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Review

How We Evaluate Postgraduate Medical E-Learning: Systematic Review

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Abstract

Background: Electronic learning (e-learning) in postgraduate medical education has seen a rapid evolution; however, we tend to evaluate it only on its primary outcome or learning aim, whereas its effectiveness also depends on its instructional design. We believe it is important to have an overview of all the methods currently used to evaluate e-learning design so that the preferred method may be identified and the next steps needed to continue to evaluate postgraduate medical e-learning may be outlined.

Objective: This study aimed to identify and compare the outcomes and methods used to evaluate postgraduate medical e-learning.

Methods: We performed a systematic literature review using the Web of Science, PubMed, Education Resources Information Center, and Cumulative Index of Nursing and Allied Health Literature databases. Studies that used postgraduates as participants and evaluated any form of e-learning were included. Studies without any evaluation outcome (eg, just a description of e-learning) were excluded.

Results: The initial search identified 5973 articles, of which we used 418 for our analysis. The types of studies were trials, prospective cohorts, case reports, and reviews. The primary outcomes of the included studies were knowledge, skills, and attitude. A total of 12 instruments were used to evaluate a specific primary outcome, such as laparoscopic skills or stress related to training. The secondary outcomes mainly evaluated satisfaction, motivation, efficiency, and usefulness. We found 13 e-learning design methods across 19 studies (4% 19/418). The methods evaluated usability, motivational characteristics, and the use of learning styles or were based on instructional design theories, such as Gagne's instructional design, the Heidelberg inventory, Kern's curriculum development steps, and a scale based on the cognitive load theory. Finally, 2 instruments attempted to evaluate several aspects of a design, based on the experience of creating e-learning.

Conclusions: Evaluating the effect of e-learning design is complicated. Given the diversity of e-learning methods, there are many ways to carry out such an evaluation, and probably, many ways to do so correctly. However, the current literature shows us that we have yet to reach any form of consensus about which indicators to evaluate. There is a great need for an evaluation tool that is properly constructed, validated, and tested. This could be a more homogeneous way to compare the effects of e-learning and for the authors of e-learning to continue to improve their product.

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KEYWORDS

distance education; learning; professional education

Introduction

Background

Electronic learning (e-learning) in postgraduate medical education has seen a rapid evolution [1,2]. Moreover, e-learning has become a central part of education, whether stand-alone, part of hybrid learning, or an essential element in the successful flipped classroom concept [3-5].

Although postgraduate medical e-learning (PGMeL) is becoming part of mainstream education, its effectiveness has been subject to debate. A Cochrane review from 2018 concludes that comparing e-learning with traditional learning seems to reveal little to no difference [6]. Yet, other studies show great benefits with regard to primary outcomes [7,8] or secondary aspects such as environmental impact [9].

A possible reason for this discrepancy can be the heterogeneity in instructional design and other elements of e-learning that are poorly evaluated [10]. PGMeL is frequently evaluated by means of a pre- and posttest of the primary learning aim (eg, new knowledge) [11]. However, every educational instrument has functionalities and elements that are used to optimize its effect. The elements required for a specific e-learning model are defined in the so-called *instructionaldesign*. These elements are also called *affordances* and have the purpose of maximizing the effect, effectiveness, and usefulness of an educational instrument [12]. Therefore, the affordance of an instrument is an action made possible by the availability of that tool (eg, interactive videos) [13]. Although several reviews of the effects of e-learning have been carried out, little has been written about the ways in which an e-learning's instructional design may be evaluated [6,14]. A valuable introduction to the design of e-learning was given by Ellaway and Masters, who provide certain guidelines but no method of evaluation [15]. We believe it is of great importance to have a better insight into the current PGMeL evaluation methods and which outcomes (primary or secondary) are used. The aim of this study was to provide an overview of the outcomes used to evaluate PGMeL and the evaluation methods of the models used. To do so, we first need to provide a working definition of e-learning for this review.

Electronic Learning Definitions

The definition of e-learning changed with the evolution of the internet, and most definitions fail to describe the subtleties and certain important aspects of e-learning. It does not simply consist of placing documents in an electronic format via the internet. It should encourage interaction, collaboration, and communication, often asynchronously [15]. For this literature review, we have chosen the following, slightly adapted, definition from the study by Sangra et al [16]:

> *E-learning is an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools for improving access to training, communication and interaction and that facilitates the adoption of new knowledge, skills and/or behaviour/attitude.*

Methods

Study Design

A systematic review was carried out to determine how PGMeL can be evaluated and which outcomes are used. Some studies compared e-learning with other learning methods in trials or cohorts, whereas others were conducted from case reports by authors who evaluated a newly used e-learning method alone. We followed all the steps laid out in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines because the risk of bias is not relevant in answering our question [17]; given that we are not looking at the results of the outcomes but, rather, at the content of the outcomes themselves, we did not evaluate the risk of bias.

Types of Studies and Participants

The types of studies included are trials, reviews, and other descriptive evaluation studies as well as all the studies that evaluated any form of e-learning, as defined above, that have postgraduate medical professionals as a target audience.

Study Eligibility

The inclusion criteria were as follows:

1. Any e-learning evaluation study (studies without any evaluation outcome were excluded)
2. Postgraduate target audience for the e-learning
3. Published in English
4. Published after the introduction of Web 1.0 (1994)

Type of Intervention and Outcomes

The type of intervention was any form of e-learning, as discussed in the introduction. Given that the purpose of this review was to overview the kinds of outcomes used, all outcomes were included. We differentiated between primary and secondary outcomes. A primary outcome was defined if the study described the outcome as a primary outcome, if a sample size was calculated based on that outcome, or when the authors defined the outcome in the research question. If it was not clear what the primary outcome was, all outcomes were used as primary outcomes.

Study Identification

The literature search was performed in November 2017, searching PubMed, Education Resources Information Center, Cumulative Index of Nursing and Allied Health Literature and Web of Science databases separately. The search string was quite extensive and used a combination of Medical Subject Headings terms and a combination of title and abstract keywords. The complete string may be found in Multimedia Appendix 1.

Study Selection

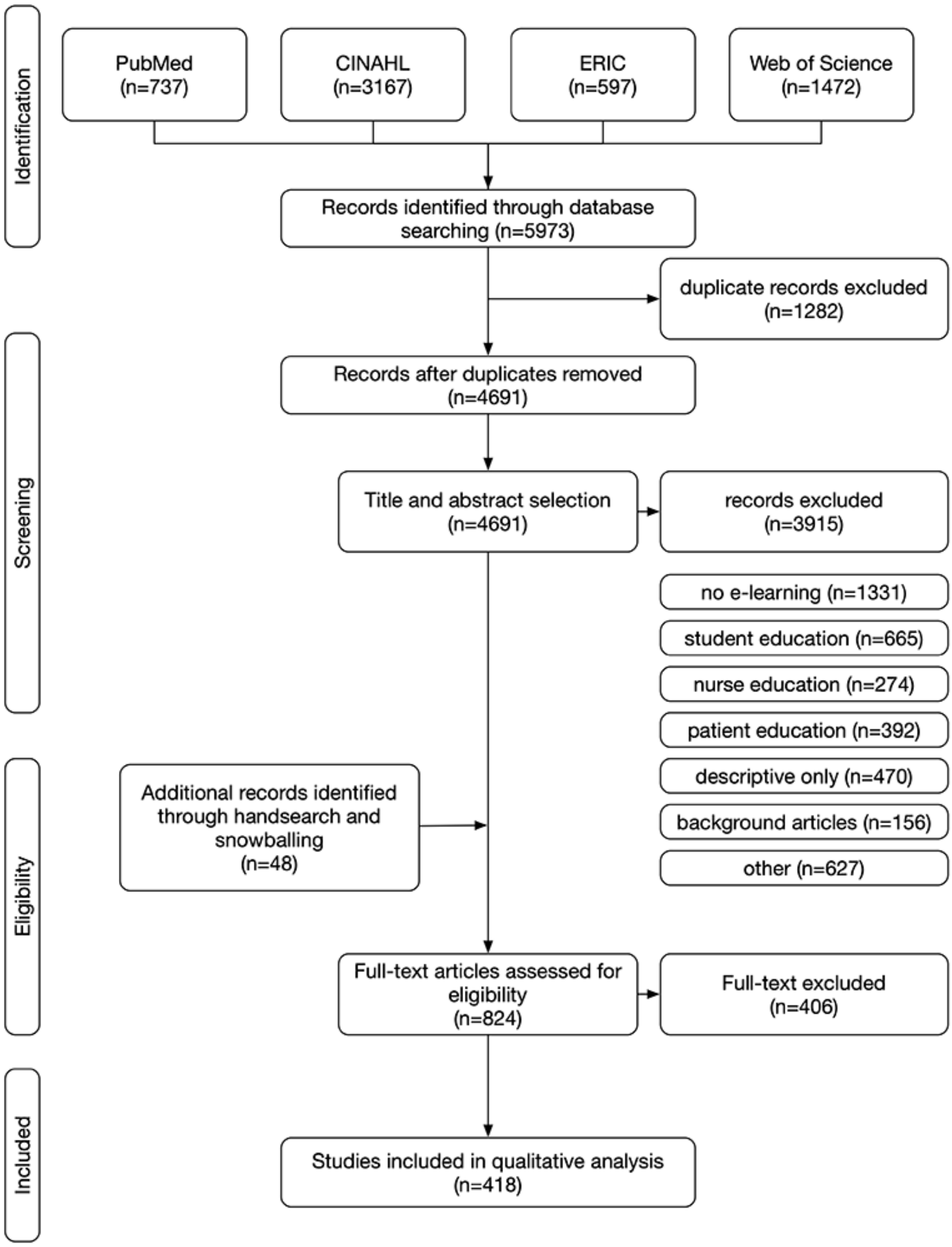
Working independently and in duplicate, reviewers (RDL, ADS, and SVH) screened all article titles and abstracts. Potentially eligible abstracts and abstracts with disagreement or insufficient information were screened in full text. Disagreements were handled by discussing the full text and the majority counts. The dataset supporting the conclusions of this study is available in the Postgraduate ME Model repository [18].

