicability of VR have been demonstrated in nearly all aspects of training and education [10,11]. The use of VR has provided engaging, individualized, and incentivized practice opportunities within immersive experiences [12], particularly under conditions like the COVID-19 pandemic, during which social distancing is encouraged.

Mobile VR simulations can be used to teach abstract ideas, illustrate real-world phenomena, and motivate students. [13]. The unpredictability of how and when neonatal resuscitation will be encountered in the clinical setting requires constant preparedness and confidence building, which can be gained via repeated practice (individually, in pairs, or as a small group). Due to the high level of user involvement in VR simulations, users may be exposed to materials more than once, lengthening the time spent actively learning and enhancing skill acquisition and retention. [9,14]. By connecting offline identities, game scenarios, and actual interactions with and within a virtual system, game-based learning enables learners to display abilities and alter behaviors that are related to clinical practice [15-19]. Evidence suggests that simulation games increase posttraining self-efficacy by 20%, declarative knowledge by 11%, procedural knowledge by 14%, and retention by 9% [20].

Although most software simulations require a PC with sufficient graphics capabilities or an advanced VR headset, mobile VR simulations can be delivered on mobile phones via a low-cost VR headset [9,21,22]. Health care professionals in low- and middle-income countries (LMICs) now have practically universal access to mobile phones, which encourages the accessibility, scalability, flexibility, and effectiveness of e-learning while lowering marginal costs. For instance, over the past 20 years, mobile subscriptions and broadband penetration have dramatically expanded in Nigeria [23]. According to the Nigerian Communications Commission, in 2020, there were 300 million connected mobile lines and 204 million active subscribers to Global System for Mobile Communications networks in Nigeria, resulting in a teledensity (the number of telephone connections) of 107 for every 100 individuals living in Nigeria [23].

This study involved a secondary analysis of data that were collected during the electronic Helping Babies Breathe (eHBB)/mobile Helping Babies Survive (mHBS) trial [24]. We explored the feasibility and educational efficacy of using mobile VR training and the digitized Helping Babies Breathe (HBB) Provider's Guide, compared to using the digitized HBB Provider's Guide alone, as an approach to precourse preparation for health care professionals attending in-person HBB courses in a low-resource setting. We hypothesized that, as measured via precourse assessments using validated HBB evaluation instruments, health care professionals who used mobile VR simulations and the digitized HBB Provider's Guide before the course would be better prepared for in-person HBB training compared to those who used only the digitized guide without exposure to VR scenarios.

Methods

Study Design

This was a substudy of the prospective randomized controlled trial of an educational intervention, which was described fully elsewhere [24].

Study Population

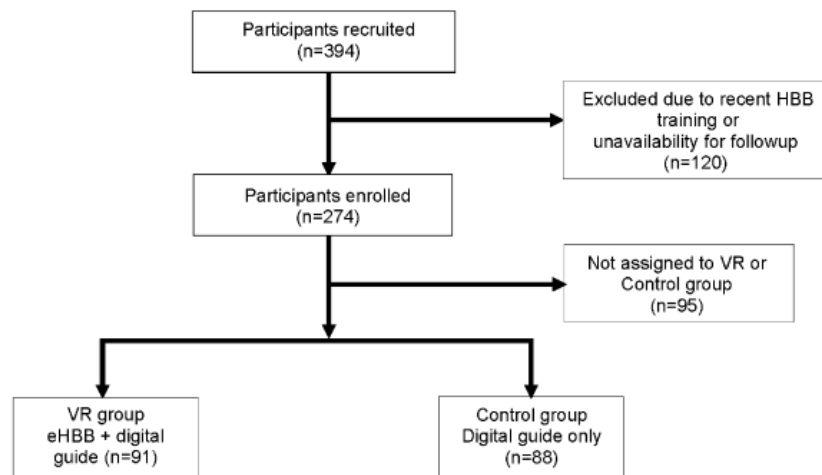
Health care professionals (nurses or nurse-midwives) who worked in labor, delivery, and newborn care units at 20 secondary and tertiary health care facilities in Lagos, Nigeria,

and Busia, Western Kenya, and had not received training in HBB within the previous 1 year were recruited to participate in the eHBB study [24].

Randomization

Participants were consented and were randomized to receive the eHBB and digitized HBB Provider's Guide (VR group) intervention or the digitized HBB Provider's Guide-only intervention (control group) before a standard in-person HBB course (Figure 1).

Figure 1. CONSORT (Consolidated Standards of Reporting Trials) flow chart. eHBB: electronic Helping Babies Breathe; HBB: Helping Babies Breathe; VR: virtual reality.



Intervention

The eHBB VR simulations consisted of 3 brief, 3- to 5-minute, interactive 3D simulation scenarios that represented a newborn requiring routine care, some resuscitation, or prolonged resuscitation via positive pressure ventilation (Multimedia Appendix 1). The simulations were accessed using a low-cost VR headset and the eHBB virtual simulation app installed on participants' study phones. The digitized HBB Provider's Guide consisted of a digital version of the standard HBB, Second Edition, Provider's Guide on the mHBS powered by District Health Information Software 2 (DHIS2; mHBS/DHIS2) app that was installed on participants' phones. The VR group had access to the VR intervention and the digitized HBB Provider's Guide. The mobile simulation scenarios were brief, and each could be completed within 3 to 5 minutes. A minimum of 20 minutes was given for the participants to familiarize themselves with their study group materials. Although they were encouraged to familiarize themselves with the eHBB VR simulation, the VR group, at enrollment, was allowed to access all of their study group materials (the eHBB VR simulation and digitized HBB Provider's Guide) without restrictions. The control group only used the digitized HBB Provider's Guide.

Precourse knowledge and skills assessments were then conducted by trained study staff using the following standardized tools: the HBB, Second Edition, knowledge check multiple-choice questionnaire; the bag and mask ventilation (BMV) skills check (a passing score was defined as correctly performing all 14 steps); and the Objective Structured Clinical Examination (OSCE) A checklist (a passing score was defined as correctly performing at least 9 of the 12 steps, including the required actions [items 4, 5, and 9]). The outcomes, which were measured by using the BMV skills check and the OSCE A checklist, were the health care professionals' neonatal

resuscitation skills before the standard in-person HBB, Second Edition, training course. The Neonatalie Advanced manikin (Laerdal Medical) was used for the standardized collection of data on BMV skills. Participants then received standard in-person HBB, Second Edition, training. Postcourse and follow-up evaluations for up to 6 months were described previously [24].

Ethics Approval

This study was approved by the University of Lagos Health Research Ethics Committee (reference number: CMUL/HREC/09/18/445); Moi University Institutional Research Ethics Committee, Indiana University Institutional Review Board (reference number: 1807371465); and University of Washington Institutional Review Board (reference number: STUDY00005297).

Data Analysis

Data were collected in real time by trained research assistants using the mHBS/DHIS2 mobile app [25] on dedicated Android mobile devices, and paper data forms were used as backups. A post hoc data analysis was performed for this study. Data were analyzed by using SAS version 9.4 (SAS Institute) and R version 4.0.0 (R Foundation for Statistical Computing) software. BMV performance data on the Neonatalie Live manikin were transmitted from the manikin to an iPad (Apple Inc) via Bluetooth and stored in a secure cloud database. Continuous variables were presented as means with SDs or medians with IQRs, and categorical variables were presented as numbers with percentages. The Kruskal-Wallis test or Wilcoxon rank-sum test was used to compare scores from the knowledge check, BMV skills test, and OSCE A test between groups. The Fisher exact test was used to compare overall test pass rates and pass rates for individual test items of interest. The sample size was

not chosen specifically for this substudy but was initially determined to meet the goals of the primary study—to detect a 20% difference in pass rates on the OSCE B test between groups at the 6-month follow-up evaluation time point with 80% power [24]. Differences were considered significant when the 2-sided *P* values were $<.05$.

Results

Demographic Characteristics

Data from 179 health care professionals who were assigned to the VR and control groups were reviewed. Table 1 shows the

demographic characteristics of the study participants, which were similar between the intervention (VR and digital guide) and control (digital guide only) groups. Most of the participants were female (162/179, 90.5%). Of the 179 participants, only 29 (16.2%) had ever undergone training on HBB, and all previously trained health care professionals were trained with the HBB, First Edition, curriculum. Nearly all of the participants (163/179, 91.1%) owned a smartphone.

The median scores (out of 18) on the precourse knowledge check were similar for both groups (VR group: 15, IQR 14-16; control group: 16, IQR 15-17; $P=.29$).

Table 1. Demographic characteristics of the study participants.

Characteristic	Group	
	VR ^a (n=91)	Control (n=88)
Age (years), mean (SD)	37 (9)	37 (9)
Sex, n (%)		
Male	9 (10)	8 (9)
Female	82 (90)	80 (91)
Profession, n (%)		
Nurse	43 (47)	44 (50)
Nurse-midwife	48 (53)	44 (50)
Country, n (%)		
Kenya	44 (48)	42 (48)
Nigeria	47 (52)	46 (52)
Ward^b, n (%)		
Labor or delivery ward	62 (71)	63 (73)
Postnatal ward	15 (17)	18 (21)
NBU ^c or NICU ^d	6 (7)	4 (5)
Operating theater	4 (5)	1 (1)
Years of postqualification experience^b, n (%)		
<5	22 (24)	26 (30)
5-10	34 (38)	25 (28)
11-15	11 (12)	13 (15)
16-20	11 (12)	8 (9)
>20	12 (13)	16 (18)
Prior HBB ^e training, n (%)	16 (18)	13 (15)
Owns a smartphone, n (%)	81 (89)	82 (93)

^aVR: virtual reality.

^bParticipants with missing values were excluded from the corresponding summary (ward: n=12; years of experience: n=2).

^cNBU: newborn unit.

^dNICU: neonatal intensive care unit.

^eHBB: Helping Babies Breathe.

BMV Skills

The overall performance on the precourse BMV skills check was also similar between groups, with a median score (out of

14) of 4.93 (IQR 3-6) in the VR group and 5.32 (IQR 4-7) in the control group ($P=34$). Among all participants, 1 participant in the VR group achieved a passing score of 14. There were no statistically significant differences in the pass rates for individual

test items between the VR and control groups, as shown in [Table 2](#).

Table 2. Precourse bag and mask ventilation performance.

Steps	Group ^a , n (%)		P value
	Virtual reality (n=83)	Control (n=79)	
Place baby on ventilation area	49 (59)	45 (57)	.87
Stand at the baby's head	38 (46)	45 (57)	.16
Check that the mask size is correct	32 (39)	39 (49)	.21
Position the head slightly extended	41 (49)	40 (51)	>.99
Apply the mask to the face	57 (69)	58 (73)	.60
Make a tight seal	25 (30)	20 (25)	.60
Squeeze the bag	25 (30)	16 (20)	.21
Ventilate	22 (27)	20 (25)	>.99
Ventilate at 40 breaths per minute	13 (16)	10 (13)	.66
Reapply mask	39 (47)	44 (56)	.28
Reposition head	36 (43)	40 (51)	.43
Clear mouth and nose of secretions	13 (16)	11 (14)	.83
Open the mouth	2 (2)	1 (1)	>.99
Squeeze the bag harder	17 (20)	19 (24)	.71

^aIn total, 83 of the 91 participants in the virtual reality group and 79 of the 88 participants in the control group had bag and mask ventilation skills check results available.

OSCE A Performance

The median scores (out of 12) on the precourse OSCE A checklist were 5.91 (IQR 4-8) in the VR group and 5.83 (IQR 4-7) in the control group ($P=.43$). Only 4% (4/90) of the participants in the VR group and 2% (2/88) of the participants in the control group achieved passing scores. Participants' performance on individual test items is shown in [Table 3](#). The two steps that the control group more frequently performed were the *identifying a helper and reviewing the emergency plan* step (VR group: 7/90, 8%; control group: 16/88, 18%; $P=.045$) and the *washing hands* step (VR group: 20/90, 22%; control group: 32/88, 36%; $P=.048$). Participants in the VR group performed better on the critical step of positioning the head and clearing the airway (VR group: 77/90, 86%; control group: 57/88, 65%; $P=.002$). In addition, the VR group tended to

perform better on the *removing the wet cloth* step than the control group (VR group: 34/90, 38%; control group: 22/88, 25%; $P=.08$).

The precourse data from the Neonatalie Live manikin showed that participants in both groups spent a median time of 160 seconds performing BMV, with a median ventilation rate of 29 (VR group: 29.4; control group: 29.3) breaths per minute. The median percentages of ventilations with low pressures (VR group: 4%, IQR 0%-12%; control group: 4%, IQR 0%-17%; $P=.27$), ventilations with high pressures (VR group: 0%, IQR 0%-9%; control group: 0%, IQR 0%-2%; $P=.20$), and valid ventilations (VR group: 19%, IQR 2%-59%; control group: 19%, IQR 0%-57%; $P=.68$) were similar between both groups. The median percentage of ventilations that were performed via head tilt was 75% (IQR 9%-98%) in the VR group and 62% (IQR 13%-97%) in the control group ($P=.35$).

Table 3. Precourse Objective Structured Clinical Examination A performance.

Steps	Group ^a , n (%)		P value
	Virtual reality (n=90)	Control (n=88)	
Identifies a helper and reviews the emergency plan	7 (8)	16 (18)	.045
Prepares the area for delivery	49 (54)	52 (59)	.55
Washes hands	20 (22)	32 (36)	.048
Prepares ventilation area	44 (49)	38 (43)	.46
Dries thoroughly	55 (61)	54 (61)	>.99
Removes wet cloth	34 (38)	22 (25)	.08
Recognizes baby is not crying	51 (57)	49 (56)	>.99
Positions head and clears airway	77 (86)	57 (65)	.002
Stimulates breathing by rubbing the back	23 (26)	24 (27)	.87
Recognizes baby is crying and breathing well	63 (70)	55 (62)	.34
Clamps or ties and cuts the cord	56 (62)	48 (55)	.36
Communicates with mother	46 (51)	40 (45)	.46

^aIn total, 90 of the 91 participants in the virtual reality group and all 88 participants in the control group had Objective Structured Clinical Examination A results available.

Discussion

Principal Findings

This study is the first to demonstrate the feasibility and educational efficacy of using mobile VR simulations and digital manuals as an approach to precourse preparation for health care professionals undergoing neonatal resuscitation training in a low-resource setting. The overall precourse performance on knowledge assessments was higher than the overall precourse performance on skills assessments. Although the precourse mobile VR simulation and the reading of a digital manual prior to training did not result in a substantial number of participants achieving a passing score on the HBB skills assessments that were administered before the session, the use of these materials may promote interest in learning. The group that only reviewed the digital manual demonstrated significantly better performance than the VR group on the OSCE A for the *identifying a helper and reviewing the emergency plan* step ($P=.045$) and *washing hands* step ($P=.048$). However, the performance of the critical *positioning the head and clearing the airway* step via head tilt to open the airway occurred more frequently in the VR group.

A growing body of evidence from well-designed studies supports the use of simulation to enhance clinical performance [1,8,20,26,27]. The use of VR simulation was associated with changes in stress physiology in a study by Chang et al [28]. Our precourse simulation introduces neonatal resuscitation to participants and may promote interest in learning. It may also save costs and shorten the in-person training time for participants who have already had an immersive experience with the HBB course [10,29].

Using mobile VR simulations can help individuals build skills and confidence for cognitive tasks; thus, such simulations complement formal in-person training that focuses on manikin-based psychomotor tasks, such as BMV [9,30]. The

VR group performed better on specific cognitive tasks. Though not statistically significant (P values were $>.05$ for various tasks; Tables 2 and 3), this incremental benefit demonstrates the potential of VR training to support knowledge and performance skills. Those exposed to the VR simulation demonstrated better knowledge of when a child should be suctioned and other cognitive steps, such as removing the wet cloth and clamping and cutting the cord. They were more likely to recognize when the baby was not crying and when the baby was crying and breathing well. These steps are relevant to quickly initiating neonatal resuscitation and appropriately discontinuing resuscitation when the baby has responded, and they are taught at later points in the in-person HBB course curriculum.

Of note, the *identifying a helper and reviewing the emergency plan* step is featured early in the HBB digital guide, as it is a part of preparing for a delivery; thus, it is possible that this concept was more easily recalled by participants in the control group. Although this concept is also presented in the VR simulation, there is no specific action required by the learner, unlike in other more active elements of the simulation. Featuring a conversational helper in the VR simulation may help to emphasize this aspect of preparing for a delivery.

Communication with the mother is an important element of respectful care [31]. There is evidence that even if health care professionals are skilled in managing pregnancy and birth complications, women may refuse to seek care and discourage others from doing so when they have previously experienced disrespectful care [32]. Manikin-based simulations and VR simulations have been used to teach nontechnical skills and have been shown to improve communication attitudes [27,33,34]. We found that participants in the VR group communicated with the mother with greater frequency during the OSCE evaluation, thereby demonstrating that they recognized the importance of prospectively providing information and engaging with the mother via effective

communication, which are essential elements of respectful care [32].

This study demonstrated the feasibility of using mobile VR simulations for precourse training on neonatal resuscitation in a low-resource setting. Computer-based training simulations, such as HeartCode Pediatric Acute Life Support and the Neonatal Resuscitation Program eSim programs, have been used to complement in-person courses in high-resource settings, with participants being assigned to perform the computer-based simulations up to 1 month before attending in-person courses [9,35,36]. Although simulation laboratories and equipment are lacking [37], the broad use of mobile devices in LMICs supports the need for innovations in the design and distribution of simulation education materials on mobile devices for self-directed learning [9,24]. Nearly all of the participants in our study (163/179, 91%) owned a smartphone. Mobile VR simulations are more accessible to learners than manikin-based simulations or computer-based simulations in low-resource settings, where mobile phones are widely used [23,24,38]. As the receptiveness to VR training is high, spending additional time in individualized precourse exposure may improve learners' performance [39-41].

Limitations to This Study

Some limitations may affect the interpretation of our results. First, although it would have been reasonable to conduct a baseline skills assessment prior to and after introducing the digital interventions to participants, this analysis was not preplanned, and due to the logistical constraints posed by

multiple assessments, we performed precourse assessments in both the VR and control groups after their exposure to the digital interventions but prior to the in-person course. Second, although the VR scenarios were brief and could be completed within 3 to 5 minutes, the minimum time (20 minutes) allotted for digital intervention familiarization prior to the precourse knowledge and skills assessments may not have permitted participants to experience the full impact of the interventions. Increasing the pretraining VR exposure time may optimize learning and reduce in-person training time. Finally, mobile VR simulations may be more suitable for gaining cognitive skills and less suitable for gaining psychomotor skills or learning how to perform manual tasks. Nevertheless, this study provides a possible insight into the relative contribution of precourse exposure and the feasibility of undergoing a mobile VR simulation prior to neonatal resuscitation training in an LMIC setting. Future studies should explore the potential for cost savings or shorter in-person training times for participants who have already been exposed (ie, immersive exposure) to the HBB course content prior to the in-person training [10,29].

Conclusions

The use of digital interventions, such as mobile VR, is feasible and may be a viable approach to precourse preparation in neonatal resuscitation training for health care professionals in LMICs. The role of mobile VR simulation should be further evaluated in the context of training health care professionals in low-resource settings, particularly when access to in-person training with manikin-based simulations is limited.

Data Availability

Data are available on reasonable request. Deidentified data are available on request from RU (nestprog@uw.edu).

Conflicts of Interest

RU and CP developed the eHBB VR app. SB and SP developed the mHBS/DHIS2 app. All other coauthors have no conflicts of interest to disclose that are relevant to this article.

Multimedia Appendix 1

Helping Babies Breathe 2 virtual reality app demo (2020).

[DOCX File, 70 KB - [mededu_v8i3e37297_app1.docx](#)]

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Abbreviations

BMV: bag and mask ventilation

DHIS2: District Health Information Software 2

eHBB: electronic Helping Babies Breathe

HBB: Helping Babies Breathe

LMIC: low- and middle-income country

mHBS: mobile Helping Babies Survive

mHBS/DHIS2: mobile Helping Babies Survive powered by District Health Information Software 2

OSCE: Objective Structured Clinical Examination

VR: virtual reality

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Original Paper

Comparing the Psychological Effects of Manikin-Based and Augmented Reality–Based Simulation Training: Within-Subjects Crossover Study

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Abstract

Background: Patient simulators are an increasingly important part of medical training. They have been shown to be effective in teaching procedural skills, medical knowledge, and clinical decision-making. Recently, virtual and augmented reality simulators are being produced, but there is no research on whether these more realistic experiences cause problematic and greater stress responses as compared to standard manikin simulators.

Objective: The purpose of this research is to examine the psychological and physiological effects of augmented reality (AR) in medical simulation training as compared to traditional manikin simulations.

Methods: A within-subjects experimental design was used to assess the responses of medical students (N=89) as they completed simulated (using either manikin or AR) pediatric resuscitations. Baseline measures of psychological well-being, salivary cortisol, and galvanic skin response (GSR) were taken before the simulations began. Continuous GSR assessments throughout and after the simulations were captured along with follow-up measures of emotion and cortisol. Participants also wrote freely about their experience with each simulation, and narratives were coded for emotional word use.

Results: Of the total 86 medical students who participated, 37 (43%) were male and 49 (57%) were female, with a mean age of 25.2 (SD 2.09, range 22-30) years and 24.7 (SD 2.08, range 23-36) years, respectively. GSR was higher in the manikin group adjusted for day, sex, and medications taken by the participants (AR-manikin: -0.11, 95% CI -0.18 to -0.03; $P=.009$). The difference in negative affect between simulation types was not statistically significant (AR-manikin: 0.41, 95% CI -0.72 to 1.53; $P=.48$). There was no statistically significant difference between simulation types in self-reported stress (AR-manikin: 0.53, 95% CI -2.35 to 3.42; $P=.71$) or simulation stress (AR-manikin: -2.17, 95% CI -6.94 to 2.59; $P=.37$). The difference in percentage of positive emotion words used to describe the experience was not statistically significant between simulation types, which were adjusted for day of experiment, sex of the participants, and total number of words used (AR-manikin: -4.0, 95% CI -0.91 to 0.10; $P=.12$). There was no statistically significant difference between simulation types in terms of the percentage of negative emotion words used to describe the experience (AR-manikin: -0.33, 95% CI -1.12 to 0.46; $P=.41$), simulation sickness (AR-manikin: 0.17, 95% CI -0.29 to 0.62; $P=.47$), or salivary cortisol (AR-manikin: 0.04, 95% CI -0.05 to 0.13; $P=.41$). Finally, preexisting levels of posttraumatic stress disorder, perceived stress, and reported depression were not tied to physiological responses to AR.

Conclusions: AR simulators elicited similar stress responses to currently used manikin-based simulators, and we did not find any evidence of AR simulators causing excessive stress to participants. Therefore, AR simulators are a promising tool to be used in medical training, which can provide more emotionally realistic scenarios without the risk of additional harm.

KEYWORDS

augmented reality; AR; salivary cortisol; galvanic skin conductance; medical simulation; medical education

Introduction

Patient simulators have demonstrated improved learning outcomes in medical training [1-4]. Consequently, over the past decade, the use of simulators has become an increasingly important and prominent part of medical training. These include mechanical manikins (ie, Laerdal SimMan) and the “buddy” system in which a fellow student pretends to be a patient. High-fidelity simulation has been defined as “an opportunity to interact within a realistic clinical environment able to reproduce a wide range of clinical conditions” [5]. The Laerdal SimMan varies by model but is capable of showing respiration, seizures, pupillary changes, auscultatable breath sounds and heart sounds, as well as palpable pulses. However, there is no literature on how realistic these methods are and whether they provoke a realistic emotional response comparable to true emergency medical scenarios in trainees. As such, they may not adequately support the development of critical decision-making behaviors in highly emotional contexts.

To address this lack of realistic emotional context, there has been movement toward using augmented reality (AR) approaches that may substantially improve realism. AR simulation has been increasingly used in medical education over the last decade [6-8]. Most studies regarding AR in medical education focus on the development and initial evaluation of utility and feasibility, particularly in surgical and anatomical education [9-12]. The MedCognition AR system, PerSim, is an augmented reality program used for this study. It uses a HoloLens (Microsoft Corp) headset showing the user a virtual patient who can display various physical exam findings and vitals that are subsequently adjusted by the instructor. Physical exam findings that can be shown include seizures, diaphoresis, retractions, respiratory distress, level of consciousness, and cyanosis, which are not well shown on standard mechanical manikins. HoloLens has been previously shown to be effective in teaching medical students [13].

Problematic here is that it is not known if this increased realism evokes a substantially different stress response in learners than traditional simulation modalities. While a small amount of stress can aid learning outcomes [14], excessive stress could be harmful to the health and well-being of medical trainees. This may be particularly problematic for individuals with certain preexisting psychological traits (eg, psychological disorder and past stressful experiences) that may predispose them to more adverse reactions during training simulation scenarios. There are no existing studies evaluating the psychological or physiological stress response that AR may evoke in learners when used for medical education simulations, and thus, there is a need for systematic evaluation of the educational and safety features of these AR simulations.

There are a variety of ways to assess the physical impact of AR as compared to past manikin approaches. Responses to acute

stress, physiologically, are most typically mapped by either the sympathetic response (a general physiological fight-or-flight change that prepares the body for action) or hypothalamic-pituitary-adrenal (HPA) axis activity, which directs a range of hormonal and immune changes in the body [15]. While acute changes are considered adaptive in the face of stress, especially when recovery is swift, at high or prolonged elevated levels, dysfunctions in these systems can lead to health problems. In human studies, HPA axis activity is most typically gauged by salivary cortisol levels, long considered a gold standard marker of acute stress [16]. Similarly, markers of sympathetic activity (eg, galvanic skin responses [GSR]) [17] in response to stressful stimulation have long been considered biomarkers of stress, cognitive load, and attention [18-20].

From the psychological perspective, there are a host of approaches that can assess how AR fares in terms of altering the well-being of those using it. Most obviously, researchers studying acute stressors focus on self-reported measures of acute stress, but also emotional changes such as an increase in negative emotions (eg, fear, anxiety, and sadness) and a decrease in positive emotions (eg, calm and happiness). While some studies have found well-being benefits from the use of certain AR games, the concern is that the negative emotional impact could be severe in medical simulations that depict realistic illness and even death [21,22]. Therefore, we conjectured that assessing both physical and psychological responses to the simulations, as well as less obvious self-report approaches (eg, approaches that detect emotion without overtly asking), is key given the possibility that demand characteristics may alter the ability to identify changes in well-being (eg, medical students may feel uncomfortable admitting feelings of depression or stress, especially in the presence of other students and instructors). This echoes previous calls for multimethod approaches in well-being research [23].

One final important consideration of using emotionally realistic depictions of a traumatic event in AR is the possibility that preexisting psychological experiences may make the simulation more damaging. For example, do individuals coming into a simulation with a history of trauma or depression face potentially aversive psychological or physiological responses, and should these preexisting characteristics be considered risk factors for the use of AR? Past research has not examined this question specifically; however, research has clearly shown that past trauma can be a risk factor for numerous future health and stress concerns [24], and the same can be said for past major stressors and other psychological traits that can similarly predict future disorder [25]. This is thought to be due to individuals with risks such as past traumas resulting in excess stress responses (eg, HPA axis and sympathoadrenal responses), thereby increasing vulnerability to stress-related disease and depression [26-28]. Thus, it is important that with this new approach to teaching, we examine whether certain individuals have excessive stress responses that could be an early indicator of future problems.

In this study, we hypothesized that the higher-fidelity, more realistic AR simulation would more successfully elicit emotional stress compared to a standard manikin simulator. Specifically, we predicted that the AR simulation would be associated with higher levels of negative emotion and self-rated stress, and lower levels of positive emotion as compared to the manikin simulation. Similarly, we hypothesized that the AR simulation would be tied to higher changes in both GSR and salivary cortisol. Finally, we predicted that preexisting psychological traits would not significantly influence the psychological and physiological responses to the simulation.

Methods

Participants

The study sample consisted of second-year medical students (N=89) at the University of California, Irvine. All 104 students enrolled in Clinical Foundations II were invited to participate in the study via email. Students were evaluated while completing both AR and standard medical simulation cases on mechanical manikins as part of their training. There were no exclusion criteria, and any medical student who wanted to participate was eligible. The participants were compensated for participating with a \$25 Amazon gift card and a free lunch.

Ethics Approval

This study was approved by both the University of California, Irvine Institutional Review Board (HS#2019-5327, approved October 24, 2019) as well as the US Army Medical Research and Materiel Command Office of Research Protection (e01201.1a, approved March 18, 2020), and the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation.

Study Design

Study sample size (as well as power) was calculated based on a similar previous study and the median salivary cortisol level differences [12]. Using Mann-Whitney *U* test and assuming an alpha of .05 and power of 90%, we calculated a sample size of 44. Allowing for data loss, we planned to enroll 72 learners.

The within-subjects crossover study design allowed for comparison of each student's psychologic response and minimized confounding due to variance in the individual psychological responses, as students acted as their own controls. The participants were randomized with a random number generator to complete the first case with either the SimMan or PerSim simulation, and subsequently completed the second case with the other modality.

Procedures

Medical students completed similar medical simulation scenarios, 3 weeks apart, on both a manikin-based simulator, SimMan, and on the AR system, PerSim, while measuring psychological parameters and evidence of stress. Participants had all previously been trained on basic operational procedure for the HoloLens headsets, which provided the hardware for the AR simulation. Before participating in the study sessions, the participants were consented and completed a baseline questionnaire from home, which assessed health behaviors, trait

affect, and demographic characteristics relevant to controls. Upon arrival on each study day, the participants were instructed as to what to expect (without disclosing the nature of the simulation), outfitted with an ambulatory wrist or hand GSR monitor and provided a resting salivary cortisol sample. Within each study session, students completed 1 of 2 scenarios centered on pediatric resuscitation and subsequent death of the patient: 1 status asthmaticus and 1 pediatric sepsis, both with unstable vital signs requiring acute resuscitation, who ultimately succumbed to their illness regardless of learner actions. These cases were integrated into the medical student curriculum with the objective of covering personal emotional stressors in work and difficult conversations; however, they also allowed maximum specific psychological effects. Scenarios lasted approximately 10 minutes each.

Electrodermal activity was continuously assessed via wrist monitor before, during, and after the scenario to establish baseline, task (stress reactivity), and recovery periods. Additionally, salivary cortisol samples were collected to align with times before, immediately following, and 15 minutes after each simulation. Psychological data (eg, stress and emotion) were collected through surveys administered before and immediately following each simulation session. The postsimulation survey additionally included qualitative debriefing questions related to the passing of the participant and the medical knowledge of the participant.

Measures

Preexisting Psychological Traits

The preexisting psychological traits that could be considered potential risk factors for adverse reactions were assessed via a survey taken at home before participation in the study. These factors included posttraumatic stress disorder (PTSD), perceived stress, and depression. Posttraumatic stress disorder was assessed with the self-reported 17-item Posttraumatic Stress Disorder-Civilian Checklist, which assesses PTSD symptoms based closely on Diagnostic and Statistical Manual of Mental Disorder, 4th edition criteria [29]. Perceived stress was assessed via the 10-item Perceived Stress Scale [30], which assesses perceptions of stress over the past month. Depression was assessed via the 10-item Center for Epidemiologic Studies Depression Scale Revised, which measures the prevalence of depression symptoms over the past week [31].

Self-reported Stress

To measure the perceived stress responses induced from the simulation, slider scales ranging from 1 to 100 were used to capture stress levels before and after the simulation [32]. Participants were asked, "How stressed do you feel right now?" The higher scores indicated more stress.

Emotion

State Affect

To assess the affective responses to these scenarios, we measured state emotion change (from before to after simulation) using items drawn from the positive and negative affect schedule (PANAS) [33]. Positive and negative affect subscales within the PANAS were used to create variables for positive and

negative affect. Mean scores were then calculated for positive and negative affect by using subscales within the PANAS, yielding a positive and negative affect score respectively for each time point.

Positive and Negative Word Use

Positive and negative emotion were also assessed via open-answer (qualitative) debriefing surveys following the simulation experiences. These surveys were coded using the Linguistic Inquiry and Word Count program, a validated text analysis software that is widely used in psychological research [34] to count the types of words used in narrative samples. For this study, we used the default positive and negative emotion dictionaries to procure measures tapping the percentage of words of these types in the open responses from participants. This analysis provides an indirect approach to tap the emotional experience of using study simulations.

Physiological Stress

Salivary Cortisol

Salivary cortisol levels, a known biological correlate of psychological stress [35-37], were monitored throughout the simulations. Samples were collected via the passive drool technique with polypropylene cryovial salivettes at 3 time points that accounted for the lag between biological stress response and hormonal detection in saliva to provide cortisol levels. Timepoints were (1) baseline (before simulation), (2) reactivity (during simulation), and (3) recovery (15 minutes after simulation). Experimental sessions were scheduled between 12 PM and 5 PM to account for the diurnal rhythm of cortisol. Salivettes were stored at -80°C until batch analysis at the end of data collection at the laboratory of the Institute for Interdisciplinary Salivary Bioscience Research (University of California Irvine, Irvine, CA). Before assaying, the samples were thawed for an hour to return to room temperature. All samples were assayed in duplicate using an expanded-range high-sensitivity salivary cortisol enzyme immunoassay kit (Salimetrics, LLC; State College, PA). The assay range of sensitivity was 0.007 ug/dl to 3.0 ug/dl, and the average intra-assay coefficient of variation was 5.5%.

Galvanic Skin Response

The GSR data were collected via a small unobtrusive device (Shimmer3) that was monitored by the researchers throughout the simulations. The device was placed on a wristband that was fastened to participants' wrists prior to the start of study tasks. To collect GSR data, the device had 2 wires that extended from the hardware and was attached to participants' palms via 2 electrodes and an additional medical tape when needed to ensure secure connection and a good signal.

Researchers monitored the GSR data using Bluetooth connectivity through a laptop and took notes of any artifacts that could cause spikes in GSR data unrelated to the simulation, such as coughing, external noises, and so on [17]. Additionally, researchers made note of participants who had connectivity issues (eg, due to exceptionally sweaty palms). All these potential artifacts were accounted for during the data cleaning process using an electrodermal activity Analysis application from MindWare Technologies. GSR means were used in the

analyses by obtaining the average GSR score for the baseline and reactivity of each simulation session.

Simulation Sickness Questionnaire

Adverse side effects were measured with the Simulator Sickness Questionnaire [38,39], a 16-item validated measurement for simulation side effects that have been previously reported in virtual reality literature [40]. This was scored on a scale of 0 to 16 with mean scores calculated and compared with a 2-tailed *t* test.

Analytic Strategy

Linear mixed model (LMM) for repeated measurements was used for data analysis by using the "MIXED" command in SPSS statistics software (Version 26.0., IBM Corp). Simulation type and time of measurements were considered as fixed effect variables and the participants as random effect variables. A separate LMM analysis was performed for each dependent variable, adjusting for potential confounders accordingly. The correlation between repeated measurements within subjects was considered as "unstructured." A square root transformation was applied to the Mean GSR and Simulator Sickness Questionnaire, and natural logarithm transformation was applied to cortisol before LMM analysis. A *P* value of less than .05 was considered statistically significant. The changes in outcome measures are presented as mean change (95% CI; *P* value). Similarly, the differences in outcome measures between AR and Manikin simulations are presented as mean (AR-manikin: 95% CI of mean difference; *P* value).

To examine whether perceived stress, depression, and PTSD modify the effect of AR on cortisol and GSR, an LMM analysis was applied to AR data only by including the potential effect modifiers. If the *P* value of a potential effect modifier was greater than .05, its effect modification on the association between AR and dependent variables was excluded.

We first report the psychological impact of the simulations, followed by the physiological impact. Finally, we briefly examine whether there was evidence of moderation due to preexisting psychological traits.

Results

Of a total of 104 possible participants, 88 (85%) participated. Of these 88 participants, 37 (42%) were male, and 51 (58%) were female medical students with a mean age of 25.2 (SD 2.09, range 22-30) and 24.7 (SD 2.08, range 23-36), respectively.

Psychological Responses to Simulations

Negative affect showed an increase of 4.68 (3.57-5.79; $P<.001$) with manikin, and 5.08 (3.96-6.21; $P<.001$) with AR simulation (Table 1). However, the difference between simulation types was not statistically significant, and was adjusted for the day of experiment (AR-manikin: 0.41, 95% CI -0.72 to 1.53; $P=.48$). Similarly, self-reported stress showed an increase of 12.21 (9.53-14.90; $P<.001$) with manikin and 12.75 (10.03-15.47; $P<.001$) with AR simulations (Table 1). However, the difference between simulation types was not statistically significant, and was adjusted for day of experiment and sex of participants (AR-manikin: 0.53, 95% CI -2.35 to 3.42; $P=.71$). Simulation

stress (Figure 1) was higher on day 1 compared to day 2 (day 2 minus day 1: -5.29 , 95% CI -10.06 to -0.52 ; $P=.03$; Table 1); however, the difference between the simulation types was not statistically significant and was adjusted for day of experiment and sex of the participants (AR-manikin: -2.17 , 95% CI -6.94 to 2.59 ; $P=.37$). Stress also reached a higher maximum on day 1 (day 2 minus day 1: -6.60 , 95% CI -10.49 to -2.72 ; $P=.001$; Table 1), but this was not related to simulation type after adjusting for day and sex (AR-manikin: -3.02 , 95% CI -6.83 to 0.80 ; $P=.12$). Finally, when examining the open-ended responses to the simulations, there was no statistically significant difference in the percentage of negative

emotion word use between simulation types, adjusted for day of experiment, sex, and the word count for Linguistic Inquiry and Word Count (AR-manikin: 0.33 , 95% CI -1.12 to 0.46 ; $P=.41$).

The percentage of positive emotion words used in the narrative descriptions was higher on the first day of simulations (day 2 minus day 1: -0.64 , 95% CI -1.18 to -0.10 ; $P=.02$; Table 1) but there was no statistically significant difference between the simulation types in terms of the percentage of positive emotion words use, which was adjusted for day of experiment, sex of the participants, and total number of words used (AR-manikin: -0.40 , 95% CI -0.91 to 0.10 ; $P=.12$).

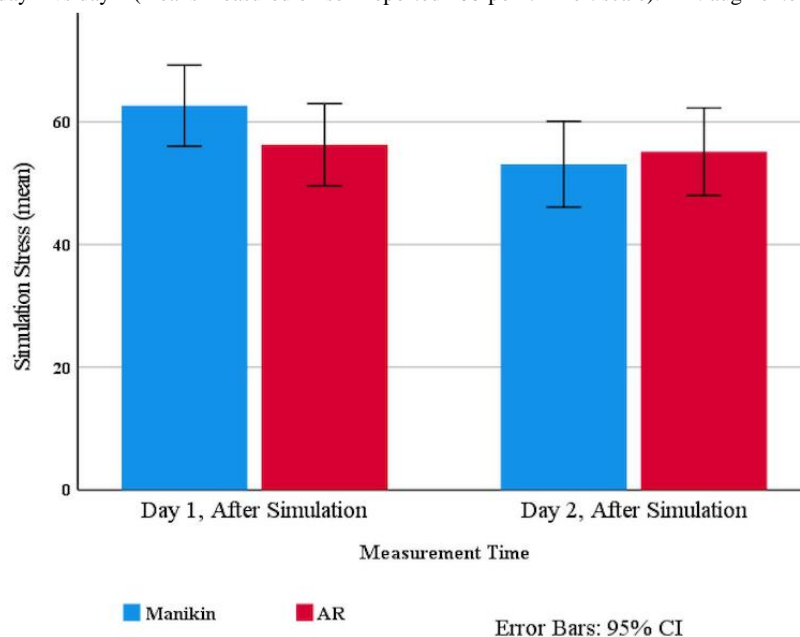
Table 1. Psychologic responses to simulation.

Measurement and simulation	Measurement time			
	Day 1		Day 2	
	Before simulation	After simulation	Before simulation	After simulation
Negative affect, mean (SD)				
Manikin	14.6 (3.38)	20.5 (5.83)	15.0 (4.35)	18.8 (5.91)
AR ^a	13.5 (2.51)	20.7 (6.44)	14.8 (5.20)	18.4 (6.11)
Self-reported stress, mean (SD)				
Manikin	44.2 (23.24)	57.8 (23.57)	45.1 (19.82)	56.3 (20.14)
AR	38.2 (17.87)	54.3 (19.11)	47.5 (27.12)	58.0 (24.72)
Simulation stress, mean (SD)				
Manikin	N/A ^b	62.6 (21.23)	N/A	53.1 (23.00)
AR	N/A	56.3 (22.28)	N/A	55.1 (22.34)
Maximum stress, mean (SD)				
Manikin	N/A	72.4 (19.19)	N/A	60.0 (24.16)
AR	N/A	64.3 (22.22)	N/A	63.0 (23.29)
Negative emotion words (%), mean (SD)				
Manikin	N/A	6.2 (3.17)	N/A	7.3 (4.10)
AR	N/A	6.4 (2.98)	N/A	6.6 (2.67)
Positive emotion words (%), mean (SD)				
Manikin	N/A	3.0 (1.81)	N/A	2.5 (1.59)
AR	N/A	2.7 (1.84)	N/A	2.1 (2.06)
Galvanic skin response ($\sqrt{\mu\text{S}}$), mean (SD)				
Manikin	12.9 (8.27)	15.3 (7.67)	11.2 (9.50)	13.6 (7.63)
AR	8.8 (6.19)	10.6 (6.11)	12.1 (5.68)	14.1 (4.99)
Cortisol (ug/dl), mean (SD)				
Manikin	0.2 (0.11)	0.1 (0.09)	0.1 (0.09)	0.1 (0.06)
AR	0.1 (0.10)	0.1 (0.13)	0.2 (0.10)	0.2 (0.11)
Simulation sickness symptoms score, mean (SD)				
Manikin	N/A	23.0 (20.59)	N/A	30.2 (25.78)
AR	N/A	27.4 (20.58)	N/A	28.1 (24.68)

^aAR: augmented reality.