Results

Search Results

The initial search identified 5973 articles, of which 4691 were left after removing all duplicates. The titles and abstracts were read to determine the relevance, outcomes, and target audience. After handsearching and snowballing, 824 possible studies remained for review. After reading the full texts of these articles, we rejected 406 as not being targeted at the right audience or not evaluating the e-learning but only describing it. We used 418 final articles for our analysis, as shown in the flow diagram in Figure 1, which all evaluated an educational intervention that satisfied our definition of e-learning. For a list of all 418 studies, please refer to Multimedia Appendix 2.

Figure 1. Search and article selection process. e-learning: electronic learning; CINAHL: Cumulative Index of Nursing and Allied Health Literature; ERIC: Education Resources Information Center.



General Characteristics

The types of studies were trials (n=201), prospective cohorts (n=110), case reports (n=98), and reviews (n=9). We found a variation of e-learning methods and combined these into 4 categories: serious gaming (n=8), virtual reality (n=90), simulation (n=79), and theoretical knowledge–aimed e-learning (n=241). We added augmented reality into the virtual reality group (Figure 2). Most of the e-learning was created for general medicine (n=86), followed by surgery (n=84), internal medicine (n=59), pediatrics (n=32), gynecology (n=28), and family medicine (n=23; Figure 3). Studies were grouped under general medicine when they were multidisciplinary. A group of 16 studies had no specified target audience. Family medicine was grouped together with primary care.

Figure 2. Types of electronic learning (%). Knowledge refers to any acquaintance with facts, truths, or principles. Simulation refers to any form of digital imitation of enactment that is not virtual reality. Virtual reality refers to a simulation of a 3-dimensional environment, experienced or controlled by movement of the body. Serious gaming refers to a learning environment with gamification elements aimed at learning rather than entertainment. e-learning: electronic learning.

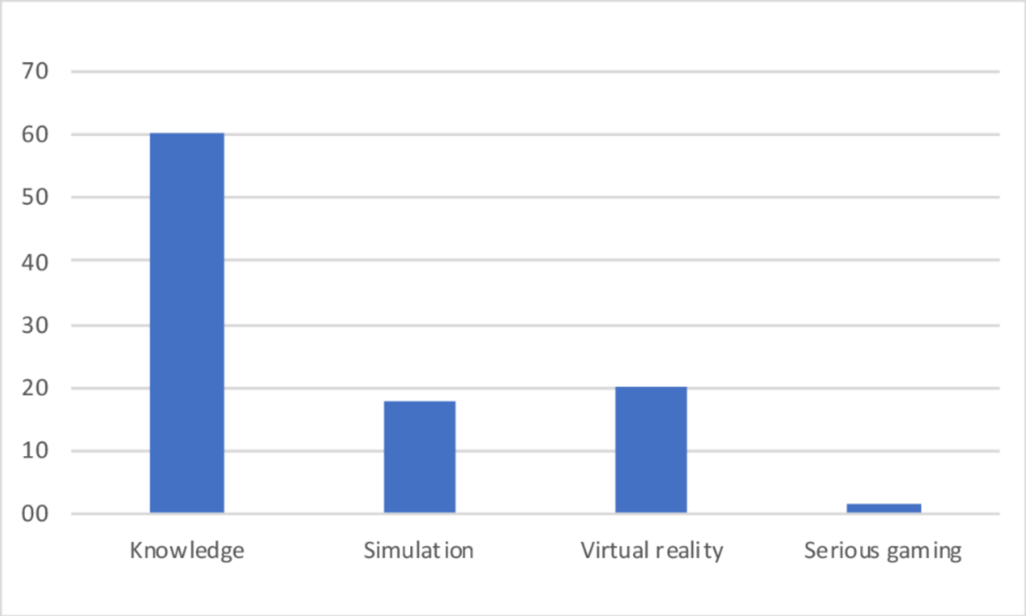
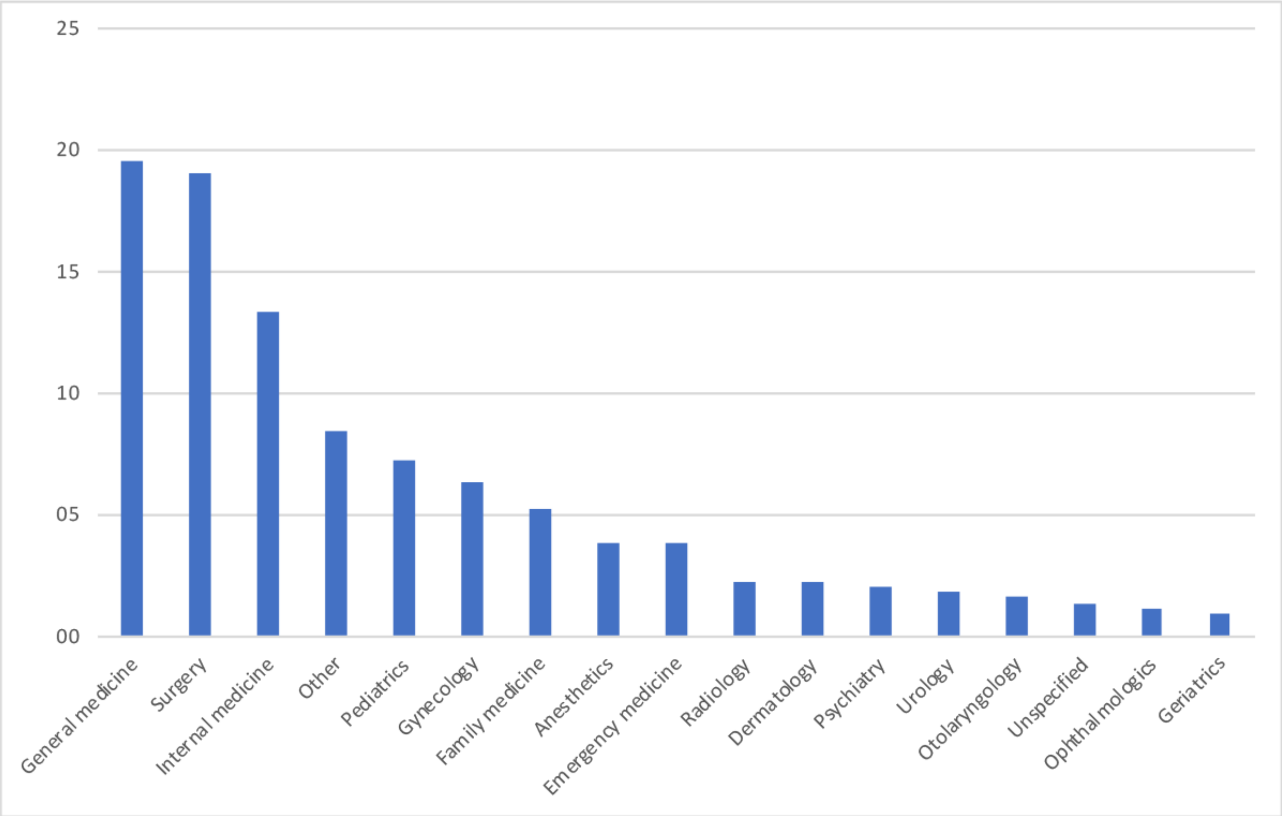


Figure 3. Electronic learning by medical subject (%).