^bN/A: not applicable.

Figure 1. Simulation stress: day 1 vs day 2 (means measured on self-reported 100-point Likert scale). AR: augmented reality.



Physiological Responses to Simulation

Manikin and AR simulations were associated with increased GSR (mean change in square root of GSR was 0.38 μ S: 0.31-0.46; $P < .001$ and 0.28: 0.20-0.35; $P < .001$, respectively; Table 1). Interestingly, GSR was higher in the manikin group as compared to AR, adjusted for day, sex, and use of any medication by the participants (AR-manikin: -0.11 , 95% CI -0.18 to -0.03 ; $P = .009$).

There was not a statistically significant difference in the mean cortisol level between the simulation groups (Table 1), which was adjusted for the day of experiment, sex of the participants, use of any medication by the participants, and the time past from wakeup to simulation (AR-manikin: 0.04, 95% CI -0.05 to 0.13; $P = .41$). Overall, cortisol was higher in male participants (male minus female: 0.22, 95% CI 0.03-0.40; $P = .02$).

Simulation Sickness Responses

There was not a statistically significant difference in simulation sickness symptoms' score between the simulation groups, which was adjusted for day of experiment and sex of the participants (AR-manikin: 0.17, 95% CI -0.29 to 0.62; $P = .47$).

Moderating Effect of Preexisting Psychological Traits

PTSD ($P = .39$), baseline perceived stress ($P = .09$), and baseline reported depression ($P = .51$) failed to achieve statistical significance when introduced to the model predicting salivary cortisol or GSR based on AR. Thus, we can conclude that these preexisting psychological traits do not predict adverse stress-related outcomes.

Discussion

Principal Findings

The goal of this study was to examine whether more realistic AR simulations would be a cause for concern because of potentially high stress, emotion, or physiological responses,

especially in a dramatic medical context involving the death of a patient. We did not find a statistically significant difference in the participants' psychological and physiological reactions to AR and standard medical manikin training simulations. Both the manikin and AR simulators elicited emotional (ie, a reduction in positive emotion and an increase in negative emotion) and elevated stress responses during and after the simulations. However, these psychological responses did not significantly differ between the simulation types.

Comparison With Prior Work

This finding is consistent with previous studies, which showed that simulation in medical education can elicit a stress response [41-43] as well as a range of emotional and cognitive changes. As these studies suggest, small stress increases are tied to better learning outcomes, which in turn suggests that both modalities of simulation can have a beneficial effect for learners; however, future studies will need to evaluate the actual learning outcomes. Of note, there was some concern that AR might be associated with a dangerously high level of stress because of the added realism and interactive nature; however, it does not seem to be any more stressful than past medical training approaches (ie, manikin here), adding some indication that dangerous levels of stress are not a concern, at least in this simulation. Further subanalysis examining preexisting trauma, perceived stress, and depression did not show statistically significant differences in stress with AR simulation, suggesting that even those with preexisting psychological conditions may not need to be excluded from AR technology in this type of context. Further, stress and negative emotion reported in these simulations do not appear to be at levels that are different compared to other study averages [44-46].

From the physiological stress perspective, this study shows no significant differences between AR and standard manikin simulation technology, except a small difference where the increase in skin conductance in response to the manikin simulator was significantly higher than that of AR—the opposite

of what was anticipated. Cortisol differences, however, were not different across the 2 platforms. This suggests that, contrary to expectations, and despite heightened realism and more animated interactions, the AR approach is psychologically and physically comparable to standard manikin-based simulators, and it is perhaps even slightly less physiologically stressful than past learning modalities.

Given the nature of the simulations involving pediatric deaths, it is not surprising that the overall stress increased during and after each simulation. However, students showed decreased stress levels in their second simulation. Previous studies have shown that stress factors in simulation-based training may help with the acquisition of stress management skills [41]. In addition to stress management skills, it could suggest a desensitization to the simulation regardless of type of simulator. Chang et al [47] suggested that VR simulation could be used to desensitize pediatric physicians from stressful situations based on their study evaluating VR stress response and real-life situations. However, Hardernberg et al [48] showed no decreased stress response in nursing students with repeated simulations, which is contradicted with our results. Decreasing levels of stress response could be very useful for educational purposes and future training for many types of medical practitioners who experience high-stress situations.

Strengths and Limitations

This study is limited as it is a single-site study comparing AR simulation to standard manikin-based simulation. While we attempted to look at multiple evaluators of emotional stress (cortisol, self-reported stress, and electrodermal activity), these still may not have fully captured the stress response of the students. Some students had higher levels of sweat on their palms making GSR data less reliable, as the sensors were more difficult to maintain on their hands. Finally, while we controlled for numerous possible confounders of our biological markers (eg, medication, time of day, and sex), there may be other factors unaccounted for, which may have resulted in bias or noise in the data.

Conclusions and Implications

AR simulators elicited similar stress responses to manikin-based simulators suggesting they are comparable tools for medical education. Furthermore, there was no evidence of AR simulators causing excessive stress to participants at a level different from existing simulation methods. Future research should evaluate whether AR simulators increase learning outcomes or help with desensitization or stress management skills with repeated use. AR technology is relatively new and its ability to elicit a stress response when compared to standard manikin simulation technology could help guide future educational practices and research.

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Conflicts of Interest

None declared.

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Abbreviations

- AR:** augmented reality
- GSR:** galvanic skin response
- HPA:** hypothalamic-pituitary-adrenal
- LMM:** linear mixed model
- PANAS:** positive and negative affect schedule
- PTSD:** posttraumatic stress disorder

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Viewpoint

Opioid Use Disorder Education for Students and the Future of Opioid Overdose Treatment

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Abstract

Opioid use disorder (OUD) is a major public health concern in the United States. The opioid crisis has taken hundreds of thousands of lives in the past 20 years, and it is predicted to take millions more. With the rising death tolls, it is essential that health care providers are able to use proper tools to treat OUD efficiently and effectively through medication-assisted treatment (MAT), particularly buprenorphine. Despite changes to buprenorphine regulations making it more accessible, clinicians have been slow to use buprenorphine to treat OUD. We believe that training student clinicians in evidence-based MAT and buprenorphine practices will address the training and competence barriers that hinder clinicians from prescribing buprenorphine to treat OUD. Students are in an ideal position to receive and benefit from this training and influence the medical community to better treat OUD.

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KEYWORDS

opioid use disorder; students; buprenorphine; education; public health; opioid; health care providers; healthcare providers; medication-assisted treatment; youth; substance use; opioid agonist; overdose

The opioid epidemic and substance use disorders have long been a major public health crisis in the United States. From 1999 to 2019, there have been approximately 500,000 opioid overdose deaths in the United States [1]. The opioid epidemic has had various social and economic effects on US society, all of which have been recently exacerbated by the COVID-19 pandemic's influence on the lack of access to treatment and mental health challenges of those with opioid use disorder (OUD). Predicted overdose deaths for the upcoming years offer a grim outlook [2] despite the steady decline of opioid prescribing since 2012 and the all-time low reached in 2020 [3]. The United States may see more than 1.2 million OUD overdose deaths in the upcoming decade if urgent action is not taken [4].

Buprenorphine is a US Food and Drug Administration (FDA)-approved medication used as a medication-assisted treatment (MAT) by acting as a partial opioid agonist. It is used to treat OUD along with a comprehensive treatment program that includes various behavioral therapies and counseling.

Buprenorphine is a key step toward increasing treatment access for patients with OUD [5]. However, the ability of a clinician to prescribe buprenorphine is contingent upon completion of specialized training and obtaining their "X" designation from the Drug Enforcement Administration (DEA-X). The X waiver was necessary in part because training for opioid overdose treatment and prevention using evidence-based MAT practices allows clinicians to be more prepared to treat patients with OUD. Due to the many accessibility barriers to obtaining an X waiver in the past, only about 7% of physicians in the United States have done so, which limits the ability to care for patients with OUD [6]. Ability to care is further limited in rural areas where there are even fewer buprenorphine-waivered clinicians.

Get Waivered (GW) is a project started in 2017 that aims to address the opioid crisis by encouraging and facilitating more clinicians to get their X waiver. GW's work focuses on behavioral nudges to address the barriers identified as to why clinicians do not obtain their X waiver: (1) absence of a social norm, (2) hassle bias in obtaining the waiver, and (3) a lack of

salience in treating OUD [7]. With the COVID-19 pandemic, social distancing practices have limited accessibility to traditional medical education, including the X waiver training courses. Thus, there has been a movement toward online platforms for medical education. To adapt to these circumstances, GW started delivering and hosting free, nationwide, digitally delivered, and interactive X waiver educational training courses. Therefore, clinicians are able to obtain their X waiver using a live, synchronized, and interactive digital platform while learning evidence-based best practices for buprenorphine prescription.

Despite recent policy changes regarding the X waiver, buprenorphine prescription education is still important for clinicians, especially student clinicians (those enrolled in health care training programs). While the legal barriers may be overcome, clinicians still need the opportunity and motivation to prescribe buprenorphine [8]. To have effective change, clinicians must be properly educated on how to use their waiver and be able to look for prescription opportunities. This training needs to start in undergraduate or medical education settings so that it can create a cultural shift [8]. It has been shown that educational interventions in opioid overdose prevention have led to students being more confident and prepared to act [9], and this can be applied to buprenorphine training as well. There is currently no unified approach to teaching student clinicians about buprenorphine administration, but training would provide meaningful education while also increasing the pool of future buprenorphine-prescribing clinicians [10]. Although medical students cannot use their waiver education until entering their residency programs, they still interact with patients with OUD during clerkship and various clinical experiences; their OUD and buprenorphine knowledge can still be vital for encouraging patients to seek treatment, decreasing stigma surrounding OUD, and encouraging superiors to take action [10]. Thus, X waiver education is still a vital component for combating the opioid epidemic.

In the past few years, there have been several changes made in the practical guidelines for obtaining an X waiver. The initial guidelines in place prior to regulatory changes dictated that a physician could give buprenorphine to a patient experiencing opioid withdrawal in a hospital setting, but prescriptions for buprenorphine in an outpatient or clinic setting require an X waiver. The process to obtain an X waiver required the completion of an 8-hour education training course for physicians and a 24-hour education training course for advanced practice clinicians. In 2016, policy changes led to an expansion of the patient limit from 100 patients after the first-year postwaiver completion to 275 patients [11]. These policy changes also expanded X waiver access to include nurse practitioners and physician assistants; the clinician list of people who can now obtain an X waiver include physicians, nurse practitioners, physician assistants, clinical nurse specialists, certified registered nurse anesthetists, and certified nurse midwives. On January 14, 2021, the US Department of Health and Human Services under the Trump administration announced the elimination of the X waiver requirement altogether for buprenorphine prescription for physicians only [12]. This decision was then canceled under the Biden administration due to legal challenges

that may be faced, and the policy was reverted and eventually changed in April 2021 [13]. As of April 28, 2021, practice guidelines dictate that clinicians can apply for exemption and do not need to undergo the educational training requirement of an X waiver. This process involves submitting a state-issued license, valid registration, and a notice of intent to the Substance Abuse and Mental Health Services Administration [5]. The alternative notice-of-intent process only applies to clinicians who are treating ≤ 30 patients; providers who wish to treat >30 patients still need to undergo the education training course.

While the policy change in April 2021 has allowed for an unprecedented expansion of the buprenorphine waiver program, the results of this increased access are still forthcoming. A recent study [11] found that while the number of clinicians who can prescribe buprenorphine and buprenorphine prescribing increased in California between 2010 and 2018, it has not necessarily been associated with changes in opioid-related health outcomes. There are still many barriers to adequate OUD treatment including lack of training and support among clinicians, care coordination, cost of treatment, and stigma [11]. Furthermore, even though buprenorphine-prescribing clinicians have increased since 2016, many choose not to be publicly listed, which limits access to treatment since many clinicians may not take new patients [14]. New clinicians have been shown to be slow to use their new buprenorphine prescription abilities, often due to a lack of confidence, fear of the prescription being misused, lack of understanding of addiction, and lack of peer pressure. This has led to very few short-term changes from buprenorphine access expansion [15].

It is imperative that student clinicians (especially medical students and residents) obtain X waivers as part of their educational training. Basic OUD prevention and treatment competence among those licensed to prescribe buprenorphine may lead to a large increase in buprenorphine prescribing and improvement of opioid-related health outcomes. These ideas have been recommended by numerous studies that have indicated that lack of training is one of the foremost barriers to buprenorphine prescription [7]. Many competence and training barriers can be addressed through brief short education and networking opportunities, which is what GW offers. In fact, in 2018, the Substance Abuse and Mental Health Services Administration started to provide funding for medical schools willing to adjust their curriculum to fulfill waiver training requirements, but only one school has done so [10]. Some recent pilot studies in the United States have shown that integrating waiver training for medical students does increase knowledge, interest, and confidence in diagnosing and treating OUD [16,17], and calls attention to the need for a standardized, nationwide course, as there is currently none. A key advantage of GW courses is that even though the requirements for buprenorphine prescription have been relaxed, GW can provide mentorship and education in a brief, free, virtual, and interactive setting that boosts confidence and arms clinicians with the tools they need to effectively use their X waiver. Clinicians and student clinicians have the opportunity to interact with professional peers from around the country, which facilitates networking and discussion of shared values and interests. Mentorship and education have been mentioned as the key resources to increase

buprenorphine prescribing by clinicians themselves [18]. Furthermore, the availability of remote education has opened the unique possibility of bridging the disparity in provider availability between urban and rural areas.

Student clinicians are in an ideal position to receive buprenorphine prescription training since many of them are already learning about OUD as part of their psychiatric training and can easily benefit from education on clinical applications. Additionally, students can be more easily empowered to bring change into the field of medicine since they are already involved in various advocacy and research campaigns. Student clinicians can be molded to bring a new mindset about OUD treatment into their clinical rotations and their future workplaces, and this has already been seen with the rise of social media platforms

discussing medical topics and the popularity of “medical influencers.” Implementation of GW courses or similar workshops in the curriculum of medical school, nursing school, and residency training programs have the ability to influence a generational change in the perceptions and feasibility of OUD treatment without requiring significant time or money, a vast difference from previous in-person courses. Now that regulatory policies have been relaxed, it is high time to address the other barriers to evidence-based OUD treatment and make meaningful changes. The future of mitigating the opioid crisis lies in using innovative, broad-reaching networks like social media and behavioral nudges to enhance education and connection among clinicians, and GW is in an ideal position to bring about that change.

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Conflicts of Interest

None declared.

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Abbreviations

DEA-X or X waiver: “X” designation from the Drug Enforcement Administration

FDA: US Food and Drug Administration

FORE: Foundation for Opioid Response Efforts

GW: Get Waivered

MAT: medication-assisted treatment

OD: opioid use disorder

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Original Paper

Informatics in Undergraduate Medical Education: Analysis of Competency Frameworks and Practices Across North America

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Abstract

Background: With the advent of competency-based medical education, as well as Canadian efforts to include clinical informatics within undergraduate medical education, competency frameworks in the United States have not emphasized the skills associated with clinical informatics pertinent to the broader practice of medicine.

Objective: By examining the competency frameworks with which undergraduate medical education in clinical informatics has been developed in Canada and the United States, we hypothesized that there is a gap: the lack of a unified competency set and frame for clinical informatics education across North America.

Methods: We performed directional competency mapping between Canadian and American graduate clinical informatics competencies and general graduate medical education competencies. Directional competency mapping was performed between Canadian roles and American common program requirements using keyword matching at the subcompetency and enabling competency levels. In addition, for general graduate medical education competencies, the Physician Competency Reference Set developed for the Liaison Committee on Medical Education was used as a direct means of computing the ontological overlap between competency frameworks.

Results: Upon mapping Canadian roles to American competencies via both undergraduate and graduate medical education competency frameworks, the difference in focus between the 2 countries can be thematically described as a difference between the concepts of clinical and management reasoning.

Conclusions: We suggest that the development or deployment of informatics competencies in undergraduate medical education should focus on 3 items: the teaching of diagnostic reasoning, such that the information tasks that comprise both clinical and management reasoning can be discussed; precision medical education, where informatics can provide for more fine-grained evaluation; and assessment methods to support traditional pedagogical efforts (both at the bedside and beyond). Assessment using cases or structured assessments (eg, Objective Structured Clinical Examinations) would help students draw parallels between clinical informatics and fundamental clinical subjects and would better emphasize the cognitive techniques taught through informatics.

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KEYWORDS

undergraduate medical education; medical informatics; curriculum; medical education; education; North America; framework; clinical; informatics; Canada; United States; US; teaching; management; cognitive

Introduction

Competency frameworks in undergraduate medical education (UME) are the key components of curricular development. Such frameworks include those developed and promulgated by internal medicine organizations and those that are used by accreditation bodies, applied in both undergraduate and graduate education. Popular competency frameworks in American UME, such as the Reporter-Interpreter-Manager-Educator framework [1], have been enhanced by commentary suggesting the addition of clinical skills relevant to the use of the electronic medical record [2]. While competency frameworks are one facet of the methods that circumscribe learning in medical education, accreditation is another facet. Accreditation serves the purposes of quality assurance and standardization. The Liaison Committee on Medical Education (LCME) standards harmonize undergraduate medical degree programs in both the United States and Canada [3]. The LCME is the primary American accreditor and a joint accreditor with the Committee on Accreditation of Medical Schools in Canada.

Standardization between the countries supports the advancement of medicine and the mobility of practice across North America. For example, as either country develops specialties, competencies can be promulgated into undergraduate and graduate medical education (GME) to best advance the general education of medical students and residents. A recent example of this phenomenon is the creation of the Canadian subspecialty of forensic psychiatry [4]. Forensic psychiatry is now a recognized specialty in both the United States and Canada, necessitating instruction alongside child and geriatric psychiatry as part of general psychiatric education in both undergraduate and GME.

In the United States, the Accreditation Council for Graduate Medical Education (ACGME) competencies for residency are a means to describe the components of the GME curriculum. These competencies span both general program requirements [5] as well as those that are specific to a particular discipline of medicine (eg, clinical informatics [6]). Similarly, supported by the Royal College of Physicians and Surgeons of Canada since 1996, Canadian medical education (both UME and GME) has developed a competency framework setting the standards for medical education and practice. The CanMEDs framework defines a set of roles for the physician, broken up into key and enabling competencies [7]. The general framework is expanded upon by the Royal College of Physicians and Surgeons of Canada or the Canadian College of Family Physicians for GME in each discipline. Furthermore, a working group from the Royal College and the Association of Faculties of Medicine of Canada has developed recommendations for nondiscipline-specific aspects of medical practice, creating sets of key and enabling competencies under the core CanMEDs roles (eg, eHealth [8]). In UME, a working group from The Association of Faculties of Medicine of Canada [9] was convened to suggest the manner in which the CanMEDs framework can be expanded to include eHealth competencies within the roles of the medical student physician. We noted that the qualifiers of “clinical,” “medical,” and “biomedical” have been applied to “informatics” as a discipline in the United States, and the broader term “eHealth”

has been used in Canada. This paper selects a single term to refer to the field, *clinical informatics*, as it aligns with the formal name of the subspecialty certified by the American Board of Preventive Medicine and American Board of Pathology.

As the LCME accredits undergraduate medical programs across the North American continent, it behooves the educator to examine the Canadian approach in contrast to the American approach. Framing informatics as an additive to clinical education is contrary to Canadian efforts to integrate clinical informatics into clinical practice, be it through educational informatics (such as that developed by Ellaway et al [10,11]) or through competencies within UME. Particularly, the latter is most visible through an enabling competency within the role of *Leader* (1.4): “use health informatics to improve the quality of patient care and optimize patient safety.” If a goal of medical education is to have a unified general medical curriculum across the schools served by the LCME, it is necessary to spark a conversation about how to reconcile the Canadian role-based framework with that of the American competencies and practice. Furthermore, in reconciling the Canadian and American frameworks, we propose the beginning of an answer to the overarching question of which components of clinical informatics should be taught within UME.

Methods

Phase 1: Mapping of Common Program Requirements and Physician Roles

Overview

Mapping by keyword and content similarity was performed by human judgment of a single author (DC) and adjudicated by the remaining authors (EC, MR, and KW). Enabling competencies and key competencies were selected as the hierarchical levels at which the CanMEDs roles were to be linked to the ACGME competencies. From the 2015 CanMEDs taxonomic framework, enabling competencies are defined as the “essential components of a key competency,” while key competencies are defined as “knowledge, skills, and attitudes of a physician.” Enabling competencies are 2 hierarchical competency layers below the CanMEDs roles and link to the ACGME framework’s subcompetencies, at 1 hierarchical layer below the core competencies. The ACGME subcompetencies expand the core competencies beyond common program requirements. All maps were visualized using the *graphviz* drawing tools (using the *circo* filter; version 2.40.1; 20161225.0304).