Study Outcomes

The learning aims of the included studies were knowledge (n=286), skills (n=130), and attitude (n=2), which reflected the primary outcomes. Knowledge was tested by pre- and postcourse tests, and 12 instruments were used to evaluate an e-learning-specific primary outcome (see Table 1), such as laparoscopic skills or stress related to training.

The secondary outcomes of the studies were both more diverse and more focused on the design (see Table 2). The most prevalent evaluated outcomes were satisfaction (n=99), self-efficacy (n=60), adherence in practice (n=33), and time spent (n=32). Overall, 28 studies had some sort of qualitative evaluation, such as focus discussions or personal interviews. To prevent too diverse a series of outcomes, we grouped comparable outcomes together. Therefore, satisfaction can be measured by using a Likert scale but also by asking if someone would recommend the e-learning to other residents. Adherence in practice can be self-reported practice change or objective changes in practice, for example, subscription practice. We used the term *self-efficacy* for each form of self-assessed confidence, understanding, or comfort in clinical or theoretical settings.

A total of 5 studies used Kirkpatrick's levels of evaluation. These levels were more used as secondary outcomes of the learning aim than as a design evaluation method [29,33-36]. Kirkpatrick described a 4-level framework of evaluation for measuring the effectiveness of training or human performance technology programs originally aimed at corporate human resources [37]. The levels are reaction, learning, behavior, and results. Aitken et al evaluated their radiology e-learning material based on the first 2 levels, using the framework to build an evaluation questionnaire [34]. Sim et al focused on learning, behavior change, and impact on workplace by quantitative pre-, mid- and postmodule surveys; qualitative Wseb-based discussions; and short facilitator meetings [33]. In 2016, Bowe et al evaluated their e-learning program by means of the Kirkpatrick framework, but a narrative review provided them with the 3 other evaluation tools discussed below as well [29]. Finally, Patel et al undertook a review to establish the effectiveness of simulation in interventional radiology and evaluated which level of Kirkpatrick's hierarchy the studies reached, with only 1 reaching level 4. No proper validation of PGMeL has been carried out, and there are many concerns about the overgeneralization and misunderstandings that compromise its evaluation [38]. One study by Sears et al [39] used Robert and McDonald's revision of Kirkpatrick's levels, where the third and fourth levels fall into an overall *practice* domain and a new level, *value*, is added to better suit current technologies and continuing education approaches.

Electronic Learning Design Evaluation Methods and Theories

Overall, 19 studies (4%) used some form of tool to evaluate the e-learning design, and 13 tools were described in these studies. These 19 studies alone provided us with the methods and theories at which our initial research question was aimed.

Two instruments focused on usability, namely, the System Usability Scale (SUS) and the Software Usability Measurement Inventory (SUMI).

The System Usability Scale (n=5)

This is a 10-item questionnaire developed by Brooke that measures the usability of computer systems in 3 domains: effectiveness, efficiency, and satisfaction. It has been freely available since 1986 and has been cited in more than 1200 publications [40]. Davids et al used the SUS first to evaluate an e-learning resource for electrolyte and acid-base disorders [41] and again in 2014 to evaluate the effect of improving usability [42]. The SUS was also used by Gorrindo et al [43], Diehl et al [44], and Gillespie in 2017 [45].

Table 1. Discipline of skill-specific outcome measurement tools.

Name	Evaluation topic	Reference
Vandenberg and Kuse mental rotations test	Laparoscopic skills	Ahlborg [19]
Arthroscopic Surgery Skill Evaluation Tool	Arthroscopic skills	Waterman [20]
Stanford Microsurgery and Resident Training Scale	Microsurgery skills	Satterwhite [21]
Global Operative Assessment of Laparoscopic Skills	Laparoscopic skills	Rinewalt [22]
McGill Inanimate System for Training and Evaluation of Laparoscopic Skills	Laparoscopic skills	Martinez [23]
Objective Structured Assessment of Technical Skills	Laparoscopic skills	Tomaz [24]
Evaluating the attitude toward research tests	Attitude toward testing	Pelayo [25]
Survey of Attitudes toward Achieving Competency in Practice-Based Learning and Improvement and System-Based Practice	Managed care competencies and attitude	Yedidia [26]
Attitude, belief, and Behavior survey regarding domestic violence	Attitude to domestic violence	Harris [27]
State-Trait Anxiety Inventory	Stress	Samakar [28]
Mini-Mental State Exam	Stress	Tomaz [24]
Attitude Toward Health Care Teams Scale	Teamwork	Bowe [29] Leipzig [30]
Assessment of Care for the Vulnerable Elderly	Elderly care	Holmboe [31]
Cumulative sum analysis for colorectal histology	Histology	Patel [32]

Table 2. Secondary outcomes.

Outcome	Statistics, n (%)
Satisfaction	88 (19.9)
Self-efficacy	60 (13.6)
Adherence in practice	31 (7.0)
Long-term follow-up	28 (6.3)
Qualitative evaluation	28 (6.3)
Time spent	27 (6.1)
Skills	25 (5.7)
Attitude	20 (4.5)
Usefulness	16 (3.6)
Efficiency	8 (1.8)
Confidence	8 (1.8)
Usability	8 (1.8)
Acceptability	6 (1.4)
Preference	6 (1.4)
Costs	5 (1.1)
Presentation quality	5 (1.1)
Knowledge	4 (0.9)
Motivation	4 (0.9)
Stress	3 (0.7)
Patient satisfaction	2 (0.5)
Agreement	1 (0.2)
Discomfort	1 (0.2)
Overall reaction	1 (0.2)
Participation	1 (0.2)
Readiness to change	1 (0.2)
Screening percentage	1 (0.2)
Cognitive load	1 (0.2)

The Software Usability Measurement Inventory (n=1)

According to Deraniyagala et al, there are multiple approaches to measuring usability, but the gold standard is the SUMI because of its extensive validations and long track record of success in evaluation [46]. It consists of a 50-item questionnaire devised in accordance with psychometric practice and was inspired by the 1993 ISO 9241 definition by Kiralowski and Corbett [47].

A total of 3 instruments attempted to evaluate the motivational characteristics of the design.

The Motivated Strategies for Learning Questionnaire (n=1)

Ahlborg et al used a few items from the Motivated Strategies for Learning Questionnaire to evaluate self-efficacy [19] and Cook et al validated the entire questionnaire [48]. It consists of a self-reported, Likert scale instrument developed by Pintrich et al in 1993, which aims to assess the motivation and use of learning strategies by college students [49]. Cook et al concluded that the scores are reliable and offer meaningful outcomes for residents in a Web-based course.

Keller's Instructional Attention, Relevance, Confidence, and Satisfaction Motivation Model (n=2)

This proposes to assess the motivational characteristics of instructional materials or courses using an Attention, Relevance, Confidence, and Satisfaction (ARCS) model of motivation and was validated by Cook et al with 124 internal medicine residents [50]. Although the data were limited, they support the validity of the survey. Kawamura et al used the system as well to determine factors of motivation in serious gaming [51].

Instructional Materials Motivation Survey (n=1)

Cooke et al validated the Instructional Materials Motivation Survey (IMMS) to assess the motivational characteristics of a course [50]. The IMMS is an instrument developed by Keller using his ARCS model. The aim of the tool is to improve a course design generally or to adapt a course to an individual's needs.

The 2 scales focused on the use of learning styles as described in the following sections.

The Learning Style Index (n=2)

The Learning Style Index [52,53], developed in 1988 by Richard Felder and Linda Silverman, is designed to capture the most important learning style of engineering students, differentiated by 4 dimensions (active-reflective, visual-verbal, sensing-intuitive, and sequential-global) [54]. Cook et al evaluated whether the preferred learning style had any effect on a Web-based course and questions. Cognitive and learning styles had no apparent influence on learning outcomes [53].

Riding's Cognitive Style Analysis (n=1)

Riding's Cognitive Style Analysis (RCSA) determines whether an individual has a particular cognitive style or a preferred way of processing information [53]. The RCSA test measures the cognitive style on a verbal-imagery dimension and a holistic-analytic dimension [55].

A total of 4 tools were based on previous instructional design theories: Gagne's instructional design, the Heidelberg inventory, Kern's curriculum development steps, and a scale based on cognitive load theory.

Gagne's Events Instructions (n=1)

The instructional design by Gagne et al has been a classic in learning since 1974 and is a general, instructional design theory [56]. It has 9 parts, mirroring Gagne's idea of the cognitive stages associated with adult learning [57]. The model is used as a framework for designing any adult education instrument.