Phase 1a: Mapping of Common Program Requirements and Physician Roles by Physician Competency Reference Set

Mapping was also performed using the overlap between the 2005 CanMEDs roles and the ACGME 2013 common program requirements. Instead of using keywords and content, this mapping was facilitated based on the quantization of the Physician Competency Reference Set (PCRS) [12], an ontology to which program competencies are submitted to the LCME. The PCRS is a common taxonomy of competencies used by the LCME such that multiple curricular systems across the LCME

can be organized and connected through a common standard [12,13]. Individual CanMEDs enabling competencies and ACGME subcompetencies are assigned one or more PCRS concepts upon submission to the LCME, and the exemplar set provided by the LCME was used to construct the matrix of the overlap computed by the exact match of competencies mapped to each enabling competency or subcompetency.

Phase 2: Mapping of Clinical Informatics and eHealth Competencies

Mapping was performed between the CanMEDs eHealth key competencies and the ACGME clinical informatics subcompetencies using keywords and content in a manner consistent with the human-adjudicated approach in phase 1.

Ethics Approval

All data collected for analysis in this paper was obtained from publicly available web resources, and therefore did not necessitate review by an ethics board for any institutions affiliated by this study.

Results

Phase 1: Mapping of Common Program Requirements and Physician Roles

Overview

Figure 1 is a graph of the enabling competency and subcompetency map between the CanMEDs general competencies and ACGME common program requirements. Competencies are mapped by keywords or by content, with 2 examples as follows:

- **Keywords:** the enabling competency within the role of *health advocate* of “Incorporate disease prevention, health promotion, and health surveillance into interactions with individual patients” is mapped to a subcompetency within the competency called *patient care and procedural skills* of “Residents must be able to provide patient care that is compassionate, appropriate, and effective for the treatment of health problems and the promotion of health.” This mapping is via the keywords: “incorporate [...] health promotion” and “provide patient care that is [...] effective for [...] the promotion of health.”
 - **Content:** the enabling competency within the role of *scholar* of “engage in collaborative learning to continuously improve personal practice and contribute to collective improvements in practice” is mapped to a subcompetency within the competency of *practice-based learning* called “participate in the education of patients, families, students, residents and other health professionals.” This mapping is based on the similarity between the concept of collaborative learning to improve personal and collective practice, and the concept of participating in the education of students, residents, and other health professionals. While collaborative learning and education are fundamentally not the same concept lexically, they are part of the tasks and practices of teaching broadly. Furthermore, while collaborative learning to collectively improve practice is centered around the individual physician in the CanMEDs role, the act of educating medical students, residents, and other health professionals consists of a similar function: improving practice by improving the care delivered by trainees.
- Figure 2 details the enabling competencies from CanMEDs roles that are unmapped to the subcompetencies of the ACGME competencies.

Figure 2. CanMEDs enabling competencies that are unmapped to Accreditation Council for Graduate Medical Education subcompetencies. Text-based version of this figure is available in [Multimedia Appendix 2](#).

<ul style="list-style-type: none"> ● Medical Expert <ol style="list-style-type: none"> 1. Integrate the CanMEDs Intrinsic Roles into their practice of medicine 2. Recognize and respond to the complexity, uncertainty, and ambiguity inherent in medical practice ● Communicator <ol style="list-style-type: none"> 1. Manage disagreements and emotionally charged conversations ● Leader <ol style="list-style-type: none"> 1. Use health informatics to improve the quality of patient care and optimize patient safety 2. Set priorities and manage time to integrate practice and personal life 3. Manage a career and a practice ● Scholar <ol style="list-style-type: none"> 1. Demonstrate a commitment to excellence in all aspects of practice 2. Recognize the influence of role-modeling and the impact of the formal, informal, and hidden curriculum on learners 3. Ensure patient safety is maintained when learners are involved 	<ol style="list-style-type: none"> 4. Assess and evaluate learners, teachers, and programs in an educationally appropriate manner 5. Recognize practice uncertainty and knowledge gaps in clinical and other professional encounters and generate focused questions that address them 6. Identify ethical principles for research and incorporate them into obtaining informed consent, considering potential harms and benefits, and considering vulnerable populations 7. Pose questions amenable to scholarly inquiry and select appropriate methods to address them <ul style="list-style-type: none"> ● Professional <ol style="list-style-type: none"> 1. Recognize and manage conflicts of interest 2. Exhibit professional behaviours in the use of technology-enabled communication 3. Recognize and respond to unprofessional and unethical behaviours in physicians and other colleagues in the health care professions 4. Participate in peer assessment and standard-setting 5. Manage personal and professional demands for a sustainable practice throughout the physician life cycle 6. Promote a culture that recognizes, supports, and responds effectively to colleagues in need
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Phase 1a: Mapping of Common Program Requirements and Physician Roles by the PCRS

Figure 3 provides the direct match between the 2005 CanMEDs roles and 2013 ACGME competencies based on their mapping to the PCRS. Each edge is qualified by the PCRS competency, which is mapped to both the role and competency and is directionally assigned from the CanMEDs role to the ACGME competency. As data were available from the Association of American Medical Colleges only for the previous iterations of the CanMEDs roles and ACGME competencies, this method does not present a truly current mapping; however, it provides a method based on a standardized competency framework that we can compare with our own keywords and content approach described earlier. For example, the role of *scholar* is mapped to the competency of *practice-based learning* through the PCRS competency of “locate, appraise, and assimilate evidence from scientific studies related to patients’ health problems.” The role of *health advocates* is related to the competency of *patient care and procedural skills* through the PCRS competency of “Perform all medical, diagnostic, and surgical procedures considered essential for the area of practice.”

As a means of validation, while PCRS mapping is not equivalent to the mapping that we derived, we can examine the most and least frequent role-competency maps as a way to explore core similarities in practice between the CanMEDs and ACGME frameworks. Similar to the author-derived network in Figure 1, a comparison of the frequency of edges between CanMEDs roles and ACGME competencies in the PCRS mapping shows

that the connection from *scholar* to *practice-based learning* is the most frequent. At the opposite end of the spectrum, *health advocates* and *patient care and procedural skills* were mapped only once in both graphs.

For *scholar* to *practice-based learning*, the mapping is via a subcompetency, under the competency of *practice-based learning*, called “locate, appraise, and assimilate evidence from scientific studies related to their patients’ health problems,” as well as via the CanMEDs role of *scholar* with the enabling competency of “Identify opportunities for learning and improvement by regularly reflecting on and assessing their performance using various internal and external data sources.” For *health advocate* to *patient care and procedural skills*, the mapping is via a subcompetency, under the competency of *patient care and procedural skills*, called “competently perform all medical, diagnostic, and surgical procedures considered essential for the area of practice” and via the enabling competency under the role *health advocate* called “identify the health needs of an individual patient.” *Scholar* to *practice-based learning* is a clear case of keyword mapping, and *health advocate* to *patient care and procedural skills* is more of a case of fuzzy conceptual mapping. The identification of the health needs of an individual patient is a component of performing essential procedures, such as components of the entrustable professional activities of “Form Clinical Questions and Retrieve Evidence to Advance Patient Care” and “Collaborate as a Member of an Interprofessional Team” [14]. The conceptual mapping here is deeper than the keyword overlap of “performing all essential procedures for practice” due to the circumscription

of an area of practice and the determination of essential procedures (both part of the entwined acts of clinical cognition and discourse).

Figure 4 details the PCRS competencies that are not mapped between the CanMEDs roles and ACGME competencies. They primarily involve the comportment and ethic of the individual physician’s practice (such as “demonstrate trustworthiness that makes colleagues feel secure when one is responsible for the care of patients” or “recognize that ambiguity is part of clinical health care and respond by utilizing appropriate resources in

dealing with uncertainty”). While some of these unmapped PCRS competencies are components of the aforementioned entrustable professional activities (such as trustworthiness), others are unique aspects of the CanMEDs or ACGME frameworks (such as the *medical expert* enabling competency to “recognize and respond to the complexity, uncertainty, and ambiguity inherent in medical practice”), which produce the unique cultures of medicine as practiced in Canada and the United States. However, fundamentally, these unmapped competencies reflect necessary qualities and responsibilities of the physicians.

Figure 3. Exact graphical map between CanMEDs 2005 roles through general enabling competencies [7] and Accreditation Council for Graduate Medical Education (ACGME) 2013 common program requirement core competencies [5] detailing the Physician Competency Reference Set competencies. CanMEDs roles are red diamonds, while ACGME core competencies are in black boxes, with directional mapping labels. Higher-resolution version of this figure is available in Multimedia Appendix 3.

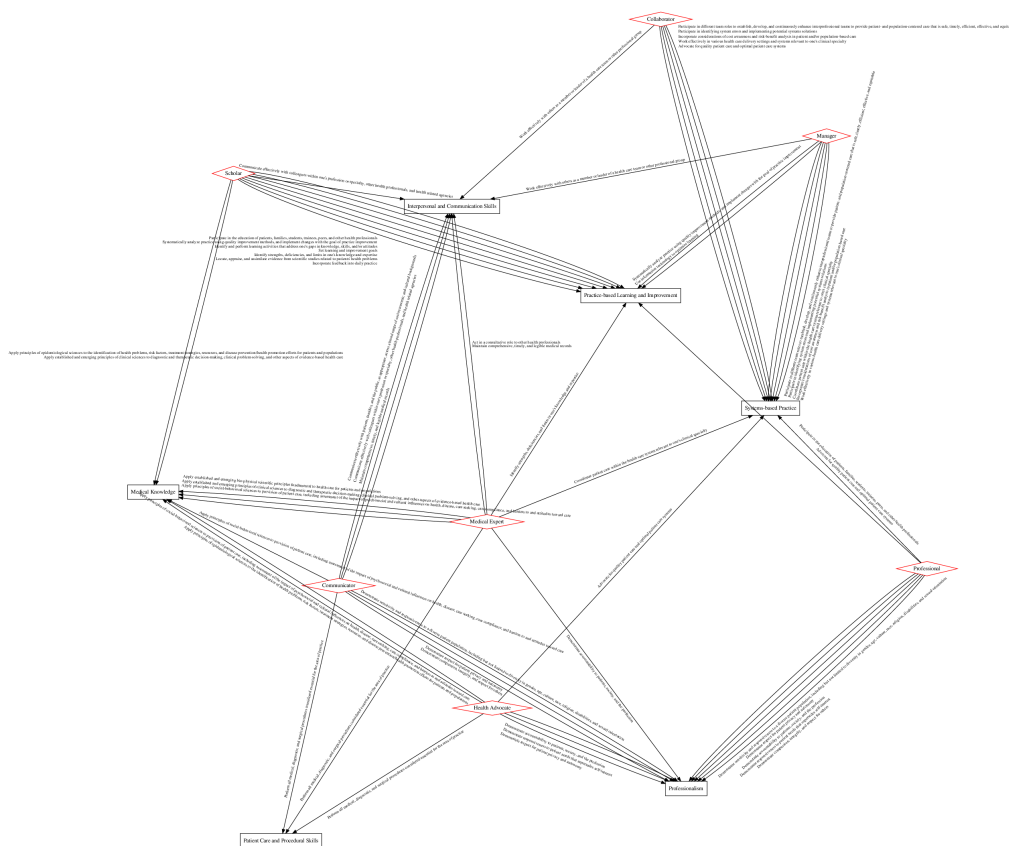


Figure 4. Physician Competency Reference Set (PCRS) competencies that are not mapped to either CanMEDs enabling competencies or Accreditation Council for Graduate Medical Education (ACGME) subcompetencies such that roles and competencies share a PCRS competency. Text-based version of this figure is available in [Multimedia Appendix 4](#).

- Interpersonal and Communication Skills
 1. Demonstrate insight and understanding about emotions and human responses to emotions that allow one to develop and manage interpersonal interactions
 2. Demonstrate sensitivity, honesty, and compassion in difficult conversations, including those about death, end of life, adverse events, bad news, disclosure of errors, and other sensitive topics
 3. Communicate with other health professionals in a responsive and responsible manner that supports the maintenance of health and the treatment of disease in individual patients and populations
 4. Use the knowledge of one's own role and the roles of other health professionals to appropriately assess and address the health care needs of the patients and populations served
 5. Work with other health professionals to establish and maintain a climate of mutual respect, dignity, diversity, ethical integrity, and trust
- Knowledge for Practice
 1. Contribute to the creation, dissemination, application, and translation of new health care knowledge and practices
 2. Demonstrate an investigatory and analytic approach to clinical situations
- Patient Care
 1. Perform supervisory responsibilities commensurate with one's roles, abilities, and qualifications
 2. Counsel and educate patients and their families to empower them to participate in their care and enable shared decision-making
 3. Develop and carry out patient management plans
 4. Gather essential and accurate information about patients and their conditions through history-taking, physical examination, and the use of laboratory data, imaging, and other tests
 5. Interpret laboratory data, imaging studies, and other tests required for the area of practice
 6. Make informed decisions about diagnostic and therapeutic interventions based on patient information and preferences, up-to-date scientific evidence, and clinical judgment
 7. Organize and prioritize responsibilities to provide care that is safe, effective, and efficient
 8. Provide appropriate referral of patients including ensuring continuity of care throughout transitions between providers or settings, and following up on patient progress and outcomes
- 9. Provide appropriate role modeling
- 10. Provide health care services to patients, families, and communities aimed at preventing health problems or maintaining health
- Personal and Professional Development
 1. Demonstrate healthy coping mechanisms to respond to stress
 2. Demonstrate self-confidence that puts patients, families, and members of the health care team at ease
 3. Demonstrate trustworthiness that makes colleagues feel secure when one is responsible for the care of patients
 4. Develop the ability to use self-awareness of knowledge, skills, and emotional limitations to engage in appropriate help-seeking behaviors
 5. Manage conflict between personal and professional responsibilities
 6. Practice flexibility and maturity in adjusting to change with the capacity to alter one's behavior
 7. Provide leadership skills that enhance team functioning, the learning environment, and/or the health care delivery system
 8. Recognize that ambiguity is part of clinical health care and respond by utilizing appropriate resources in dealing with uncertainty
- Practice-Based Learning and Improvement
 1. Continually identify, analyze, and implement new knowledge, guidelines, standards, technologies, products, or services that have been demonstrated to improve outcomes
 2. Obtain and utilize information about individual patients, populations of patients, or communities from which patients are drawn to improve care
- Professionalism
 1. Demonstrate a commitment to ethical principles pertaining to provision or withholding of care, confidentiality, informed consent, and business practices, including compliance with relevant laws, policies, and regulations
- Systems-Based Practice
 1. Perform administrative and practice management responsibilities commensurate with one's role, abilities, and qualifications

Phase 2: Mapping of Clinical Informatics and eHealth Competencies

Figure 5 shows a graphical representation of the specific key competencies and subcompetencies mapped between the CanMEDs roles and ACGME competencies. Competencies are mapped by keywords or content, with the following 2 examples:

- Keywords: the CanMEDs key competency for the role of *medical expert*, “employ clinical decision support tools as an adjunct to clinical judgment in providing timely, evidence-based, safe interventions,” maps based on keywords (clinical decision support and interventions or implementation) to the ACGME subcompetency of *medical*

knowledge called “must demonstrate knowledge of clinical decision design, support, use, and implementation.”

- Content: the CanMEDs key competency for the role of *health advocate*, “describe how health and population information can be used for disease surveillance, adverse event tracking, population health monitoring, and risk management,” has a link to the ACGME subcompetency within the *curriculum organization and fellow experiences* core competency called “educational assignments should

have a particular focus (or foci), such as: public health informatics.” Conceptually, there is a link through the domain of public health informatics and its operationalization of disease surveillance, adverse event tracking, and population health as a matter of praxis.

Figure 6 details the enabling competencies from CanMEDs eHealth Roles that are unmapped to the subcompetencies of the ACGME clinical informatics competencies.

Figure 5. Explicit key competencies to subcompetencies map between CanMEDs eHealth Roles [8] and Accreditation Council for Graduate Medical Education (ACGME) clinical informatics core competencies [6]. CanMEDs roles are red diamonds, while ACGME core competencies are in black boxes, with directional mapping labels. Higher-resolution version of this figure is available in [Multimedia Appendix 5](#).

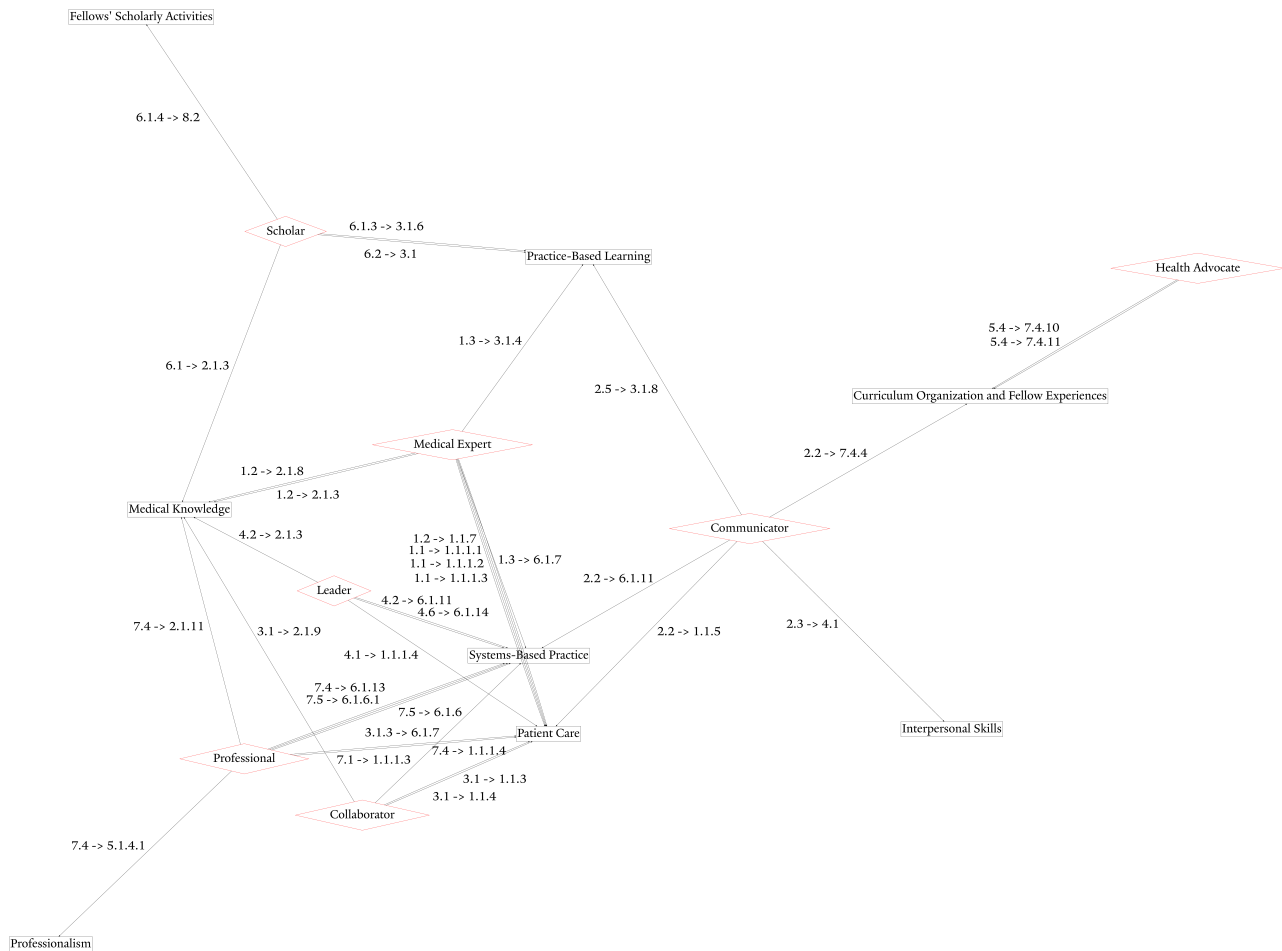


Figure 6. CanMEDs eHealth enabling competencies that are unmapped to Accreditation Council for Graduate Medical Education clinical informatics subcompetencies. Text-based version of this figure is available in [Multimedia Appendix 6](#).