Heidelberg Inventory for the Evaluation of Teaching (n=1)

The Heidelberg Inventory for the Evaluation of Teaching [58] is a. standardized, psychometric questionnaire for the didactic quality assessment of the whole program. It consists of 13 domains and 42 items/questions and was developed to evaluate teaching methods for German undergraduate students [59].

Kern's 6-Step Curriculum Development for Medical Education (n=1)

This approach [60], described by Kern et al in 2009, aimed to create a planned educational experience with a logical, systematic approach [61].

Learner's Scale (n=1)

This series of scales [62] is composed of learner satisfaction, self-efficacy, mental effort, and time on task. The questions used for these scales are based on cognitive load principles and multimedia learning, which are based on the work by Clark and Mayer [63] and van Merrienboer [64].

Finally, 2 instruments attempted to evaluate several aspects of a design, based on the experience of creating e-learning.

The 10 Golden Rules for Software Design (n=2)

Created to help in designing software in medical education, this [36,65] starts with a 51-item questionnaire based on the Context, Input, Process, and Product model by Stufflebeam [66]; the Convenience, Relevance, Individualization, Self-assessment, Interest, Speculation, and Systematic criteria [67]; and Kirkpatrick's 4 levels of evaluation. The questionnaire was then piloted and used to evaluate an interactive distance education course in obstetrics and gynecology [36]. From the qualitative data, 10 common items were identified and represented in the form of *10 golden rules*.

Quality Improvement Knowledge Application Tool-Revised (n=1)

A revision of the original Quality Improvement Knowledge Application Tool, validated to assess practice-based learning and the system-based practice of residents, the Quality Improvement Knowledge Application Tool-Revised (QIKATR) [29,68] consists of 3 subjects—aim, measure, and change—and participants are asked to score the presented scenarios on these subjects.

Apart from these evaluation methods, we found 4 studies that did not evaluate e-learning but did use evaluation methods to create their e-learning. These used instruments to create e-learning with a focus on outcomes, motivation, and technology acceptance:

The Formative Process and Outcome Evaluation Tool by Dunet

Dunet et al [69] described the evaluation process by which they created a course—formative evaluation (content and design), process evaluation (knowledge gain, motivation, and usefulness), and outcome evaluation.

The Website Motivational Analysis Checklist

The authors reviewed an education database and did not find any validated tools. Therefore, they used the Website Motivational Analysis Checklist [70], which was originally created to assess service-based commercial websites in 2000 [71].

Davis's Technology Acceptance Model and Laurillard's Model of Interactive Dialogue

A realistic review by Wong et al [72] identified these 2 main theories as having a significant focus on perceived advantage, ease of use, interactivity, and feedback.

Finally, Rosen et al describe a statistical tool to apply to the study of teleoperation, human manipulation actions, and manufacturing applications (*Hidden Markov Model*), which they suggest might also be useful for other evaluation methods [73].

The abovementioned evaluation models all evaluate certain domains, a summary of which is presented in Tables 3 and 4 as an overview. In the final column, we have added the domains evaluated by de Leeuw et al in previous studies [74].

Table 3. Domains and methods for evaluating postgraduate medical electronic learning design (part 1).

Factor	Riding's Cognitive Style Analysis	Kern's six steps	Motivated Strategies For Learning Questionnaire	Software Usability Measurement Inventory	Dunet model	Website Motivational Analysis Checklist	Davis's model	de Leeuw quality indicators
Learning aims/objectives	—[a]	x[b]	x	—	x	x	x	x
Measurement of performance	—	x	x	—	x	—	—	x
Aim for change/transfer to the job	—	x	—	—	x	—	—	x
Satisfaction	—	—	—	x	x	—	—	x
Usability and control	—	—	—	x	x	x	x	x
Integration or recall of prior learning	—	x	x	—	x	—	—	x
Confidence	—	—	—	—	x	—	—	x
Suitability/usefulness/relevance/helpfulness	—	x	x	x	x	x	x	x
Attention	—	—	x	—	—	—	—	x
Sensing or intuitive learning	x	—	—	—	—	—	—	—
Visual or verbal learning	x	—	—	—	—	—	—	—
Active or reflective learning	x	—	—	—	—	—	—	—
Sequential or global learning	x	—	—	—	—	—	—	—
Content accountability	—	—	—	—	x	x	—	x
Multimedia use	—	x	—	—	x	x	—	x
Problem-based setting	—	—	x	—	—	—	—	x
Impetus for use/motivation	—	x	x	x	x	x	—	x
Costs	—	—	—	—	—	—	—	x
Feedback and interactivity	—	x	x	—	—	x	x	x
Challenge	—		x	—	—	x	—	x
Commitment and maintenance	—	x	x	—	—	—	—	x
Implementation	—	x	—	—	x	—	—	x
Rehearsal	—	—	x	—	—	—	—	x
Time management	—	—	x	—	x	—	—	x
Tasks	—	—	x	—	—	—	—	x
Efficiency	—	—	—	x	—	—	—	x
User expectation	—	—	—	—	—	—	x	—

[a]Factor present in the model.

[b]Factor not present in the model.

Table 4. Domains and methods for evaluating postgraduate medical electronic learning design (part 2).

Factor	Quality Improvement Knowledge Application Tool-Revised (model of improvement)	System Usability Scale	Instructional Materials Motivation Survey	Attention, Relevance, Confidence, and Satisfaction motivation model	Index of learning styles	10 golden rules	Gagne's events instructions	Heidelberg inventory for the evaluation of teaching
Learning aims/objectives	x[a]	—[b]	—	—	—	x	x	x
Measurement of performance	x	—	—	—	—	—	x	x
Aim for change/transfer to the job	x	x	—	—	—	—	x	x
Satisfaction	—	x	x	x	—	x	—	x
Usability and control	—	x	—	—	—	x	—	x
Integration or recall of prior learning	—	x	—	—	—	—	x	x
Confidence	—	x	x	x	—	—	—	—
Suitability/usefulness/relevance/helpfulness	—	x	x	x	—	x	x	x
Attention	—	—	—	x	—	x	x	—
Sensing or intuitive learning	—	—	—	—	x	—	x	—
Visual or verbal learning	—	—	—	—	x	x	x	—
Active or reflective learning	—	—	—	—	x	—	x	—
Sequential or global learning	—	—	—	—	x	—	x	—
Content accountability	—	—	—	—	—	x	x	x
Multimedia use	—	—	—	—	—	x	x	x
Problem-based setting	—	—	—	—	—	x	x	—
Impetus for use/motivation	—	—	—	—	—	x	—	x
Costs	—	—	—	—	—	x	x	—
Feedback and interactivity	—	—	—	—	—	—	x	x
Challenge	—	—	—	—	—	—	—	x
Commitment and maintenance	—	—	—	—	—	—	—	x
Implementation	—	—	—	—	—	—	—	—
Rehearsal	—	—	—	—	—	—	—	—
Time management	—	—	—	—	—	—	—	—
Tasks	—	—	—	—	—	—	—	—
Efficiency	—	—	—	—	—	—	—	—
User expectation	—	—	—	—	—	—	—	—

[a]Factor present in the model.

[b]Factor not present in the model.

Discussion

Principal Findings

There are many ways to evaluate PGMeL, and evaluation is clearly focused on the outcomes of the intervention. We found 14 e-learning-specific and 3 general primary outcomes, 27 secondary outcomes, and 13 evaluations tools. More than half of the studies (60%) had knowledge gain as their primary aim, which is almost the same finding as that in the 2016 review by Taveira-Gomes et al [2], who looked at all kinds of education. We are looking at PGMeL only and found that 38% were simulation and virtual reality studies. This kind of e-learning was not mentioned specifically in the study by Taveira-Gomes et al but might be comparable with the skills outcome (14.6%). The difference could be the result of postgraduates' need to undertake more task- and real-life-related e-learning, as described in our focus groups [74]. The experts from that study emphasized real-world translation as an important factor for PGMeL. Looking at the outcomes of the studies, Seagull identified similar domains in surgical simulation studies [75]. Self-efficacy, satisfaction, relevance/adherence in practice, and attitude are frequently used as outcomes of e-learning in both our study and that by Seagull et al. Table 1 shows a list of methods used to evaluate an outcome, which may be laparoscopic skills, attitude, or stress. They focus on the defined outcome rather than the method used to achieve it. Many other instruments are available (such as the critical thinking index [76]), but they are either not yet used in a PGMeL e-learning evaluation setting or were not revealed by our search.

Our research question asked which evaluation methods are used. As mentioned above, only 4% used a method, and of those methods, we can differentiate between theories and instruments.