<ul style="list-style-type: none"> • Communicator <ol style="list-style-type: none"> 1. Document patient outcomes and safety considerations in an accurate, complete, timely, and retrievable manner, in compliance with legal, privacy, and regulatory requirements and in the interest of effective and efficient clinical decision-making. 2. Assist patient and their families to identify and make use of information and communication technologies to support their care and manage their health (for example telecommunications, smart phone applications). • Collaborator <ol style="list-style-type: none"> 1. Share electronic information with other health care professionals collaboratively for the purpose of integrating and optimizing care and improving outcomes for individuals and populations. 2. Complete the electronic handover of professional responsibility and accountability to another health care professional in a manner that ensures quality, continuity, and patient safety. • Leader <ol style="list-style-type: none"> 1. Acknowledge that human–computer interface issues, organizational culture, technological restrictions, and device and infrastructure malfunction may generate errors or distortion of data that negatively affect patient safety. Advocate for and implement harm reduction strategies in the workplace. 2. Understand the terms “health system use” in the Canadian context and “interoperability” with respect to their application to electronic health data and relevance to medical practice. 	<ol style="list-style-type: none"> 3. Customize the output from digital health records for purpose-driven use to improve patient care. 4. Describe the impact of health record interoperability and data exchange on collaborative patient-centred care. <ul style="list-style-type: none"> • Health Advocate <ol style="list-style-type: none"> 1. Employ health informatics to enhance quality of care and service delivery in the context of acute and chronic disease management in community settings. 2. Advocate for balance between an individual’s right to privacy and the needs of the health care system when using aggregated health information in decision-making. 3. Appreciate that analysis of pooled health and demographic data informs health policy decision-making at local, regional, provincial/ territorial, national, and international levels. 4. Speak out against harmful medical misinformation portrayed in social media. • Professional <ol style="list-style-type: none"> 1. Demonstrate that professional judgment prevails over technologies designed to support clinical assessment, interventions, and evaluation. 2. Uphold professional obligations, comply with legislation, and maintain appropriate personal boundaries when engaging in the use of social media platforms and digital technologies to record, convey, and respond to information.
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Discussion

History of UME in Clinical Informatics

Early efforts to integrate clinical informatics into UME hit a tipping point in 1998 with the Medical School Objectives Project (MSOP) [15]. The MSOP suggested the integration of technical skills related to the storage, retrieval, and management of information for medical problem-solving and decision-making. More recently, efforts to integrate clinical informatics into UME have used the ACGME clinical informatics competencies as a means to articulate how informatics can help prepare medical students for residency and beyond. Hersh et al [16] note that the competencies required for clinical informatics go beyond the simple information retrieval tasks described in the MSOP and that the definition of clinical informatics has evolved beyond solely the “how, what, when or why of information use” for problem-solving and clinical decision-making. Clinical informatics is not alone as a subspecialty whose content is a useful addition to UME. Other facets of the MSOP, such as public health, epidemiology, and medical ethics, have been suggested as useful additions to UME, most recently under the umbrella of health systems science [17-20]. However, it is important that when adding to the UME curriculum, medical schools attend to the need to integrate additive content into that

of clinical medicine in a manner that supports the development of skills central to medicine: diagnosis and medical decision-making [21].

The use of the ACGME competencies to inform curricular elements was demonstrated by Silverman et al [22] and Hersh et al [23]. These and other previous efforts to integrate clinical informatics into UME curricula at a school level have resulted in a curriculum patterned after 2 sources: the graduate competencies for clinical informatics developed for the ACGME [6] and the core content for clinical informatics developed by the American Medical Informatics Association [24]. In these contexts, informatics serves as an integrating component at the nexus of the domains of clinical care, the health system, and information and communications technology. The resulting categories of clinical informatics content derived from the ACGME competencies were as follows: (1) fundamentals (basic knowledge and common vocabulary for the discipline), (2) clinical decision-making and care process improvement (for the implementation of systems and development of processes supporting clinical care), (3) health information systems (for the development or selection of information systems), and (4) leadership and management of change (in the implementation of clinical information systems). In an effort to refresh the core content of informatics to meet the current generation of technology, and to work toward rewriting the ACGME

competencies and core content, Silverman et al [25] performed a practice analysis and developed a new set of categories (domains): (1) fundamental knowledge and skills, (2) improving care delivery and outcomes, (3) enterprise information systems, (4) data governance and data analytics, and (5) leadership and professionalism. This refresh adds a category (data governance and analytics), as well as modifies the prior focus on clinical decision-making and care process improvement. Furthermore, the shift from decision support as a core category in clinical informatics to a more generalizable focus on systems and processes is a crucial inflection point for the emergence of the discipline of clinical informatics. This shift in clinical informatics broadens its emphasis to include methods or applications work rather than focus on the fundamental clinical problems of medical decision-making. Clinical informatics is now broader than medicine and encompasses the formalized subdisciplines of nursing informatics, public health informatics, and health informatics, and it loses the focus on clinical problem-solving with the absence of a practice focus in medicine. As is alluded to with the inclusion of clinical informatics as a facet of medical education reform within the health systems sciences, this shift further separates informatics from medicine and moves it into a curricular space alongside public health, epidemiology, and medical ethics, purely additive elective components of medical education.

Mapping

Evaluating the mapping, including the detailed unmapped content, we observe that the Canadian competencies focus on physician responsibilities (to both self and patient) in clinical practice, while the American competencies focus on the managerial aspects of medical practice. The American clinical informatics competencies focus on the management and operation of clinical data and information, rather than on patient-facing technology and interactions. The informatics distinction that can be made would be between learning to use a clinical decision support tool rather than having knowledge of the information and data that went into the design and operation of the tool. There are 2 fundamental types of reasoning: clinical or diagnostic, and management. Clinical or diagnostic reasoning is “the integration of clinical information, medical knowledge, and contextual (situational) factors to make decisions about medical care,” whereas management reasoning is the “process of making decisions about patient management, including choices about treatment, follow-up visits, further testing, and allocation of limited resources” [26]. The decision-making emphasized in the American competencies is less about “medical care,” and more about patient management. For example, the American *patient care and procedural skills* competency is to “use informatics tools to improve assessment, interdisciplinary care planning, management, coordination, and follow-up of patients.” The Canadian *medical expert* competency is to “adopt a variety of information and communication technologies to deliver patient-centred care and provide expert consultation to diverse populations in a variety of settings.” The tasks involving management reasoning (management, care planning, coordination, and follow-up) differ somewhat from those tasks for direct patient care (consultation and patient-centered care). An integrative solution would help

reconcile the differences between the American and Canadian framings of clinical informatics. Teaching both management and clinical reasoning methods would best serve the current model of reasoning in medicine (suggested by Patel and Bergl [27]), given the inherent complexity of the contextual processes girding medical art and science. The need for such reconciliation is evident in the noted difference between the countries’ clinical documentation, where the semantic value of information in the American medical record is driven by compliance and reimbursement rather than by essential clinical information [28].

In thinking toward a better solution for clinical informatics education during undergraduate medical education, it is worth mentioning that a concern raised in curricular deployment is the applicability of the content to clinical practice when it is delivered in the preclerkship curriculum [29]. Curriculum design at multiple universities has resulted in either a threaded or entangled curriculum emphasizing clinical informatics [22,23] or clerkship electives focused on clinical informatics [30]. With entangled curricula, schools typically emphasize epidemiologic or decision science principles that drive the scientific fundamentals of informatics practice, rather than an elective’s emphasis on operations and clinical decision support. In addition, when attempting to teach quality improvement (aspects of which are components of the ACGME clinical informatics competencies) during the preclerkship curriculum, informatics has focused on issues of salience to students rather than on fundamental clinical value [31].

Next Steps

Fundamentally, integrating sequenced clinical informatics content to provide experiential engagement beyond the classroom (eg, connecting terminology and standards to other clerkship rotations) and within the academic health sciences center offers a means to ensure that informatics education is not overshadowed by clinical education [32]. We acknowledge the potential challenges of reconciling Canadian and American competencies, both at the political scale of 2 national medical education schemes as well as given the oversight of the LCME. However, as a starting point, future informatics education approaches should integrate both clinical and management reasoning and should emphasize that informatics supports the pragmatic components of clerkship education that reinforce the practice and art of doctoring.

Furthermore, within clinical informatics education, there is a lack of focus on clinical judgment and meta-cognition, both educational outcomes of clinical informatics beyond those of computer use and simple information retrieval [16]. Resolving this lack is crucial, given that in a systematic review of informatics education interventions in medical education, students have been shown to be inadequately trained on extracting, aggregating, or visualizing clinical data, leading to deficits in their practice as physicians looking to work with the electronic medical record [33]. As such, informatics training beyond that initially outlined from existing efforts such as the MSOP (ie, general computer use) is necessary. We recommend the following ways to best support future curricular development:

1. Focus clinical and informatics education on the teaching of diagnostic reasoning such that management and clinical or diagnostic reasoning can be discussed in the context of the clinical encounter and health system.
2. Develop precision medical education such that informatics-supported educational outcomes can be encouraged (and assessed) via health systems science, distributed learning, and other technology-supported pedagogical platforms [11,34,35].
3. Translate clinical and clinical informatics skills into clinical practice through an objective structured clinical examination or other structured assessments familiar to students, such that the formal assessment of informatics training can occur by a method parallel to that of clinical skills, ultimately creating cognitive and pedagogical links between the two for both graduate and postgraduate education.

In teaching reasoning, be it clinical or management-based, an understanding of how physicians shape it in practice is crucial. The curriculum should ensure that the rigor of the logical practice of diagnosis (through differential diagnosis) is enhanced in its complexity rather than via shortcuts [36]. While the oldest empirical examples of this approach demonstrated promise [37,38] and heralded current successes [39,40], the key to these successes has not been in their technological sophistication but in their ability to teach and serve the physician's logical calculus.

This notion to augment clinical practice is behind the suggestion by Hersh et al [41] that a necessary competency to add to clinical informatics should include the use of artificial and augmented intelligence in clinical settings (as well as an understanding of the biases in algorithmic approaches). Such an inclusion of artificial intelligence in the clinical information used for diagnosis has clear links to the notions of Sir Thomas Clifford Allbutt in his seminal work titled *A System of Medicine*. Allbutt [42] suggests that information integration is the pillar of the

core acts of medicine, such as diagnosis. Articulating a next step for UME to teach clinical informatics, the focus of using the computer and the electronic medical record should be to facilitate the management of uncertainty through the imprimatur of the physician's clinical guidance. This management of uncertainty would inform medical students that information and evidence are the symbols with which the clinical encounter is interpreted by the physician. Fundamentally, the management of uncertainty strengthens the physician's information-based resilience, fighting against the automation of care, and a technician-executor model of physicianship [43]. With appropriate informatics education, the physician encountering technology would thereby be augmented rather than supplanted. The physician's cognition would not be replaced by "the master algorithm" [44].

Finally, to assess this augmentation, future informatics education should align with the staged assessment mechanisms of medical education rather than those of cognitive theories of learning [45], such that the clinical translatability of the knowledge gained is first and foremost in the students' mind. Shifting to a paradigm of data-driven education that mirrors the current approach to clinical care, effective measurement and assessment [11] are crucial in determining how the (hidden) curriculum with which physicianship is borne is not rendered obsolete by digitization. Therefore, this analysis can be concluded with a final paean to the clinical informatics community in seeking to advance medical education:

Wrap your thoughts in the cloth of logic and reasoning, such that they would slip easily between the wisps of shadow that link the disciplines of medicine and complot with the complexity of that curriculum which is hidden to render the fuller modern physician.

Acknowledgments

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Data Availability

The data used for this study are available on request, but all the information was obtained from publicly available sources.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Higher resolution version of [Figure 1](#). Explicit subcompetencies or enabling competencies map between CanMEDs roles through general enabling competencies [7] and Accreditation Council for Graduate Medical Education (ACGME) common program requirement core competencies [5]. CanMEDs roles are red diamonds, while ACGME competencies are in black boxes, with directional mapping labels.

[[PDF File \(Adobe PDF File\), 29 KB - mededu_v8i3e39794_app1.pdf](#)]

Multimedia Appendix 2

Text-based version of [Figure 2](#). CanMEDs enabling competencies that are unmapped to Accreditation Council for Graduate Medical Education subcompetencies.

[[PDF File \(Adobe PDF File\), 30 KB - mededu_v8i3e39794_app2.pdf](#)]

Multimedia Appendix 3

Higher-resolution version of [Figure 3](#). Exact graphical map between CanMEDs 2005 roles through general enabling competencies [7] and Accreditation Council for Graduate Medical Education (ACGME) 2013 common program requirement core competencies [5] detailing the Physician Competency Reference Set competencies. CanMEDs roles are red diamonds, while ACGME core competencies are in black boxes, with directional mapping labels.

[[PDF File \(Adobe PDF File\), 28 KB - mededu_v8i3e39794_app3.pdf](#)]

Multimedia Appendix 4

Text-based version of [Figure 4](#). Physician Competency Reference Set (PCRS) competencies that are not mapped to either CanMEDs enabling competencies or Accreditation Council for Graduate Medical Education (ACGME) subcompetencies such that roles and competencies share a PCRS competency.

[[PDF File \(Adobe PDF File\), 31 KB - mededu_v8i3e39794_app4.pdf](#)]

Multimedia Appendix 5

Higher-resolution version of [Figure 5](#). Explicit key competencies to subcompetencies map between CanMEDs eHealth Roles [8] and Accreditation Council for Graduate Medical Education (ACGME) clinical informatics core competencies [6]. CanMEDs roles are red diamonds, while ACGME core competencies are in black boxes, with directional mapping labels.

[[PDF File \(Adobe PDF File\), 14 KB - mededu_v8i3e39794_app5.pdf](#)]

Multimedia Appendix 6

Text-based version of [Figure 6](#). CanMEDs eHealth enabling competencies that are unmapped to Accreditation Council for Graduate Medical Education clinical informatics subcompetencies.

[[PDF File \(Adobe PDF File\), 30 KB - mededu_v8i3e39794_app6.pdf](#)]

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Abbreviations

ACGME: Accreditation Council for Graduate Medical Education

GME: graduate medical education

LCME: Liaison Committee on Medical Education

MSOP: Medical School Objectives Project

PCRS: Physician Competency Reference Set

UME: undergraduate medical education

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Original Paper

Use of Social Media for Implementing Diagnoses, Consultation, Training, and Case Reporting Among Medical Professionals to Improve Patient Care: Case Study of WeChat Groups Across Health Care Settings

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Abstract

Background: Health professionals in low- and middle-resource settings have limited access to up-to-date resources for diagnosing and treating illnesses, training medical staff, reviewing newly disseminated guidelines and publications, and preparing data for international disease reporting. A concomitant difficulty in high-resource settings is the need for continuing education and skills up-training in innovative procedures on unfamiliar social media platforms. These challenges can delay both patient care and epidemiological surveillance efforts. To overcome these challenges, health professionals have adapted WeChat Groups to implement timely, low-cost, and high-quality patient care.

Objective: The primary study aim was to describe the processes taken by medical professionals across their diverse physical and virtual networks in adapting a bottom-up approach to collectively overcome resource shortages. The secondary study aim was to delineate the pathways, procedures, and resource/information sharing implemented by medical professionals using an international publicly available popular social media app (WeChat) to enhance performance of facility-based procedures and protocols for improved patient care.

Methods: In-depth interviews, observations, and digital ethnography of WeChat Groups communications were collected from medical professionals in interconnected networks of health care facilities. Participants' WeChat Groups usage and observations of their professional functions in interconnected networks were collected from November 2018 to 2019. Qualitative analysis and thematic coding were used to develop constructs and themes in NVivo. Constructs incorporated descriptions for the implementation and uses of WeChat Groups for professional connections, health care procedures, and patient care. Themes supporting the constructs focused on the pathways and venues used by medical professionals to build trust, to establish and solidify online networks, and to identify requests and resource sharing within WeChat Groups.

Results: There were 58 participants (males 36 and females 22) distributed across 24 health care settings spanning geographical networks in south China. Analysis yielded 4 constructs and 11 themes delineating the bottom-up usage of WeChat Groups among clinicians, technicians, nurses, pharmacists, and public health administrators. Participants used WeChat Groups for collectively training hospital staff in complex new procedures, processing timely diagnoses of biological specimens, staying abreast of latest trends and clinical procedures and symptoms, and contributing to case reporting for emergent illnesses and international surveillance reporting. An unexpected strength of implementing clinical, training, and research support on a popular app with international coverage is the added ability to overcome administrative and geographic barriers in resource distribution. This advantage increased

a network's access to WeChat Groups members both working within China and abroad, greatly expanding the scope of shared resources.

Conclusions: The organic, bottom-up approach of repurposing extant social media apps is low cost and efficient for timely implementation to improve patient care. WeChat's international user base enables medical staff to access widespread professional networks across geographic, administrative, and economic barriers, with potential to reduce health disparities in low-resource settings.

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KEYWORDS

mHealth; WeChat; implementation research; low-resource settings; innovative medical technologies; digital health; medical education; social media; mobile health technologies; bottom-up approach

Introduction

Background

Health care facilities in low-and-middle-income countries (LMICs) are continually confronted by the public health conundrum of maintaining and upgrading the skills of medical professionals while concomitantly keeping operating costs manageable. The main problem plaguing staff working in LMIC health facilities is that clinicians, technicians, and researchers have limited access to the most up-to-date facilities and knowledge for completing their work. Other difficulties include the need to collectively train the complement hospital staff in complex new procedures, to provide timely analyses of biological specimens for diagnosis, to keep staff abreast of latest developments in trends and clinical procedures and symptoms, and to conduct case reporting for emergent illnesses and update surveillance reports for coordinated international epidemiological efforts. For medical facilities in high-income countries (HICs), a related problem arises in the difficulties associated with the time and resources to formally train clinicians to deliver professional patient services in new online and social media formats [1].

One of the innovative approaches to dealing with these problems is that medical professionals have organically implemented a bottom-up solution by using existing popular apps to devise a mobile health (mHealth) approach [2-9]. Based on publicly available social media technology, the solutions of medical professionals repurposing extant social media application functions are both low cost and efficient in timely implementation. For example, medical doctors use functions within social networking sites (SNSs) to better communicate with each other [4,7,8], and as is the case with WeChat Groups, to coordinate mHealth solutions with medical colleagues to offer around-the-clock question-and-answer support for recently discharged patients with COVID-19 [5]. Since the advent of mHealth into medicine and patient care as early as the mid-1990s [10], and widespread adaption in the 2000s [11,12], social media and internet-based networking apps have demonstrated their usefulness for improving health management systems and coordination of resources for patients and doctors across a range of health care process and institutional settings in LMICs and HICs [10-16].

Recently, the applicability of social media-based tools is becoming more targeted toward application to overcome

challenges of limited location-based resources and to improve speediness of information sharing for health care procedures. In addressing these emerging areas of innovation and medical development, there are calls by the international research community for more in-depth [4,17] and qualitative evaluation of the mechanisms of adaption [10,13,14,18,19]. Furthermore, in light of recent pandemics, and national implementation of pandemic-fighting measures such as lockdowns in China and in other countries, these applications are even more critical in ensuring the quality and availability of patient-centered care across diverse socioeconomic settings [20]. In the age of swift-moving global pandemic pressures, the increased burden and mobility restrictions on essential workforce mean that such low-cost, quick, and highly adaptable functionalities become even more important in implementing timely medical assessments and treatment in LMICs and HICs. In fact, in the early days of the COVID-19 pandemic, overseas Chinese in Europe used WeChat Groups to access medical care and consultations from doctors in China [21].

This article contributes to public health discourse by describing the ways that medical professionals use WeChat Groups, an internal function of WeChat app, to overcome barriers in cost, time, physical, and bureaucratic restrictions toward improving patient treatment, diagnosis, training, and information sharing and reporting across geographic and institutional boundaries. The impact of these bottom-up innovative adaptations have resulted in improved diagnoses, consultations, and wider circulation of emerging case reporting information both within and outside the physical territory of China for public dissemination to the global medical community. The implications of these findings are pertinent to resource management in fighting pandemics, such as COVID-19 [21], and to coordinating resources speedily and efficaciously across geographic, administrative, and bureaucratic barriers in LMICs and HICs [22].

In China, the predominant social media app is WeChat, boasting the greatest number of users [23,24], with over 1.2 billion regular monthly users at the start of 2020 [25]. As of 2021, WeChat has over 1.25 billion monthly active users internationally, a growth of 500 million users [26]. Along with Facebook, YouTube, WhatsApp, Facebook Messenger, and Instagram, WeChat is among the top most popular social networking apps globally [27,28]. While Facebook and WhatsApp have the greatest presence internationally, a 2013-2014 consumer behavior study of 170,000 internet users

in 32 countries, by Global Web Index (GWI), reported that WeChat is growing faster than rival social media apps in many regions, including in the Americas, that is, Canada (134%), United States (547%), Mexico (2502%), Brazil (1108%), Argentina (835%); in Europe and the Middle East, that is, the United Kingdom (923%), Sweden (152%), Germany (667%), France (778%), Spain (666%), Italy (6587%), Turkey (708%), Saudi Arabia (320%), United Arab Emirates (2716%); and in the Asia-Pacific region, that is, India (1774%), Taiwan (1927%), Singapore (503%), Malaysia (1332%), Indonesia (1094%), the Philippines (2820%), Thailand (191%), and Australia (347%) [29]. WeChat was also the fastest growing app in South Africa (4084%), and the second fastest in Russia (331%), South Korea (259%), and Vietnam (204%) [29]. In fact, WeChat's platform and success serve as South Africa's model for extending technology infrastructure and integrating other countries into one social networking system in Africa [30].