Of the theories, Kirkpatrick's hierarchy is the most used to evaluate or create e-learning. A 2017 review by Patel et al evaluated the effectiveness of simulation in interventional radiology training [35]. It also found different studies using the levels of Kirkpatrick's hierarchy to establish or evaluate the success of the e-learning. Of the educational instructional theories, 2 are leading in e-learning in general and were also found in our studies: Gagne's principles of instructional design and Mayers and Clark's e-learning and the science of instruction, also referred to as *Mayers' multimedia learning*. Mayers and Clark base their instructions on the cognitive load theory, which provides design guidelines based on a model of human cognitive architecture. Cook et al validated a cognitive load index in 2017 [77]. The last theory from our search is from Kern's curriculum development for medical education: a 6-step approach. All these theories are either based on education in general (eg, the work of Gagne and Mayer) or medical education (eg, the work of Kirkpatrick and Kern), but none of the theories are aimed at PGMeL. They are used to evaluate PGMeL but not specifically aimed at this audience. The Heidelberg inventory for the evaluation of teaching is even aimed at undergraduate students and only used because of the lack of a better alternative [59].

Apart from these theories, some instruments focused on 1 aspect of the design. Although these instruments have a specific focus, Table 1 shows that they cover a wider range of domains. Instruments that aim to evaluate the course as a whole are QIKATR, 10 golden rules, and Dunet's formative process and outcome evaluation tool. The QIKATR is an answer to the Accreditation Council for Graduate Medical Education, which required practice-based learning and improvement. It is a description of 3 scenarios depicting quality problems. Although the domains are not very specific (describe the aim, measure the effect, and require change), they are aimed at postgraduates and provide a good basis for any education. Conversely, they are not aimed at e-learning education [68]. In 2002, Jha et al created an e-learning model for gynecology called the Distance Interactive Learning in Obstetrics and Gynaecology. They then evaluated the e-learning, and the lessons learned were described as 10 golden rules [65]. These golden rules are aimed at postgraduates and are specific to e-learning. The most significant downside of these rules is that they are based on 1 e-learning experience only; therefore, they may be incomplete or biased by the single case that created the fundament. Finally, Dunet's formative process and outcome evaluation tool is the result of an evaluation plan based on the experience of creating a hemochromatosis training course for continuing education credits and continuing nurse education. The course has been intensively evaluated by several experts, and the key findings can be summarized in 2 domains: instructional design and content, and usability and navigation. Although aimed at postgraduate education and specific to e-learning, it is based on 1 course only and might, therefore, lack important domains and items that were not available in that course.

As demonstrated in Tables 3 and 4, Gagne's science of instruction covers most of the domains. Our search did not identify any e-learning evaluation methods that are not expert opinion–based or the result of a single evaluation and aimed at PGMeL. A previous study by our group identified all these domains in literature [78], then evaluated their relevance with the focus groups [74] and an international Delphi [79]. The domains are added in the last column of Tables 3 and 4, which illustrates that all domains, except learning styles, are identified as important in these studies. The learning styles were identified in the review, but the effect of learning style–specific education is disappointing [53]. The conclusion was that it was better not to evaluate the learning style but to offer a diversity in each e-learning [74].

Strengths and Limitations

We believe that the biggest limitation is our search. Had we included papers not aimed at postgraduate education, we would have found many more papers and evaluation models. We could also have included papers that did not actually evaluate a course but only described a theoretical model. However, our research question asked not what is available but what is actually used. We also believed in differentiating between graduate and postgraduate education, hence the choice in our search. However, we also believe that making this distinction is a strength. This paper provides an insight into the diversity of evaluating e-learning and how little is known of and targeted at the right audience. Almost all quality models signify the importance of knowing your target audience but our evaluation tools do not.

Conclusions

It may be asked what comes next. We have reached the point at which we should stop evaluating only the outcomes of e-learning as an educational intervention and start evaluating the e-learning design that goes with it. However, to do so, we need a validated instrument to help us assess the nuances of all the different electronic education instruments. We believe that our previous studies have provided us with validated content for such a tool [74,79] and that this paper emphasizes the need for such a system.

PGMeL is evaluated in very diverse ways, almost exclusively based on its outcomes or learning aims. Although there is a need to evaluate the e-learning itself as well, we lack the instruments to do so. This paper provides an overview of available instruments; however, they are not aimed at postgraduate medical education, not expert opinion–based, or the result of lessons learned from a single case study. With the increasing ease of creating and distributing e-learning, the need for a content-validated evaluation tool is of ever greater importance.

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Authors' Contributions

All authors participated in the study design and manuscript revisions. RDL performed the search with help from Hans Ket (see Acknowledgments). RDL, ADS, and SVH reviewed the search results. RDL, KW, and FS drafted the first version of the manuscript, added background data, and participated in the interpretation of the results. MW, ADS, and SVH revised the manuscript accordingly. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Search string in detail.

[PDF File (Adobe PDF File), 261KB - mededu_v5i1e13128_app1.pdf]

Multimedia Appendix 2

Search results (sorted by year).

[PDF File (Adobe PDF File), 270KB - mededu_v5i1e13128_app2.pdf]

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Abbreviations

ARCS: Attention, Relevance, Confidence, and Satisfaction
e-learning: electronic learning
IMMS: Instructional Materials Motivation Survey
PGMeL: postgraduate medical e-learning
QIKATR: Quality Improvement Knowledge Application Tool-Revised
SUMI: Software Usability Measurement Inventory
SUS: System Usability Scale

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Viewpoint

Not Just a Medical Student: Delivering Medical Education Through a Short Video Series on Social Media

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Abstract

"Not Just a Medical Student" is an innovative bite-size medical education video series founded and hosted on social media. Its primary aim is to inspire tomorrow's doctors to be creative while engaging and informing them with the latest innovations, technology, and conferences within various specialties. To our knowledge, these themes are scarcely covered in the structured medical curriculum. Created and launched in August 2017, "Not Just a Medical Student" quickly gained traction; with over 1000 followers on Facebook and a rapidly increasing number of views, it reached the medical community across the globe. The video series features a trailblazer in virtual reality surgery and its potential impact on the evolution of medical education, reviewing future medical technology apps, such as Touch Surgery, and reporting on the latest medical education and health apps. The series engaged in topical medico-politics at the British Medical Association House and reported on global health issues and innovations at the Royal Society of Medicine Conference. The video series has further received several national awards including the *Association and Study of Medical Education (ASME) Educator Innovator 2017* award, runner up to the *Zeshan Qureshi Outstanding Contribution to Medical Education Award*, and the *Alternative Docs National Social Media Influencer* award. The concept has been presented at international conferences (eg, the Healthcare Leadership Academy conference) and gained international recognition upon personal invitation at the Norwegian Annual Junior Doctors Conference. With the rise of the social media generation, innovative methods to inspire, engage, and inform students contributing to the continuous evolution of medical education should be encouraged and further explored.

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KEYWORDS

social media; medical student; medical education; innovation; videos; Facebook

Introduction

From our experience, themes on medical innovation and entrepreneurship are rarely covered in the current saturated medical curriculum. To inspire tomorrow's doctors to be creative and entrepreneurial, there is a need to engage them with the current leaders in the medical profession and the latest technological innovations. For example, the relevance and benefits of leadership and management skills for doctors to enhance patient outcomes, have, in recent years, become more apparent [1]. Many reports, frameworks, and organizations have been created to increase efforts to evolve medical education to reflect such need [2,3]. However, changing the currently saturated medical curriculum to accommodate additions remains challenging [4].

With the rise of the "social media generation," social media platforms have become an integral part of communication for medical students across the world. Online platforms provide an innovative avenue to educate medical students about current developments and research within the medical profession. There has been a growing trend on the use of social media to aid education, be it through Twitter, Instagram, Facebook, or LinkedIn [5-7]. The integration of medical education into social media can enhance the student experience by taking advantage of a platform to aid educators to connect, debate, inform on topics, and distribute educational materials in an instant. Without limitations of location or time, virtual communities are formed. Social media is an equal playing field for any student to contribute to with ease of accessibility.

The learning experience of videos for medical education on platforms such as YouTube in the literature has previously been published [8,9]. A study on 1083 Australian medical students showed that the vast majority (92%) use online teaching videos to supplement their learning [10]. The use of videos is now becoming a mainstay of medical education. Therefore, we questioned how we can use videos and social media to bridge the gap with topics currently not covered in the core medical curriculum.

Prior Work

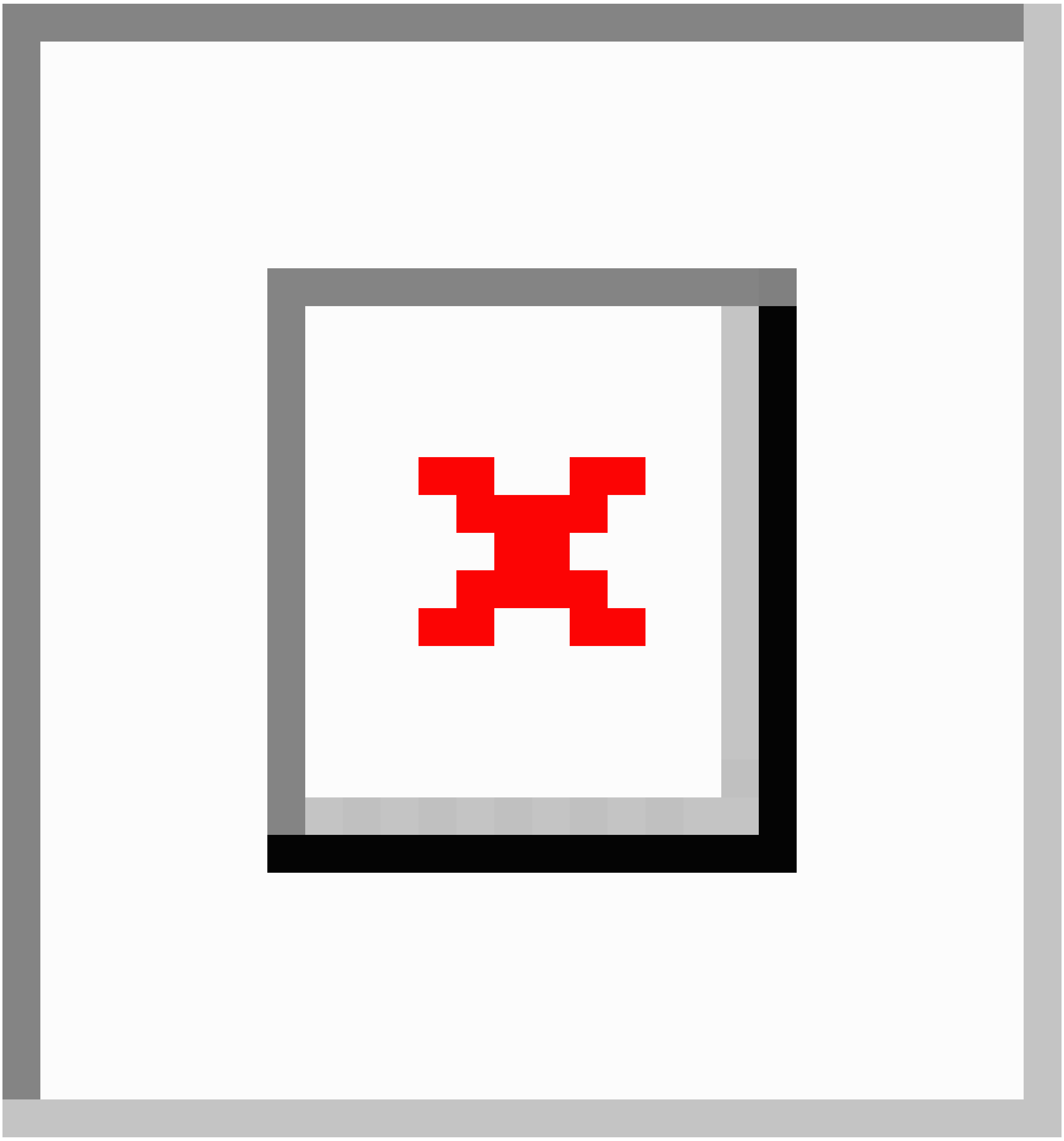
“Not Just a Medical Student” is a multi-award winning, innovative, bite-size medical education video series that was created and launched by a medical student in August 2017 on Facebook (Figure 1) [11]. It seeks to inspire, engage, and inform tomorrow’s doctors with high-quality videos about the latest developments in medicine and surgery in order to combat the lack of exposure found in the core medical curriculum. It aimed to use an established platform to be able to enhance the learning experience and collaboration for students. On inception, it gained traction quickly with over 1000 followers on Facebook, reaching medical students worldwide. To our knowledge, such a concept was never tried before.

“Not Just a Medical Student” aims to replicate short-length videos generally found on social media. These videos were recorded in several different locations including the British Medical Association offices and the Royal Society of Medicine. The video series featured esteemed physicians, surgeons, entrepreneurs including Professor Shafi Ahmed, a trailblazer in virtual reality surgery, and Touch Surgery [12], which is an app that allows a user to practice surgical procedures. The videos discussed and debated a range of topical subjects from global health issues to gender equality in medicine. It finally also leaves the viewers with an engaging take-away message for students.

The process of creating these videos consisted of gaining prior consent from the establishment or individual featured to film the videos. Once filmed, the videos were edited by an experienced video editor. Scripts were written to aid the video narrations. The final video was then sent for approval before it was published online.

These video series have also featured medical students from universities across the United Kingdom, thus building a strong nationwide network of students interested in medical education and innovation.

Figure 1. "Not Just a Medical Student" design.



Videos

Below, we present examples of the videos released on Facebook:

- "How to learn surgery on a train" - Exploring learning surgery from a mobile app (4700 views)
- "An end to boring hospital placements?" - Exploring innovations by the current generation of students and junior doctors from King's College London (5100 views)
- "Why is this still happening in the 21st Century?" - Reporting on maternal deaths across the globe and the latest technology set to make a difference (2400 views)
- A personal account and tips on how to publish, from a medical student who managed to obtain 16 publications throughout medical school (2700 views)
- "Will Virtual Reality forever change medical education?"- (3000 views; Figure 2)
- "An increase in medical school places: A detriment to current students?" - Informing and discussing the latest medico-politics currently affecting students (8500 views)
- "From Medical Student to President of The Royal College of Psychiatrists" - An interview with The President, Wendy Burn, on her journey as a medical student, with her take on leadership, resilience, and the future of medical education (3500 views).

Figure 2. Snapshot of Professor Shafi Ahmed's virtual reality surgery video.

Survey Feedback

We constantly receive comments on how these videos have inspired students to undertake their own projects, and therefore, we created an online survey to anonymously collect responses from viewers as feedback. Respondents of our online feedback survey consisted of medical students as well as nurses, nursing student, doctors, and medical education academics. Our survey showed that all 27 respondents felt that the "Not Just a Medical Student" videos achieved their aims to inspire, engage, and inform medical students. Of the 27 respondents, 24 felt that within the core medical curriculum, there was a gap in the teaching of topics such as medical technology, leadership, and global health. All respondents believed that videos were an effective tool for teaching, and the vast majority (26/27) agreed that social media could be an effective teaching tool. One respondent disagreed and stated that social media was not "sufficiently controlled environment for teaching." Of the themes explored on "Not Just a Medical Student," leadership-themed videos were ranked the most beneficial. The vast majority of respondents (26/27) agreed that the topics covered in the videos were relevant to their interests. Our survey and online engagement highlighted an obvious need and appetite for inspiration amongst students via innovative methods found outside of the medical curriculum.

Recognition

The concept of "Not Just a Medical Student" has won the prestigious *Association and Study of Medical Education (ASME) Innovator Award 2017* [13] and the *Social Media Influencer Award* at the Alternative Docs Conference 2017 for the video series. Additionally, it won runner up for the *Zeshan Qureshi Outstanding Contribution to Medical Education Award*.

International recognition was achieved through personal invitation to present and host a workshop on "Not Just a Medical Student" at the Norwegian Annual Junior Doctors Conference—Yngre legers forening. The video series was orally presented at the ASME Annual Conference 2018 and received high praise. It was also accepted for oral presentation at the Healthcare Leadership Academy Conference 2017 [3].

Lessons Learned

Creating an ongoing video series on a social media platform has been a new and exciting experience. We realized that for videos, many factors contribute to gaining traction on a platform, such as the number of likes, clicks, shares, and comments. Therefore, the initial period required persistent effort to have our colleagues and peers spread the videos.

Releasing videos on a regular basis and maintaining the high-impact quality of videos requires multiple skilled videographers. Therefore, balancing a medical degree with videography required effective time-management skills.

Despite the advantages of social media previously expressed, the current absence of universally agreed metrics to measure medical education outcomes on social media contributes to the lack of research in the field. At present, publishing on a social media platform does not offer the option of peer review, but as methods of publishing change, traditional publishers will need to embrace this change.

Conclusions

Innovative methods to inspire, engage, and inform students contributing to the evolution of medical education should be encouraged. Social media platforms are not without their flaws.