At the start of 2014, WeChat had garnered a strong user base, capturing significant portions of the social media apps market in Malaysia (33%), Hong Kong (32%), India (21%), and Indonesia (18%) [29]. By the end of the same year, WeChat solidified its position, with its user base representing 39% in the Asia-Pacific region and 23% globally of GWI study participants [31]. In 2015, there were 697 million, with over 70 million located outside of China [32], with user interphase support available in over 20 languages, including simplified and traditional Chinese characters, English, Indonesian, Spanish, Portuguese, Turkish, Malaysian, Japanese, Korean, Polish, Italian, Thai, Vietnamese, and Russian [32]. Extending its reach beyond regional neighbors, WeChat is reportedly used on a regular basis in Europe—Russia (1%), Finland (1%), France (2%), Germany (2%), Spain (2%), the United Kingdom (2%), Netherlands (3%), and Italy (3%)—and in the United States (3%), Canada (6%), Brazil (2%), and Australia (5%), according to Statista's Global Consumer Survey 2020 [33]. By 2021, WeChat became the most popular mobile messenger app in Asia [34].

WeChat is a popular app with a global reach, and its user base and influence as a social media app are growing. WeChat's reach among China's global diaspora is undoubtedly significant and serves as a vital means to maintain international connections, despite the controversial bans in the United States and state-sponsored censorship in China [35,36]. Studies of its comparative impact on people's international information-sharing behaviors, vis-à-vis other prominent social media apps, are underway [37]. Despite its growing influence, the application and adaption of WeChat among health care professionals, along with the implementation of health care innovations, have received less attention. This study contributes to elucidating these processes. As has been illustrated from the start of and throughout the COVID-19 pandemic, connections on social networks have been invaluable for sharing key medical and health care information in a timely manner. Across HICs and LMICs, clinicians are increasingly turning to trusted professional groups on social media to disseminate timely health information across international borders. For example, UK doctors identified a rare blood clot condition for the AstraZeneca COVID-19 vaccination, then turned to WhatsApp to begin

sharing symptoms, diagnosis, and treatments, posting daily to 500 colleagues located around the world [2]. WeChat's popularity and expansive applications for diverse health care settings have grown greatly since its domestic launch in 2011. This paper contributes to the discussion of how the social media app WeChat contributes to technology transfers in health care innovations among medical and health care professions, particularly for patient-centered care.

WeChat has been used in medical and health care settings to improve patient care in China. Clinicians, health-oriented businesses, medical schools, hospitals, and public health infrastructure have adapted it to facilitate scores of innovative solutions to health care management and patient access [15,23,38-40]. As one of the most prominent and inexpensive apps, it has been adapted institutionally in medical technologies in internet (desktop) and social media (mobile-based) platforms for organizing and coordinating patient care. Among hospitals and health care facilities, WeChat has been adapted by administration in several forms, including a WeChat Media (Guanzhonghao) [38], patient registrations and payment (guahao) [41], and appointments with doctors over smartphone consultation and follow-up (dianhua menzhen). Initial costs for facilities include technology support for establishing the pages, in-house technical support to calibrate internal operating systems to online user interfaces, and supplement compensation for doctors and support medical staff who participate in WeChat initiatives (e-consultations) in addition to their regular clinical duties. The origins and general functionalities of the early adaption of WeChat as a mobile app are described in-depth elsewhere [42]. Reports in English-language medical journals further describe WeChat's versatility and the resulting tangible improvements for a variety of users. Notable examples of the innovative application of WeChat by doctors include their forays to implement pilot randomized controlled trials and feasibility studies [42,43] and to improve patient comprehension of treatment and services by increasing patient-doctor communication [44]. Hospitals have used WeChat to improve patient registration, reduce wait times, and increase timely access of patients to medical staff and health services [41]. Private health care support companies improved the monitoring and collection of personal health data and linkage of health behaviors to medical records and health information [15,16,39]. More recently, WeChat is being incorporated into medical training—implemented in medical and dental schools to organize and train students [45], with a focus on problem-based learning [46,47]; for internship coordination and externship practicums [46]; and to improve the quality of connections between students and their medical instructors for more detailed field evaluation performance assessments [48]. WeChat has also been adapted to indicate health status for patients with COVID-19 and for monitoring public health of the general population [20,22,40].

Despite the institutional applications implemented by medical schools and hospitals, arguably the most exciting development is the emerging bottom-up approach by medical professionals themselves to expedite improvement of services, resource coordination, and information sharing for research purposes. Even before the global push to pitch in for coordinated care on international initiatives to combat COVID-19, medical

professionals organically used WeChat Groups to self-coordinate scarce resources, treatment, diagnosis, training, and information sharing of pertinent medical reporting, beyond the boundaries of the traditional hospital. Specifically, doctors, nurses, clinicians, and laboratory technicians and biomedical researchers collectively use self-invited colleague groups via WeChat Groups—unbounded by geography, country, or hospital affiliation. There are private groups and public groups [49-51]. This article describes the private groups created by health care professionals, where entry and information access is gated (ie, only members of the group are able to post and share information with each other). Depending on the number of participants in the group, parameters allow for between 3 and 500 members [50]. Entry is permitted primarily in 1 of 2 ways: invitations are extended by either the group moderator, or by a current group member, to a new potential member [49-51]. The most well-publicized example of WeChat Groups was the international description of how Li Wenliang, an ophthalmologist in Wuhan, announced to his fellow clinical doctors from his medical school alumni group of the presentation of SARS-like symptoms in the early days of the COVID-19 pandemic [52]. Although this disclosure received great attention on the international media as a shocking introduction into the world of WeChat Groups, long-term WeChat users were already familiar with the “Groups” function of the popular mobile app. It is a means of staying in touch and sharing photos with friends across great physical distances and international borders.

In this vein, this article contributes to this growing body of the use of social media in innovative health care solutions by describing the pathways and mechanisms adapted by health care professionals in China to improve diagnoses, consultation, training, and information sharing using WeChat Groups (weixin quan). Specifically, they use a function known as WeChat Groups to create gated groups among their personal network of medical professionals. By doing so, individual medical professionals improve their professional skills and extend institutional capacities of their primary health care facilities by expanding their access to knowledge and technologies beyond their immediate work environments. Using WeChat, clinicians, laboratory technicians, and health care researchers can access new reports, diagnosis, and improve their medical training.

Objectives

The primary aim of this study was to describe the bottom-up approach adapted by medical professionals across their diverse physical and virtual networks to collectively overcome resource shortages. To accomplish this aim, data collection was focused on delineating the conditions, circumstances, and venues used by medical professionals to connect with other professionals, physically and virtually, before they can begin to ask for and share resources across geographically diverse networks. The secondary aim was to delineate the pathways, procedures, and resource and information-sharing behaviors adapted by medical professionals during the process of repurposing the diverse networks for tasks targeting improvement in patient-centered care. To accomplish this aim, data collection was focused on delineating the specific hospital and health facilities tasks that medical professionals sought assistance for from their social media groups. Specifically, to identify the health care procedures

and protocol that medical professions completed by repurposing an international publicly available social media app, to request and share resources to improve patient care.

Methods

Setting and Participants

For this project, data collection of ethnographic observations, interviews, and digital ethnography of WeChat person-to-person messaging and WeChat Groups communications occurred from November 2018 to November 2019. Participant observations, qualitative interviews, and digital ethnography of clinical doctors, laboratory technicians, nurses, and medical researchers were based in hospitals/medical facilities in 5 major metropolitan areas (Guangzhou, Shenzhen, Dongguan, Huizhou, and Qingyuan) across the Greater Bay Area/Pearl River Delta of south China. Health facilities covered specializations in dermatology, surgery, chronic illnesses, clinics for treating sexually transmitted illnesses and diseases, general medicine, and oncology.

Approach

An institutional-level approval for site-based activities was obtained from department/facility administrative leaders. Written and digital copies of project description and informed consent were provided in English and Mandarin. Informed consent for participants was obtained verbally in person and digitally on WeChat. Digital ethnographies of WeChat Groups were compiled in both Chinese and English. Face-to-face interviews and on-site participant observations were conducted in Cantonese, Mandarin, and English.

Study Inclusion and Exclusion Criteria

Inclusion into the study was determined as follows: (1) employed as a medical/health care professional with experience working in hospital/medical settings or having attended schooling for medical, nursing, pharmacy, laboratory, or health sciences; (2) had prior/current exposure to or application of international transfers of technology, in the form of knowledge, skills, abilities, work competencies, or training; (3) had acquired these knowledge, skills, abilities, and competencies through formal study abroad, overseas training or conference participation, domestic training from international partners, domestic engagement with international working/scholarly partnerships, and training materials; and (4) uses internet-based technologies (ie, social media) to communicate for professional/work interactions. Exclusion from the study was determined as follows: (1) not a trained medical or health care professional despite currently working or formerly having worked in hospital or medical settings; (2) was not exposed to, does not work, or does not follow or use any international guidelines, equipment, reading or training materials, or technologies; (3) not currently nor has ever engaged in any medical or health professional social networks with international connections; or (4) did not use internet-based technologies in any work-related tasks or functions.

Construction of the frame for participant enrollment was a multistep process. To ensure a robust framework for enrollment into the study, prospective participants were contacted through

3 categories of network connection types: formal networks, semiformal networks, and informal networks. In interactions across these 3 network categories, informants were asked if they could help identify potential participants throughout the Greater Bay Area region to encompass major urban centers, semirural peripheries, as well as rural areas. Further, informants were asked to help ensure diversity of participant background by identifying and introducing contacts who have experience working in each of China's 3-tier system of hospital and medical facilities [53], defined as primary level (village/community/township; <100 beds), secondary level (district/county; 100-500 beds), and tertiary-level (comprehensive-city/provincial/national; 500+ beds). At each meeting with informants, and after the conclusion of each participant interview, informants and participants would be asked if they had colleagues or acquaintances to recommend for the study. If the response was positive, then they would be asked if they could ask their contacts, and send along a copy of the researcher's WeChat business card, curriculum vitae, and bilingual copy of the informed consent.

Formal networks were based on institutional connections made through requests at medical establishments, such as medical schools, hospital and hospital administrative systems, medical associations, and government/public health administrative agencies. Major medical establishments in the Greater Bay Area (consisting of Guangdong Province in China, Hong Kong, and Macau) were contacted to obtain institutional support for the study. Support meant that the establishment would provide a liaison to help contact potential participants employed as staff at their home institution, or those that were alumni or active association members (ie, doctors, nurses, pharmacists, laboratory technicians, medical researchers, public health administrators with medical training). During the prospective enrollment process, local leaders and the study liaisons confirmed to potential participants that there would be no adverse impact for participating in the study, and that no data would be shared with their work units or network institution. The approval process involved firstly sharing a copy of the study informed consent, written in English and in Chinese, a digital copy of the researcher's curriculum vitae in English, and a digital copy of the researcher's bilingual business card via WeChat. Next, upon approval from the medical establishment, the institutional liaison assigned to formally support the study would establish appropriate departmental clearance and make connections with potential participants. Finally, institutional support for the study at these sites meant that participants could sit for an interview during normal work hours and at work facilities. At these sites, the institutional liaison conformed to the study inclusion criteria in identifying potential participants. Specifically, inclusion into the study from these formal connections included having worked in their hospital/medical facility as a medical or health professional as current full-time employees. Potential participants were then invited to face-to-face interviews individually on a 1-on-1 basis, sitting for an interview and sharing their WeChat contact information in an enclosed, secure, physical location separate from other colleagues. At the start of the interview, participants were asked if they willingly want to participate in the study, and if they agreed, were presented with

a hard copy of the informed consent. Each participant was asked a series of inclusion questions to verify eligibility.

Semiformal networks were connections made from study participants (originally from the formal networks) who were willing to serve as informants to make introductions to prospective participants from their own social networks. These prospective participants would be personal or professional network contacts, originally met through work, school alumni associations, or some type of professional capacity. They do not have current formal institutional (reporting or administrative) relationships with informants, to ensure that the interviews are not compelled. As semiformal networks did not require institutional support, informants who were already familiar with the interview and participant observation processes assessed which members of their social networks were trained medical and health professionals who fulfilled the inclusion criteria. Serving as informants, these participants would ask their contacts individually. If the prospective agreed to being interviewed, the informant would then send each party a contact card invitation within WeChat. After a prospective participant accepted the invitation to connect on WeChat, a copy of the informed consent and the bilingual business card would be sent. Interviews were then conducted either in-person at a neutral public location, online via WeChat, or in-person at the workplace of the participant.

Informal networks were connections made without the assistance of formal and semiformal informants, primarily through 1-on-1 engagement and interactions at health-oriented conferences, conventions, meetings, and networking events. These events were advertised to or promoted by informants from the formal and semiformal networks, but there were no direct links or contacts from them for connections at these venues. These venues were recommended by informants as professional events they themselves would normally attend, or be invited to, to connect in a professional capacity. At these events, potential participants from well-known health facilities (with operational presence in the Greater Bay Area) were approached, and asked if their organization as an institution, or health professionals from their organization individually, would be interested in participating in the study. At the initial meeting, prospective participants were presented with a hardcopy of the informed consent, and given a hardcopy of the bilingual business card. If they were then interested in participating, they would be asked the series of inclusion questions to verify eligibility. Prospective participants could decide when and where to conduct the face-to-face interview.

During the interview, participants were asked about their use of online social networking, WeChat usage, if they could describe or demonstrate some of the ways they use WeChat and their smartphones to support their medical and health care-related work tasks, and if they would be willing to connect on WeChat for digital communication and continued participation. When individual 1-on-1 connections were then made on WeChat, participants were sent an electronic copy of the study institutional review board approval. To observe participants using WeChat Groups as part of the digital ethnography, throughout the study, participants from formal, semiformal, and informal networks would share invitations with

specific WeChat Groups that they were members of, making introductions to the other WeChat Groups participants. The researcher would then introduce the study, and share a copy of the informed consent and bilingual business card.

Data Management and Analysis

Qualitative data comprising field notes were typed in English and interviews were transcribed into Mandarin and English. These data were inputted and managed in NVivo. Thematic analysis [54,55] was supported by a deductive approach to the data and coded within NVivo. The main themes from interviews and descriptive observations from field notes and interviews were reported across the occupational specialty of participants.

Ethical Approval

This study was conducted in accordance with General Data Protection Regulation (GDPR) and approved by the University of Oslo Ethics Committee as part of IKOS grant number 275002 (2018).

Results

Overview

Interviews, digital ethnographies, and observations were conducted for 58 people (36 men, 22 women) and were included in the final analysis. Participants included doctors (clinicians, surgeons, and medical researchers), nurses, laboratory technicians, hospital pharmacists, and public health administrators (Table 1).

Table 1. Participant demographics, Guangdong, China, November 2018-2019 (N=58).

Characteristic	Participants
Gender, n (%)	
Male	36 (62)
Female	22 (38)
Medical profession, n (%)	
Doctors ^a	39 (67)
Nurses	3 (5)
Laboratory technicians	7 (12)
Pharmacists	2 (3)
Public health administrators	7 (12)

^aIncludes clinician, surgeons, and researchers.

Field sites included 24 health care facilities from Guangzhou (n=19, 79.2%), Dongguan (n=2, 8.3%), Shenzhen (n=1, 4.2%), Qingyuan (n=1, 4.2%), and Huizhou (n=1, 4.2%). Digital ethnographies were collected from online sources for each site. On-site visits were performed for 13 of the 24 (54.2%) health care facilities for extended interviews and in-person observations.

Constructs and Themes on WeChat Groups to Improve Patient-Centered Care

Analysis of the digital ethnography, field observations, and qualitative interviews revealed 4 construct sets grouped into 11 main themes for categorizing observations from site visits and participant interviews. Results are summarized in Table 2.

Overall, the bottom-up-driven creation of WeChat Groups among medical professionals' networks facilitated participants' skill development and knowledge broadening, leading to the improved ability to provide patient care and enhance specialization in their respective subfields. Specific pathways and mechanisms include establishing and utilizing connections in a widening network, enhanced opportunities in training and continuing education, improved access to knowledge base and equipment for diagnostics and procedures, and higher quality contact and linkage to patient histories. These processes collectively improve patient care via diagnosis, consultations, symptom/history reporting, and treatments, thereby improving quality and frequency of information sharing across diverse settings and geographic boundaries.

Table 2. Constructs and themes for use of WeChat Groups to improve patient care, medical training, and case reporting in health care settings in China, 2018-2019.

Construct	Theme
Establishing and Utilizing Connections in a Widening Network (Construct 1)	<ul style="list-style-type: none"> Physical mobility improved knowledge of resource location, variety of activities, patient subgroup, disease concentrations (Theme 1) Geographic coverage and bridging administrative boundaries (Theme 2) WeChat Groups connectivity strengthened connections for support and opened up opportunities for information sharing, training venues, and continuing education (Theme 3)
Training and Continuing Education (Construct 2)	<ul style="list-style-type: none"> Reading groups to improve skills up-training and continuing education (Theme 4) Access to paywall articles and books outside of China (Theme 5) Reducing barriers to differential access to international conference reporting, surveillance data, and medical treatment guidelines (Theme 6)
Improved Access to Knowledge Base and Equipment for Diagnostics and Procedures (Construct 3)	<ul style="list-style-type: none"> Tapping the hive mind for knowledge and resources for diagnostic interpretation (Theme 7) Improved communication, better access to scarce resources located far away, group-mind/collective diagnosis (Theme 8) Research coordination and manuscript preparation (Theme 9)
Higher-Quality Patient Contact and Linkage to Patient Histories (Construct 4)	<ul style="list-style-type: none"> Local-to-provincial consultation support (Theme 10) Better initial and follow-up contact and care for patients (Theme 11)

Construct 1: Establishing and Utilizing Connections in a Widening Network

Theme 1: Physical Mobility Improved Knowledge of Resource Location, Variety of Activities, Patient Subgroup, Disease Concentrations

While most participants were based in health facilities in Guangzhou, there was in fact a great deal of mobility among participants. As part of their clinical work, surveillance reporting, and continuing education, medical professionals routinely engaged in intraprovincial travel within Guangdong Province, and across the border to Hong Kong, Macau, and Taiwan. There were several annual medical conventions that were held in Shenzhen and Zhuhai, whereby participants would intermingle and engage with their networks. With frequent contact from these annual international, national, and provincial conventions, along with annual and quarterly professional training meetings, participants could meet other medical professionals in person, learn about facilities and resources of their colleagues, and maintain contact to ask for support in their expanding WeChat Groups connections.

Theme 2: Geographic Coverage and Bridging Administrative Boundaries

Participants described that their professional networks on WeChat Groups extended beyond their home health care facility. WeChat Groups connections were created based on similarities in alma mater via informal alumni networks, professional colleagues in study abroad/medical internship programs, continuing education/professional specializations, formal affiliate hospital programs, and surveillance-reporting administrative structures. Hence, these WeChat Groups connections map onto professional networks that geographically span neighboring hospitals, across city-province connections, extending into the South China region to Hong Kong, Macau,

and Taiwan, and reaching into international major research hubs in Japan, the United States, and Europe.

Theme 3: WeChat Groups Connectivity Strengthened Connections for Support and Opened up Opportunities for Information Sharing, Training Venues, and Continuing Education

After meeting in person, participants used these WeChat Groups connections to stay in touch digitally on a regular basis for professional support, sharing training event updates and relevant materials, and coordinating site visits with colleagues in other hospitals and health facilities. This was particularly the case for locations that specialize in certain treatments, procedures, operations, or patient populations. Participants located in more remote locations (away from Guangzhou) learned about the implementation of new technologies and techniques, and asked counterparts to share more information for local skills upgrading and training. Once part of an invited private group within WeChat Groups, it was possible to submit requests for assistance to other people in WeChat Groups that one may not have met in person before.

Construct 2: Training and Continuing Education

Theme 4: Reading Groups to Improve Skills Up-Training and Continuing Education

One of the more novel ways of using WeChat Groups observed in the field is the establishment of thematic reading groups (for English-language materials). Medical professionals, particularly doctors, would identify subject topics they collectively want to learn more about. Then they would share relevant research articles, book chapters, or diagnostic guidelines. On WeChat Groups, common problems in digesting the text were discussed, and supplemental materials would be shared. The materials most often shared among WeChat Groups connections established as reading groups were general public access medical guidelines published online, PDF files of biomedical articles

from online digital research repositories (eg, PubMed), PDF files of paywall-access materials obtained via an institutional account from a WeChat Groups member, digital copies of book chapters or medical textbooks shared by publishers with WeChat Groups members, and professional conference presentations content. Oftentimes, the reading groups would meet in person to collectively read the text to identify new terminology, procedures, and cutting-edge techniques and procedures applicable to clinical duties, biological sampling protocols, and out-patient surgical procedures.