However, their unique properties allow new innovative teaching-learning experiences to thrive.

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Authors' Contributions

NA was involved in the conception, design, and drafting of the manuscript. UO was involved in the conception and editing of the manuscript. Both authors approved the final manuscript.

Conflicts of Interest

NA is the founder of the video series "Not Just a Medical Student."

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Abbreviations

ASME: Association and Study of Medical Education

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Original Paper

Health Care Providers' Profiles and Evaluations of a Statewide Online Education Program for Dissemination of Clinical Evidence on HIV, Hepatitis C Virus, and Sexually Transmitted Disease: Cross-Sectional Study

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Abstract

Background: Timely and effective dissemination of the latest clinical evidence to health care providers is essential for translating biomedical research into routine patient care. Online platforms offer unique opportunities for dissemination of medical knowledge.

Objective: In this study, we report the profiles of health care providers participating in the New York State HIV-HCV-STD Clinical Education Initiative online program and their evaluations of the online continuing professional development courses.

Methods: We compiled professional and personal background information of the clinicians who completed at least one online course. We collected their self-reported program evaluation data with regard to the course content, format, knowledge increase, and impact on clinical practice.

Results: We recorded a total of 4363 completions of 88 online courses by 1976 unique clinicians during a 12-month study period. The clinicians' background was diverse in terms of demographics, education levels, professional disciplines, practice years, employment settings, caseloads, and clinical services. The evaluation of online courses was very positive (*usefulness/relevance*, 91.08%; *easy comprehension*, 89.09%; *knowledgeable trainer*, 92.00%; *appropriate format*, 84.35%; *knowledge increase*, 48.52%; *intention to use knowledge*, 85.26%; and *plan to change practice*, 21.98%). Comparison with the reference data indicated that the online program successfully reached out to the primary care communities. Both the younger generation and the senior health care providers were attracted to the online program. High-quality multimedia resources, flexibility of access, ease of use, and provision of continuing professional development credits contributed to the initial success of this online clinical education program.

Conclusions: We have successfully characterized a diverse group of clinicians participating in a statewide online continuing professional development program. The evaluation has shown effective use of online resources to disseminate clinical evidence on HIV, hepatitis C virus, and sexually transmitted disease to primary care clinicians.

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KEYWORDS

information dissemination; online systems; continuing education; HIV; hepatitis C; sexually transmitted diseases; multimedia

Introduction

Background

Timely and effective dissemination of the latest clinical evidence to health care providers is essential for translating biomedical research into routine patient care [1]. Dissemination and implementation science has become a priority of the national health research agenda in the United States [2] and been advocated by researchers in other countries [3-5]. With the development of information and communication technologies, online platforms offer unique opportunities for medical knowledge dissemination, owing to advantages such as wide availability, rapid outreach, flexibility in resource access and use, and cost efficiency [6-8].

Since 2008, the New York State Clinical Education Initiative (CEI) program has developed hundreds of multimedia learning modules, online continuing medical education (CME) and continuing nursing education (CNE) courses, interactive case simulation tools, and other online resources [9-10]. These resources have been disseminated to tens of thousands of health care providers from more than 170 countries [11-12]. In this study, we report the profiles of health care providers participating in the CEI online education program and their evaluations of the online CME/CNE courses. As part of a larger initiative for dissemination of clinical evidence through integrated technologies, the data presented here provide important information about the participating clinicians as well as their assessment of the content, format, effectiveness, and impact of a specific category of online resources. The results from this study will guide future research on targeting interprofessional audiences and specific approaches of online resource development for more effective knowledge dissemination.

Dissemination of Clinical Evidence Through Information Technology

Previous research found that the traditional methods for dissemination of clinical evidence to health care providers were mostly ineffective [13]. Limitations of traditional approaches included difficulty in outreaching to geographically remote areas [7], concerns from health care providers regarding the inflexibility of access and the associated costs [8], and variations in fidelity for information delivery [14].

Early initiatives to use information technology for dissemination research generated mixed results [15,16]. With the wide use and acceptance of the internet and digital media, studies in recent years showed more effective application of online platforms for dissemination of medical knowledge to clinicians, including improvement in usefulness of information, satisfaction to format and learning environment, increase of knowledge and skills, and intention to use knowledge in practice [17-20]. Many of these dissemination initiatives had associated continuing professional development credits, which proved an important incentive to health care providers [21]. However, most of the reported findings were from pilot studies with a small sample of participating clinicians (typically in a single health profession), involving only one or a few clinical topics and a limited number of learning modules. Few studies assessed the profiles of the participating clinicians. Here we report a study of a large-scale, statewide online clinical education program for a variety of health care professionals on a comprehensive set of clinical topics related to HIV, hepatitis C virus (HCV), and other sexually transmitted diseases (STDs). Our study focused on the personal and professional profiles of the participating clinicians and their assessment of the online CEI CME/CNE courses from the perspectives of content, format, knowledge increase, and impact on clinical practice.

Clinical Research in HIV, Viral Hepatitis C, and Other Sexually Transmitted Diseases

The HIV pandemic has been a serious threat to global public health for decades. According to the Joint United Nations Programme on HIV/AIDS, there were 1.8 million new diagnoses, 1 million deaths, and 36.7 million people living with HIV worldwide in 2016 [22]. In the United States, the Centers for Disease Control and Prevention (CDC) estimated that 1.1 million people were living with HIV and 39,782 individuals were newly diagnosed in 2015 [23]. Although we have made significant progress in treatment and prevention after decades' fight against HIV [24-25], the scale and severity of the problem are still daunting.

In recent years, HCV also has increasingly become a major concern of public health. CDC estimated 33,900 acute HCV cases in 2015 and 3.5 million people with chronic HCV in the United States [26]. HIV and HCV co-infection is frequently seen, as are co-infections of HIV and other STDs [27-28]. The total medical costs associated with the diagnosis, treatment, and prevention of STDs were estimated to be US $16 billion per annum [29].

HIV research has advanced very rapidly since the 1990s, with many completed and ongoing clinical trials on treatment, prevention, and behavioral intervention [30]. More than 100 clinical practice guidelines have been developed over the years [31]. On average, there is a new or updated guideline every few months. Recent advances in HCV medications have made the treatment shorter, less difficult to tolerate, and more effective [32]. With the frequently updated clinical evidence, effective dissemination of the latest medical knowledge to community health care providers working on the frontline to fight HIV, HCV, and other STDs has become an essential requirement.

New York State HIV-HCV-STD Clinical Education Initiative

The CEI program [33] is sponsored by the New York State Department of Health, with additional support from other federal, regional, and local resources. It started in 1993 as a traditional, in-person continuing medical professional education program focusing on HIV. The target audience of the CEI program is primary care clinicians such as physicians, nurses, nurse practitioners, case managers, and social workers, who are currently providing or plan to provide care to HIV patients. The program aims to increase access and quality of HIV care, expand the base of clinicians who can effectively manage HIV patients, disseminate the latest clinical guidelines, and foster partnerships between community-based care providers and HIV specialists. Over the years, the CEI in-person program has successfully trained thousands of clinicians.

To leverage the latest development in information technologies and to explore the opportunities offered by the widely used digital platforms, we initiated the CEI online program in 2008. We collaborated with domain experts across the nation and developed a large repository of online resources, including hundreds of multimedia learning modules, online CME/CNE courses (the focus of this study), and guideline-driven interactive case simulation tools [9-10,34]. We disseminated these resources through multiple channels, including a main website, a mobile website, mobile apps, online social networks, rich site summary feeds, and email newsletters [11-12,35-36]. Over a period of 6 years since its launch, the CEI website has recorded nearly 200,000 visit sessions and 1 million pageviews by audiences from over 170 countries around the world. The various CEI mobile apps have been downloaded 10,000 times. Since 2013, the program scope has expanded to include HCV and other STDs to address the emerging challenges in the field. By 2015, the program had 5000 registered clinician users. The CEI website is now consistently ranked by Google and other search engines as a top site for HIV, HCV, and STD clinical education.