Theme 5: Access to Paywall Articles and Books Outside of China

In recent years, health care facilities in China have gained greater access to medical databases and peer-reviewed journals. The push for open publishing and wider access to PubMed have made it much easier for medical professionals to access information on symptoms and disease development and progression. However, there are still many articles that are behind pricy subscription paywalls, and books that are too expensive for the acquisition budgets of smaller hospitals. Hence, participants turn to different connections in separate WeChat Groups, asking if group members have electronic copies that they can share directly. Participants in government institutions and in primary- and secondary-level rural-based hospitals acknowledge that colleagues in academic settings tend to have better access to these key resources. Within WeChat Groups, members with access to institutional accounts would obtain PDFs by searching for and accessing paywall articles, digital book chapters, and digitized books and textbooks. As these institutional accounts fulfill copyright laws and regulations, the subsequent limited amount of scholarly sharing is generally thought of as covered by the fair use exception for sharing these materials for educational and scholarly purposes.

Theme 6: Reducing Barriers to Differential Access to International Conference Reporting, Surveillance Data, and Medical Treatment Guidelines

Similarly, there seems to be differential access to international surveillance reports and reporting updates to international benchmark guidebooks. Participants indicated that doctors and technicians involved in international research collaborations tend to know about and gain access to international reports more readily than clinicians and public health administrators. As many medical professionals in China (and other LMICs) experience financial and bureaucratic constraints on attending international conferences, colleagues from academic institutions and competitive research–implementation collaborators share the newest guidelines, medications, and treatment regimens for patient care via their participation in various WeChat Groups activities.

For doctors, use of WeChat Groups helped improve their efficiency in patient-oriented care processes by facilitating their work in 3 primary ways. First, by using WeChat Groups, doctors could ask for help in locating descriptions of symptoms on articles posted on PubMed. PubMed is a free online resource as part of the US National Library of Medicine, and consists of search-and-retrievable open-access abstracts and links to millions of high-quality peer-reviewed biomedical and life

sciences research studies. However, because the interphase is in English, and being unfamiliar with site layout and system navigation, WeChat Groups users may need assistance in acquiring the knowledge and ability to navigate the English language site, to perform content searches and to access the relevant linked articles. Second, WeChat Groups helped doctors, particularly those located in primary and secondary hospitals in rural locations or low-resources settings, access the newest international guidelines on disease symptoms. These doctors are aware that updated content may have been presented at international conferences and national meetings attended by WeChat Groups members with access to greater financial resources. To help them accomplish their diagnostic and clinical work more efficiently by learning about updated guidelines, new clinical biological specimen sampling, and surgical procedures, WeChat Groups members may ask for copies of slides, PDFs, short videos, or presentation papers circulated at these events. Third, in reviewing the guidelines on the WeChat Groups platform, the members would hold discussions on how, where, when, and under which conditions the guidelines can be applied in clinical evaluations of symptoms for patient consultations and laboratory specimens. These mechanisms are now more easily performed via WeChat Groups. Overall, WeChat Groups support more efficient peer-to-peer upskill training of medical professionals for acquiring knowledge and skills delineated in updated guidelines, medications, and treatment regimens for patient consultation and surgical care.

Construct 3: Improved Access to Knowledge Base and Equipment for Diagnostics and Procedures

Theme 7: Tapping the Hive Mind for Knowledge and Resources for Diagnostic Interpretation

It is common practice for medical professionals to take photographs of patients' ailments, unprocessed biosamples, and processed specimens for health record documentation, surveillance and reporting, and research dissemination purposes. The innovative application by medical professionals is the uploading of these photographs to specialist WeChat Groups to support diagnostics and interpretation.

During analyses, the concept of becoming more efficient in accomplishing health care processes arose from interviews and observations of the health care professionals as they carried out their daily work. They described how their use of WeChat Groups helped them become more efficient at their tasks. Turning to WeChat Groups, members can streamline processes and procedures that previously took a great deal of time, required multiple steps, or were just not feasible before the implementation of bottom-up work-arounds using WeChat Groups. This access to a hive-mind approach is a shift in the ways that health professionals conceptualize their "available resources at hand." For example, it is customary for doctors at primary facilities (usually based in rural areas with low resources) to refer patients with unresolved ailments up to secondary (at township or city levels) or tertiary facilities (at provincial centers and regional hubs). Because the doctors, nurses, and laboratory technicians are part of a larger, integrated health care infrastructure, they can now use WeChat Groups to readily share pertinent information on symptoms, treatments,

and evaluations of laboratory specimens. Previously, these upstream consultations with higher-level doctors may happen at quarterly in-person check-ins. It is now feasible to directly message the connections in WeChat Groups for support in diagnoses and consultations. For particularly difficult cases, it would be feasible to ask for support and help from WeChat Groups members working in facilities with more advanced equipment, either overseas or at national centers. Knowledge of these international linkages and nodes of resources are often shared at conferences during presentations and at large-scale yearly/quarterly training sessions across multiple hospitals in the same health care system. By connecting with members on WeChat Groups, medical professionals based in primary and secondary hospital settings can more quickly treat their local patients. For particularly difficult cases that required higher levels of access to medical diagnostic equipment or diagnosis evaluations, laboratory staff and medical clinicians would request support from WeChat Groups members based overseas for traineeships in medical and research facilities in locations such as the United States, Europe, and Japan. Hence, despite being based in a rural or low-resource hospital, health professionals are better connected to a wider medical knowledge base and diagnostic services in their home country, with increased access to high-quality Chinese- and English-language medical knowledge and diagnostic resources available abroad.

Theme 8: Improved Communication, Better Access to Scarce Resources Located Far Away, Group-Mind/Collective Diagnosis

Related to the hive minding of resources, if a health facility lacks specific equipment to provide an in-depth analysis, the photographs and accompanying medical information (deidentified of linkable patient data) are shared with members via WeChat Groups. The result being a hive-mind processing for knowledge base assessment and access to equipment at resource-rich locations. This pathway of accessing resources was described by laboratory technicians, whereby they take photographs of biospecimens, and would share the initial reporting with colleagues based in health facilities with more advanced equipment to obtain diagnostic support. This process could be considered an alternate form of telemedicine. Participants described using this process on WeChat Groups to connect with members located in the United States, asking for assistance to help run diagnostics for patients from health facilities in China.

Theme 9: Research Coordination and Manuscript Preparation

An increasingly prevalent concern among medical professionals in China is the growing pressure to produce research concomitant with clinical duties. As promotion and pay become linked to publication and journal prestige in Chinese medical systems, participants began using WeChat Groups to support research coordination and manuscript preparation. Clinically oriented staff and functional departments began to develop resources for sharing literature reviews, guidelines for implementing systematic reviews, sharing results of quantitative and diagnostic analyses, and manuscripts drafts using WeChat Groups.

Construct 4: Higher-Quality Patient Contact and Linkage to Patient Histories

Theme 10: Local-to-Provincial Consultation Support

In China, public hospitals are organized in a tiered hierarchy, with affiliate hospitals at the province, county, and township levels. When dealing with an ailment, many patients tend to try their local hospitals first. However, if the health professionals are unsure of the symptoms, clinical procedures, treatment, or medications, they may contact their colleagues higher-up in their surveillance reporting hierarchy to ask for clarification and assistance.

Theme 11: Better Initial and Follow-Up Contact and Care for Patients

Similar to the in-network patient referral process in US health systems, patients in China can be referred to specialists and departments at a higher-level affiliate hospital. This process can be disorienting for patients, so clinicians at local hospitals may contact their doctors in their surveillance reporting unit to ask for help in treating patients with problematic symptoms. In severe cases, the patients will be referred to the county, city, or provincial hospital. When necessary, doctors will coordinate care for patients in this manner, organizing surgeries and special consultations in affiliate units. The progression up this hierarchy is often used of organizing surgeries for patients. This practice is now becoming commonplace for diagnosis and treatment of infectious diseases and sexually transmitted illnesses and diseases. In this study, participants described how if patients are not able to get enough help in remote locations, or lower-tier locations, they go to Guangzhou. Then, it is possible for doctors to coordinate help with diagnostics and referrals and establish history of symptoms and treatment regimes.

Discussion

Principal Findings

How does WeChat Groups help medical professionals? In many LMICs, hospitals often lack access to the latest medical information and equipment for treating patients. In devising solutions to this dilemma, doctors and their support staff have come up with innovative ways to utilize online technologies and social media networks to overcome barriers in physical infrastructure. These solutions are beneficial to improving patient-centered care in LMICs and HICs alike.

One of the important findings of this study is that the establishment and agentic utility of a professional network for medical professionals are magnified and widened by using WeChat Groups. In fact, WeChat Groups now serve as a vital pathway for doctors, nurses, technicians, pharmacists, and public health administrators to access resources and share important occupation-based knowledge and procedures across geographic and administrative boundaries. This finding builds on reviews published by JMIR about health professionals using SNSs to build virtual communities and engage in professional communication [4,7-9]. It extends on previous findings by documenting the channels and mechanisms used to adapt SNSs [4], showing how doctors have progressed beyond using SNSs

for discussions about medical topics into repurposing apps to better perform health facility-based procedures and protocols [7]. Perhaps most importantly, WeChat Groups support communication across administrative barriers and great geographical distances internationally to improve dissemination of emerging local health crises along trusted member networks. By repurposing SNSs, doctors shared life-saving information on health care procedures to combat COVID-19 [2,5,21,52,56]. To coordinate resources for addressing localized emergencies, it is possible to notify members with differential resources to share them with members working with fewer resources. Willing members share resources and information, overcoming some of the distribution inequities by tapping into richer regions in China and abroad. Participants who have better access to paywall resources or better virtual private network (VPN)-controlled access to international materials can share these resources more easily using WeChat Groups. For example, first during their 1-on-1 interviews participants who reported obtaining information, and later, during participant observations, were observed using WeChat Groups to access World Health Organization (WHO) reports, country-specific Centers for Disease Control and Prevention (CDC) updates, including diagnostic guidelines and reports; conference proceedings from international events; and international diagnostic treatment and medication guidelines for illnesses. They requested and shared these materials collectively from WeChat Groups members and connections dedicated to occupational reading, paper writing, and implementing new international procedures.

Participants described how they use WeChat Groups to share information with each other. Using the sharing functionalities within WeChat Groups, health professionals are exchanging materials in English and Chinese, reflecting the internationalization of medical care and China's engagement within the international medical community. Collectively, resources shared include open-source journals, industry-specific guidelines and reports, and paywall subscription products that group members access via their institutional credentials to then share with their colleagues.

Within a large-scale health care structure, such as a comprehensive hospital, there may be several important health facilities/subgroups. From the analysis and results, WeChat Groups offer complementary mechanisms to achieve larger health care goals of improved patient care, lower opportunity costs in time and resources, and quicker sharing of pertinent health-related information. For example, hive-mind group-based diagnosis of images and laboratory results (laboratory technicians); sharing articles, medical papers, and reports for symptoms and diseases (doctors and nurses); textbooks and guidelines used for prepping surgeries and operative care (surgeons); newest diagnosis/screening techniques (clinicians and nurses); better access to international conference materials, guidelines, evidence-based surveillance reports (public health administrators); newer drug information; and wider networks to sell and source medications for hospital's in-house needs (pharmacists). These functions indicate that WeChat Groups not only concretely improve the pathways and mechanism of patient-centered care, but also provide additional opportunities

to improve the timetable, budgeting, and strategic operations of health care facilities.

The description of health and medical professionals using WeChat Groups, and finding it offers an "efficient" approach to carrying out procedures, arose from analysis of the interviews and participant observations. During fieldwork and interviews, clinical doctors and health care professionals who work in hospital settings, namely, laboratory staff, described the efficiency as saving time and labor, and reducing steps to completion of procedural steps in patient care. Participants described increasing their efficiency by tapping into the specialist colleagues via WeChat Groups for help in the diagnosis of samples. For doctors, tapping into their professional contacts facilitated their work in 3 primary ways. First, it helped them locate descriptions of symptoms on articles posted on PubMed. Second, it helped them access the newest international guidelines on disease symptoms and on updated content presented at international conferences attended by WeChat Groups members with access to more financial resources. Third, in reviewing the guidelines on the platform, members would hold discussions about how, where, when, and under which conditions the guidelines can be applied in the clinical evaluations of symptoms for patient consultations and laboratory specimens. These 4 key mechanisms, described by and observed among clinicians and laboratory staff, delineate concrete ways in which using WeChat Groups helped them perform necessary health care procedures more effectively. In sum, health care professionals found this approach to be efficient because it helped in reducing the time from first consultation to diagnosis, checking for continued adherence to newly updated diagnostic and treatment guidelines, and obtaining second opinions from other doctors and health care professionals in their networks who logged more experience and continued medical education training via international conferences, national meetings, and overseas traineeships.

Collectively, clinicians, technicians, and researchers have limited access to the most up-to-date facilities and knowledge for their work. The difficulties include the need to train the hospital staff, provide analyses of biological specimens for diagnosis, and keep staff abreast of latest developments in trends and clinical procedures. Overall, medical professionals use WeChat Groups to access information and resources and support their staff's capacity to share resources across social networks. These functions, both offline and online, are becoming increasingly important in the transfer of technologies, skills, and knowledge from HIC into LMIC settings to support equitable global development and improve global health equity. In this vein, clinicians across several disciplines have identified novel ways to utilize WeChat Groups for training of students in multimodal curriculums [46-48]. The solution that organically arose is to use WeChat Groups to effectively pool resources and knowledge from social networks that map beyond the physical limitations of a hospital or single medical facility.

Limitations

This study demonstrates the pathways of information sharing engaged by medical professionals within and outside of China, but is limited in discerning the strength of these interactions.

During the study data collection, participants highlighted the locations and venues where their connections were first made, describing why trust was important for validating linkages, and relating how trust was established for other members in a given professional group established within WeChat Groups. In-person observations, interviews, and digital ethnographies were used to identify the differentiated roles that various members in a group performed. However, one of the limitations of this study is that follow-ups with individual participants were limited, hence information on why individual connections within a group were made is reliant on interview information collected during initial entry into the study. Observations of which individuals were tapped for various types of information, what kind of resources were used to obtain the information, or how the data shared in the online setting of social media transcended into improvements in medical transcription of patient records or offline patient care services are limited to WeChat Groups chat functions only. Further studies into the next steps of patient care could help improve knowledge of how medical professionals implement tailored services for patients across LMIC settings across geographic barriers.

Another limitation of the study is that there was minimal documentation, interview questions, and participant observations of the technological deficiencies in the functions of WeChat, or the impact of these technological issues on the dynamics of WeChat Groups. For example, in the wider literature, issues such as restrictions on the maximize size of a file upload may have imposed size limitations on information sharing for large files, such as videos clips of presentations. Another technological difficulty was that images and files that are not immediately downloaded and saved onto the hard drive of the smartphone or onto a synced-up account on a computer could be deemed “unavailable” after the regularly scheduled purge. At times, when certain websites or links could not go through due to censorship algorithms, WeChat Groups members would take screenshots of the websites or content, then share the screenshots as a series of photograph images. Overall, these technological deficiencies in WeChat and WeChat Groups had minimal impact, and were readily dealt with in the data collection process because WeChat users in China are accustomed to creative solutions in circumventing restrictions

[56]. As part of the digital ethnography data collection process, when technical issues arose on WeChat or within WeChat Groups, the impacted study participants were directly contacted on WeChat via text message or WeChat call on a 1-on-1 basis, by phone call or email, and alternative methods for sharing large files, for circumventing censorship algorithms, or for resharing the “unavailable” files again, and thus succeeding in completing data collection. Future research could delve into the technological deficiencies and the bottom-up work-arounds developed by health professionals to overcome restrictions in information sharing.

Conclusion

Implementation of new digital technologies in medicine is important in maintaining excellence and innovation in health care across low-, middle-, and high-income settings. Publicly available popular social media apps can help save time and reduce costly staff upskills training, offering an increasingly invaluable option for continuing medical education and eHealth around the world [13]. In the wake of the global pandemic caused by COVID-19, health professionals are increasingly turning to social media messaging apps to share life-saving diagnosis and treatment information across closed international borders [2]. This paper illuminates emergent, ethnographic, and qualitative methodologies to investigate the linkages, actors, and pathways in the sharing of information and resources across spatial differentials. Moreover, these results can help inform feasibility and scalability studies [13,18] by providing evidence-based development of appropriate metrics for future quantitative assessments and evaluations of social media implementation programs. Furthermore, this paper describes the socioeconomic and geospatial disparities experienced in LMICs, and the innovative, bottom-up approaches and concomitant pathways and mechanisms devised by medical professionals to overcome these barriers. These processes of information sharing and internal resource redistribution can improve health equity in international patient-centered care. This paper contributes to efforts in implementing transfers of technologies, knowledge, skills, and abilities to support equitable global development and global health equity in low-resource settings.

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Conflicts of Interest

None declared.

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Abbreviations

CDC: Centers for Disease Control and Prevention

GDPR: General Data Protection Regulation

HIC: high-income country

LMIC: low-and-middle-income country

mHealth: mobile health

SNS: social networking site

VPN: virtual private network

WHO: World Health Organization

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Original Paper

Assessing Medical Student Readiness to Navigate Language Barriers in Telehealth: Cross-sectional Survey Study

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Abstract

Background: The COVID-19 pandemic has greatly increased telehealth usage in the United States. Patients with limited English proficiency (LEP) face barriers to health care, which may be mitigated when providers work with professional interpreters. However, telehealth may exacerbate disparities if clinicians are not trained to work with interpreters in that setting. Although medical students are now involved in telehealth on an unprecedented scale, no educational innovations have been published that focus on digital care across language barriers.

Objective: The aim of this study is to investigate advanced medical students' confidence in caring for patients with LEP during telehealth encounters.

Methods: We administered a written survey to medical students on clinical clerkships at one US institution in August and September 2020. We assessed students' overall confidence in working with interpreters; confidence in performing 8 clinical tasks during in-person versus telehealth encounters; and frequency of performing 5 different clinical tasks with patients with LEP compared to English-speaking patients during in-person versus telehealth encounters. Wilcoxon signed-rank tests and chi-square tests were used to compare confidence and task performance frequency, respectively, for patients with LEP versus English-speaking patients during telehealth encounters. Students were also asked to identify barriers to care for patients with LEP. The free-response questions were qualitatively analyzed using open coding to identify key themes.

Results: Of 300 medical students surveyed, 121 responded. Furthermore, 72 students answered >50% of questions and were included in the analyses. Compared to caring for patients with LEP during in-person encounters, respondents were less confident in working with interpreters ($P<.001$), developing trust ($P<.001$), identifying agenda ($P=.005$), eliciting preferences for diabetes management ($P=.01$), and empowering patients in lifestyle modifications ($P=.04$) during telehealth encounters. During both in-person and telehealth encounters, approximately half of students (40%-78%) reported engaging less frequently in every clinical task with patients with LEP and this was as low as 22% (13/59) for some tasks. Students identified these key barriers to care for

patients with LEP: time pressure, interpretation quality and access, technical difficulties, cultural differences, and difficulty with rapport building.

Conclusions: Advanced medical students were significantly less confident caring for patients with LEP via telehealth than in person. Broader implementation of training around navigating language barriers is necessary for telehealth care, which has rapidly expanded in the United States. Our study identified potential key areas for curricular focus, including creating patient-centered agendas and management plans within the constraints of virtual settings. These developments must take place simultaneously with systems-level improvements in interpreter infrastructure to ensure high-quality care for linguistically diverse patients.

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KEYWORDS

interpreters; language barriers; medical students; medical education; limited English proficiency; telehealth; telemedicine; online education; clinician; health care professional

Introduction

In the last two years, we have seen a massive increase in telehealth use as hospitals and clinics work to minimize COVID-19 transmission [1]. In the United States alone, one study estimated that usage has increased by 8336% from pre-pandemic levels [2]. These changes, which will likely last beyond the pandemic [3], have the potential to broaden access to care and decrease health care costs; however, they may also widen existing disparities [4-6].

Decades of research have shown that patients with limited English proficiency (LEP), who comprise 8% of the US population [7], have poorer health outcomes compared with their English-speaking counterparts. These outcomes, ranging from hospital admission to medication-related adverse events [8], can be partially explained by worse access to care [9-11]. For telehealth, patients with LEP had lower rates of use than proficient English speakers even before the pandemic [12]. This gap has persisted throughout the pandemic-driven telehealth expansion [13,14]. Additionally, patients with LEP who do access care, even in traditional modalities, may continue to experience poorer outcomes unless seen by a language-concordant provider or a provider working with a professional interpreter [15-17], which is not always the case. In one national study, 40% of ambulatory physicians reported never working with professional interpreters for their patients with LEP [18].

Formal training around care for patients with LEP is associated with more frequently engaging with professional interpreters for residents [19] and improved skills during clinical simulations for medical students [20]. However, not all institutions provide training, and for those that do, the curricular content can vary widely from simulated patient cases to online videos [19,21]. Although schools are rapidly developing novel telehealth curricula to prepare their trainees for the changing health care landscape, to the authors' knowledge, no innovations have been published that focus on digital care across language barriers [22-25]. Further, students' baseline confidence and attitudes around virtual care for patients with LEP, which would help guide the development of such curricula, are unknown.

We set out to examine advanced medical students' confidence and attitudes toward caring for patients with LEP via telehealth

compared with their experiences caring for these patients in person.

Methods

Study Design and Participants

This was a cross-sectional survey study of medical students, using a modified version of a survey previously used to assess resident physicians' experiences working with patients with LEP during in-person interactions [26]. For the medical student survey, we added questions related to telehealth encounters and removed questions that were outside the scope of care provided by medical students. This survey ([Multimedia Appendix 1](#)) included questions about respondent characteristics (year in medical school, languages spoken other than English); clinical experience (time spent on clinical rotations at the time of survey, total number of in-person and telehealth encounters with patients with LEP); and any relevant training for caring for patients with LEP outside of the school curriculum. The current curriculum includes a 1-hour lecture on working with interpreters and a 3-hour simulated encounter involving a patient with LEP in which learners communicated with a standardized patient in Spanish or Chinese (Cantonese) by working with nationally certified health care interpreters.

Survey Administration

This version of the survey was pretested with 2 medical students prior to distribution. The target population of this cross-sectional survey study was third- and fourth-year clerkship medical students at a single US institution. From August to September 2020, we electronically distributed the survey (through Qualtrics) to students who had started clerkships. Our study team sent 4 reminders to encourage participation in the survey, which was voluntary for all students. Students were not required to answer all survey questions.

Primary Outcomes

The survey included questions on students' overall confidence in care of patients with LEP. To explore whether students' confidence would differ when performing clinical tasks of varied complexity, respondents rated their confidence in 8 different clinical tasks for an imagined Amharic-speaking versus English-speaking patient in a telehealth and in-person encounter. These 8 clinical tasks included identifying the patient's agenda, negotiating visit agenda, assessing medication adherence,

developing trust, understanding the patient's beliefs regarding diabetes mellitus (DM), eliciting patient preferences for DM management, empowering the patient in lifestyle modifications for DM, and incorporating patient preferences and goals in action planning. We asked students to rate their confidence working with a patient with LEP compared with an English-speaking patient using a 5-point Likert scale ranging from very confident to not at all confident. At the time of this study, medical student involvement in telehealth was still in its early stages, making objective assessment challenging; thus, we chose confidence as our outcome based on previous studies in this area and in medical education [26-32].

Secondary Outcomes

Respondents also compared how frequently they performed 5 different clinical tasks for patients with LEP compared with English-speaking patients during in-person and telehealth encounters. These tasks included performing teach-back, discussing social history details, determining beliefs regarding the management plan, making a personal connection, and asking about nonmedical interests. Students chose from a 5-point Likert scale (ranging from much less often to much more often with LEP patients).

To identify potential explanations for the quantitative findings, in 2 free-response questions, students were asked for their impressions of barriers to caring for patients with LEP in person and in telehealth settings.

Ethical Considerations

This protocol was approved by the Institutional Review Board of the University of California, San Francisco (#19-29759). All survey responses were completely anonymous. Respondents viewed and agreed with the informed consent statement before proceeding to the first page of survey questions.

Analysis

All statistical analyses were conducted using SPSS software (version 27; IBM Corp). For all tests, we defined significance as 2-sided $P < .05$.

For our primary outcomes, we used Wilcoxon signed-rank tests to compare students' overall confidence working with interpreters in telehealth versus in-person settings.

For our secondary outcome of task confidence, we used Wilcoxon signed-rank tests to compare confidence in each of

the 8 clinical tasks with patients with and without English proficiency in the telehealth setting, and confidence with care for patients with LEP between in-person and telehealth modalities. For our secondary outcome of relative frequency, we dichotomized the frequency of performing each of the 5 clinical tasks into performing the task less frequently with patients with LEP or equally/more frequently with patients with LEP. We used a chi-square test to compare the relative frequencies of students performing each clinical task during in-person encounters versus telehealth encounters.

We performed bivariate analysis using chi-square tests or Fisher exact tests to identify associations between the outcomes and students' languages spoken or number of total past encounters with patients with LEP.

To explore potential explanations for our quantitative findings, we summarized the emerging themes from written responses to the free-response questions about barriers to care for patients with LEP in telehealth settings. One author (LY) reviewed all the responses and coded the key barriers using a modified grounded theory methodology [33]; a second author (FN) reviewed the coding. Consensus was reached through discussion and any disagreement was adjudicated by a third author (ECK).

Results

Participant Characteristics

A total of 121/300 (40%) medical students responded to the survey. Only respondents who completed at least 50% of survey questions were included in the statistical analysis ($n=72$; response rate=24%). As not all 72 respondents answered every survey question, we report data using denominators that reflect those who responded to the specific questions analyzed. One respondent had submitted the survey twice. Only data from the survey where this respondent had completed more survey questions were included in the statistical analysis. Among the 72 respondents, 43% ($n=31$) attended the 3-hour standardized patient encounter approximately 8-9 months prior to completing the survey. Most respondents have had more than 15 in-person encounters with patients with LEP. Conversely, most respondents have had less than 5 telehealth encounters with patients with LEP. Respondent characteristics are provided in [Table 1](#).

Table 1. Characteristics of medical student respondents (N=72).

Characteristic	Participants, n (%)
Year in medical school^a	
Third year	25 (35)
Fourth year and above	46 (65)
Fluently speaks a non-English language	26 (36)
Number of encounters with patients with limited English proficiency	
In person	
≤5 encounters	2 (3)
6-15 encounters	19 (27)
>15 encounters	51 (71)
Telehealth	
≤5 encounters	57 (79)
6-15 encounters	14 (20)
>15 encounters	1 (1)

^aSample size (N=71; missing=1).

Primary Outcomes

Overall Confidence in Working With Interpreters

Among the 72 respondents, 61% (44/72) were either confident or very confident working with interpreters in person (Table 2).

In comparison, respondents were significantly less confident in working with interpreters in telehealth encounters; only 30% (21/72) of respondents were confident or very confident ($P<.001$).

Table 2. Respondents' confidence in working with interpreters in different clinical settings.

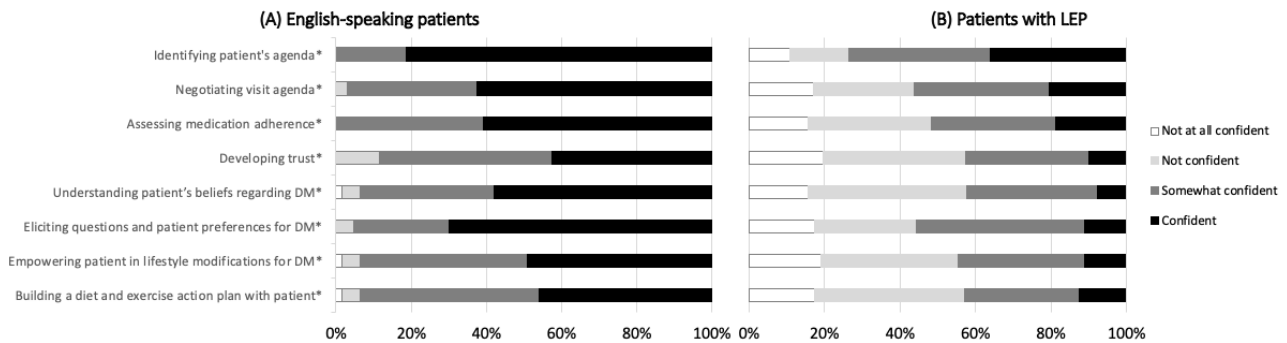
	In-person encounters (N=72), n (%)	Telehealth encounters (N=72), n (%)
Confidence levels		
Not at all confident	0 (0)	4 (6)
Not confident	3 (4)	8 (11)
Somewhat confident	21 (29)	31 (43)
Confident	29 (40)	15 (22)
Very confident	15 (21)	6 (8)

Confidence in Performing Patient-Centered Clinical Tasks

At least 40% of the 72 respondents reported confidence in performing each of the 8 tasks for an English-speaking patient during a hypothetical telehealth encounter (Figure 1; see Table S1 in Multimedia Appendix 2 for complete data). In the telehealth setting, respondents were significantly less confident

when performing each of the 8 clinical tasks with a patient with LEP than with an English-speaking patient ($P<.001$). Less than 20% of students reported confidence performing each of the 8 tasks with a patient with LEP, except identifying the patient's agenda (23/64, 36%). Respondents felt the least confident in developing trust (6/61, 10%) and understanding the patient's beliefs regarding DM (5/64, 8%) for the patient with LEP.

Figure 1. Confidence performing clinical tasks during telehealth encounters. Comparing medical students' self-reported confidence in performing 8 patient-centered tasks in the telehealth setting when working with patients with LEP versus English-speaking patients. Graphs show the percentage of respondents who were "confident" in performing each of the 8 tasks with either patient in the telehealth setting. Percentages reflect only those who rated their confidence in performing clinical tasks with both patients in the telehealth setting (N=61-64). * $P < .001$ (Wilcoxon signed-rank test, see Table S1 in Multimedia Appendix 2). DM: diabetes; LEP: limited English proficiency.

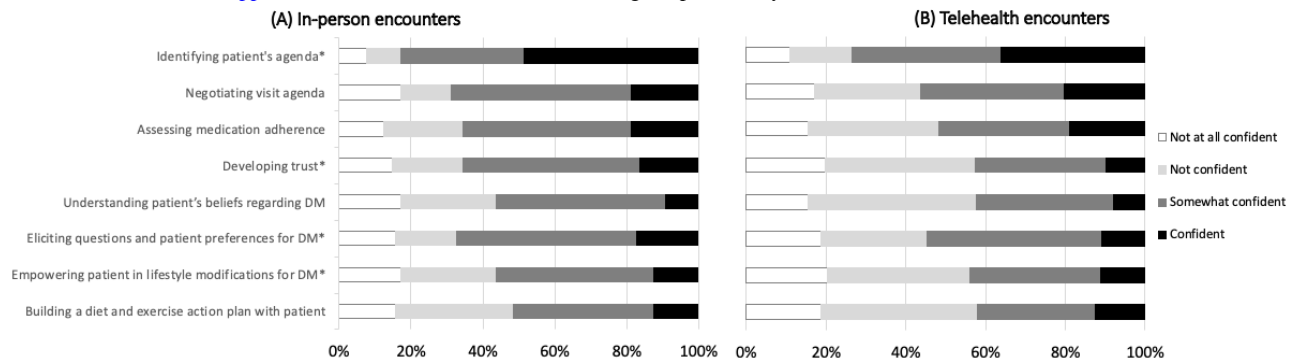


Patients With LEP in Telehealth Versus In-Person Settings

Across all 8 tasks, a greater proportion of respondents were not confident in working with patients with LEP in a telehealth encounter compared to an in-person encounter (Figure 2).

However, these differences were only significant for developing trust ($P < .001$), identifying the patient's agenda ($P = .005$), eliciting patient preferences for DM management ($P = .01$), and empowering the patient in lifestyle modifications for DM ($P = .04$; see Table S2 in Multimedia Appendix 2 for complete data).

Figure 2. Confidence performing clinical tasks when caring for patients with LEP by clinical setting. Comparing medical students' self-reported confidence in performing 8 patient-centered tasks during in-person versus telehealth encounters with patients with LEP. Percentages reflect only those who rated their confidence in performing clinical tasks in both settings with patients who have LEP (N=61-64). * $P < .05$ (Wilcoxon signed-rank test, see Table S2 in Multimedia Appendix 2). DM: diabetes; LEP: limited English proficiency.



Secondary Outcomes

Frequency of Performing Patient-Centered Clinical Tasks

For both in-person and telehealth encounters, more than 40% of respondents reported completing each of the 5 patient-centered clinical tasks less frequently with patients with LEP than with English-speaking patients (Table 3). Specifically, 78% (46/59) and 66% (39/59) of respondents reported asking

about patients' nonmedical interests less frequently when the patient had LEP during in-person and telehealth encounters, respectively. The distribution of relative frequencies for all 5 tasks did not differ by clinical setting ($P > .05$; see Table S3 in Multimedia Appendix 2 for the chi-square test results).

None of the primary or secondary outcomes discussed above were associated with languages spoken by the respondent or number of previous encounters with patients with LEP ($P > .05$).

Table 3. Medical students performing clinical tasks less frequently with patients with LEP compared to English-speaking patients.

Task	In-person encounters, n (%)	Telehealth encounters, n (%)
Perform teach-back	30 (52)	31 (53)
Make a personal connection	26 (44)	27 (46)
Determine beliefs about diagnosis and workup	24 (41)	24 (41)
Discuss details of social history	26 (44)	29 (49)
Asking about patients' nonmedical interests	46 (78)	39 (66)

Barriers to Working With Interpreters: Qualitative Results

A total of 54 of the 72 respondents (75%) answered the qualitative survey questions. All mentioned at least one barrier to in-person care for patients with LEP, including time pressure, interpreter quality and access, technical difficulties, cultural

differences, and difficulty with rapport building (Table 4). When asked how these barriers might differ for telehealth encounters, students reported barriers were the same or exacerbated, with specific concerns for the loss of nonverbal cues and physical exam data to inform clinical decision-making as additional barriers. In addition, 24% of respondents (13/54) said they have not had enough telehealth encounters to speak from experience.

Table 4. Barriers to care for patients with limited English proficiency.

Themes	Respondent quote
Time	
Subtheme 1: Additional time needed when working with an interpreter	
	“Using [working with] an interpreter inherent[ly] prolongs the length of an appointment, oftentimes by more than double what it would take with an English-speaking patient. As such, certain topics that are deemed less essential are often left out in discussions...”
Subtheme 2: Direct observation and technical difficulties add to sense of time pressure in telehealth visits	
	“Sometimes I feel like...on the televisit, the preceptor is watching impatiently (usually I have time in the room alone with the patient and interpreter and don't feel as rushed).”
Quality of interpretation	
	“I speak Spanish and Farsi though I am not certified, so I use [work with] an interpreter each time as required. I have found that occasionally, what I try to communicate is not interpreted as medically desired.”
	“In Spanish which I'm generally accustomed to the visits are quicker, I can understand the patient, I know how the interpreter will interpret...so there is less to wonder about. In other languages it can be harder to know that everyone is on the same page.”
Cultural differences not mitigated by language	
	“I was in the room with a provider and a Hindi speaking patient. The patient kept shaking head when provider spoke. In their culture, that means yes...But the provider thought it meant no, disagree and so got frustrated.”
Access to interpreters: unfamiliar protocols or limited resources	
	“There are some languages that it is impossible to get an interpreter for in the needed time frame.”
	“We have really struggled to get ASL interpreters for either in-person or telehealth encounters...Some [Deaf patients] have apparently been told to just bring their own interpreter with them.”
Technical difficulties: with audio, video connection, etc	
	“Some phone interpreters we cannot hear very well and limit the time for discussion.”
Building rapport	
Subtheme 1: Difficult when speaking through a third party	
	“I feel that the personal connection that I am able to build with patients is significantly impaired when I am using [working with] an interpreter despite the fact that I try to follow best practices...”
	“These barriers are similar but magnified [in telehealth] - it's even harder to assess patient understanding and ... form a bond/connection with the patient.”
Subtheme 2: Deprioritized due to time pressure	
	“When using [working with] an interpreter the consultation tends to take longer and our encounter, therefore, at times must be more focused and big-picture to make sure we are seeing all clinic patients in a timely manner. There is less time to go through all the details in just one encounter.”
Navigating own language skills	
	“...sometimes I have patients say that my Spanish is fine for them... I am just not as fluent as I'd like to be and I worry that patients are too polite to ask for an interpreter after we've already started the visit.”
Telehealth only: loss of nonverbal cues and objective data to support communication	
	“With telehealth encounters, you lose body language, eye contact, gestures between you and the patient...and the ability to use physical exam to add to your assessment (if I have less knowledge about their foot injury, I'm less confident communicating it to the patient...)”

Discussion

Principal Findings

Our study found that advanced medical students were significantly less confident caring for patients with LEP via telehealth than in-person settings. Moreover, students were significantly less confident developing trust, identifying an agenda, eliciting preferences for management, and empowering patients in lifestyle modifications when caring for patients with LEP virtually compared to in person.

Prior literature has shown that trainees feel less prepared to care for patients with LEP [34]; our findings demonstrate that, although telehealth is a more novel care modality, this gap persists in the virtual setting, and may even be greater, as indicated by the lower confidence reported by participants in this study. Compared with previous studies, however, a greater percentage of students in our sample were confident or very confident in working with interpreters in person [29]. This may reflect institutional differences in education or patient diversity, or a small sample biased toward participation from students interested in culturally and linguistically appropriate care.

A major strength of our study is the breakdown of confidence into specific clinical tasks based on gradation in the complexity of communication skills. Although students reported a lower overall confidence in providing telehealth to patients with LEP, our study provides insights on which specific aspects of the clinical encounter may be more difficult through telehealth. Specifically, tasks such as developing trust or identifying the patient's agenda and preferences for management may explain the lower confidence while more direct tasks such as assessing medication adherence may be less impacted by the telehealth modality. We found that the overall lower confidence students felt around telehealth care for patients with LEP may be accounted for by some tasks, but not others. According to students' qualitative responses, loss of nonverbal cues in telehealth is a major barrier; lack of ability to read and portray facial expressions, hand gestures, and other emotional signals may explain perceived challenges with developing trust. This loss is felt more acutely in phone encounters, which patients with LEP are more likely to receive [35]. For the more complex tasks that involve eliciting, processing, and applying information from patients with LEP (eg, eliciting preferences, empowering patients), variation in interpretation quality and time pressure may be barriers to confidence.

Limitations

This study is limited by the low response rate, small sample size, and single-institution survey, which may restrict a broader application of our findings. Additionally, like many other studies in the field, we have chosen to use a self-reported measure as

a proxy for true proficiency [26-29,34]. Although self-assessment is inconsistently correlated with competency [36], there is evidence that providers tend to overestimate their competence working with interpreters [37], suggesting that medical students may be even less prepared to care for patients with LEP than our results have shown. Finally, there may have been factors that we did not account for, such as length of relationship and familiarity with the interpreter, that may influence student confidence.

Future Directions and Conclusion

In summary, our study demonstrated that self-efficacy and confidence for working with interpreters in the in-person setting were not automatically transferred to the telehealth setting. Additionally, while effective curricula already exist for guiding learners toward best practices for in-person care for patients with LEP, it is unclear whether these curricula are consistently implemented [21]. This lack of education is a possible explanation for why patients with language barriers experience lower quality care [38]. Thus, to better serve our increasingly diversifying patient population, educators should work to adopt these proven curricula while simultaneously building intentional, skills-based sessions [39] that consider the unique challenges that patients with language barriers might face in telehealth encounters. For example, our study highlights several competencies where students may benefit from specific guidance, such as developing patient rapport and cocreating a management plan while working within the constraints of virtual settings. Although this study conducted during the early stages of the COVID-19-driven telehealth expansion used self-competency measures, we recommend that these future interventions be evaluated with knowledge assessments [20], clinical performance scales [40], and other objective tools so we can continue to identify and propagate truly effective curricula.

Finally, it is critical to recognize that provider education is necessary but not sufficient for bridging the gap experienced by linguistically diverse patients [41]. At the policy level, the Joint Commission or other regulatory agencies could develop minimum standards for interpreter quality, including a uniform certification process. Institutions such as universities and hospitals should recruit and support adequate numbers of interpreters as well as bilingual clinicians; this could include appropriate compensation as well as enforcement of universal language access policies across settings. Such steps are essential to ensure that patients with LEP truly receive the best quality of care.

As the COVID-19 pandemic introduces permanent changes to health care delivery, we must ensure that the next generation of providers is prepared to close, not widen, disparities for diverse patient populations.

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Authors' Contributions

LY, FN, ECK, MR, MW, SC, AF, and MEG had substantial contributions to the conception of the work. FN and LY led acquisition and interpretation of the data with guidance from AF and ECK. FN and LY drafted the work and MW, MR, SC, AF, MEG, and ECK revised it critically for important intellectual content.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Survey.

[[PDF File \(Adobe PDF File\), 376 KB - mededu_v8i3e36096_app1.pdf](#)]

Multimedia Appendix 2
Supplementary tables.

[[PDF File \(Adobe PDF File\), 129 KB - mededu_v8i3e36096_app2.pdf](#)]

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Abbreviations

DM: diabetes mellitus

LEP: limited English proficiency

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