Methods

To compile the clinicians' profiles and their evaluations of the CEI online CME/CNE courses, we queried the CEI Student Portal and obtained data of: (1) all clinicians who successfully completed at least one online CME/CNE course from November 2014 through October 2015; and (2) their evaluations of all completed online CME/CNE courses during this period. The CEI Student Portal is a centralized system to manage clinician students, online courses, and program evaluations. A clinician user can sign up for the student portal at any time. As part of the registration, clinicians need to provide their personal (contact information, demographics, and education levels) and professional (clinical discipline, employment setting, practice years, patient caseload, and clinical services) background information. When taking an online CME/CNE course, a clinician must complete watching the multimedia materials and pass a short exam to test his/her knowledge related to the topics covered by the course. After completion of each online CME/CNE course, the clinician student must provide an evaluation with self-reported data on: (1) usefulness/relevance of the information presented in the course; (2) ease of comprehension; (3) knowledge of the trainer; (4) appropriateness of the online training format; (5) knowledge level on the course topic before and after the training; (6) intention to utilize the learned knowledge; and (7) plan to change practice after the training. Here, for items (1), (2), (3), and (6), we used a five-point Likert-scale measure (*strongly agree*, *agree*, *neutral*, *disagree*, and *strongly disagree*), and the responses were further grouped into positive (*strongly agree* and *agree*) and nonpositive (*neutral*, *disagree*, and *strongly disagree*) responses for data analyses. For item (5), we used five discrete levels to indicate a clinician's knowledge on a specific training topic (*novice*, *not very knowledgeable*, *knowledgeable*, *very knowledgeable*, and *expert*) before and after the training, and then calculated the difference (*at least one level increase* vs *no increase*) for data analyses. In addition to these structured questions for course evaluation, clinicians can provide free-text comments on their experiences of the CEI online training program. Once the evaluation is completed, the CME/CNE credits associated with an online course are immediately awarded. At any time, the clinician student can review and print the CME/CNE certificate. Partial screenshots of the CEI Student Portal to collect course evaluation and student profile data are shown in Figures 1 and 2.

For data analyses, we categorized the online CME/CNE courses based on a custom-developed domain ontology of HIV-HCV-STD clinical topics [9]. We then profiled all clinicians' backgrounds and computed their evaluations of the online CME/CNE courses with the seven measures discussed above. As the last step, we reviewed the themes from the free-text comments to capture additional feedback for the CEI online training program. This study was approved by the University of Rochester Research Subjects Review Board and Arizona State University Institutional Review Board.

Figure 1. A partial screenshot of the Clinical Education Initiative Student Portal to collect course evaluation data.

The information and/or skills provided in this event were useful and relevant

- [1] Strongly Agree
- [2] Agree
- [3] Neutral
- [4] Disagree
- [5] Strongly Disagree
- [6] Not Applicable

The information and/or skills taught in this event were easy to comprehend

- [1] Strongly Agree
- [2] Agree
- [3] Neutral
- [4] Disagree
- [5] Strongly Disagree
- [6] Not Applicable

The trainer was knowledgeable about the topic

- [1] Strongly Agree
- [2] Agree
- [3] Neutral
- [4] Disagree
- [5] Strongly Disagree
- [6] Not Applicable

As a result of this event I intend to use the knowledge/skills I have learned today in my clinical practice

- [1] Strongly Agree
- [2] Agree
- [3] Neutral
- [4] Disagree
- [5] Strongly Disagree
- [6] Not Applicable

How might the format of this activity be changed in order to be most appropriate for the content presented?

- [1] Format was appropriate; no changes needed
- [2] I would like the following format change (select all that apply)
  - [3] Include more case-based presentations
  - [4] Add breakouts for subtopics
  - [5] Increase interaction with attendees
  - [6] Schedule more time for Q&A

What was your level of knowledge about the training content BEFORE this training?

- [1] Novice
- [2] Not Very Knowledgeable
- [3] Knowledgeable
- [4] Very Knowledgeable
- [5] Expert

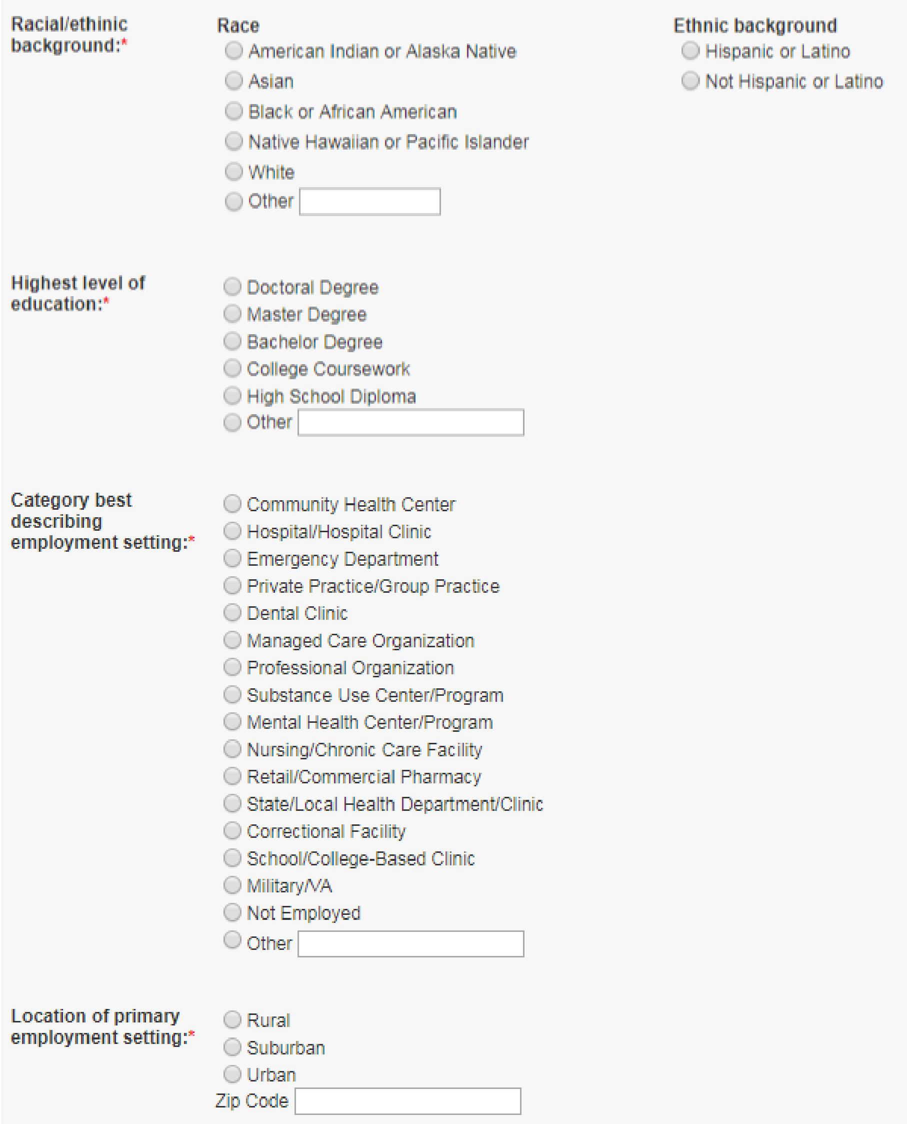
What was your level of knowledge about the training content AFTER this training?

- [1] Novice
- [2] Not Very Knowledgeable
- [3] Knowledgeable
- [4] Very Knowledgeable
- [5] Expert

How will you change your practice as a result of attending this activity?

- [1] Not appicable, I am not a direct care provider
- [2] I will not make any changes to my practice because (select all that apply)
  - [3] This activity validated my current practice
  - [4] Other reasons:
- [5] I will make the following changes to my practice (select all that apply)
  - [6] Create/revise protocols or policies
  - [7] Create/revise procedures in my clinical practice
  - [8] Change the management and/or treatment of my patients

Figure 2. A partial screenshot of the Clinical Education Initiative Student Portal to collect student profile data.


Racial/ethnic background:*
Race
American Indian or Alaska Native
Asian
Black or African American
Native Hawaiian or Pacific Islander
White
Other
Ethnic background
Hispanic or Latino
Not Hispanic or Latino
Highest level of education:*
Doctoral Degree
Master Degree
Bachelor Degree
College Coursework
High School Diploma
Other
Category best describing employment setting:*
Community Health Center
Hospital/Hospital Clinic
Emergency Department
Private Practice/Group Practice
Dental Clinic
Managed Care Organization
Professional Organization
Substance Use Center/Program
Mental Health Center/Program
Nursing/Chronic Care Facility
Retail/Commercial Pharmacy
State/Local Health Department/Clinic
Correctional Facility
School/College-Based Clinic
Military/VA
Not Employed
Other
Location of primary employment setting:*
Rural
Suburban
Urban
Zip Code

Results

We recorded a total of 4363 completions of 88 online CME/CNE courses by 1976 unique clinicians during the study period. Among these clinicians, 1333 (67.46%) were female, 1103 (55.82%) were white, 492 (24.90%) were African American, 128 (6.48%) were Asian, and 436 (22.06%) were Hispanic. In terms of the clinicians' education level, 308 (15.59%) held a doctoral degree and 486 (24.60%) held a master's degree. The details of the clinicians' demographics and education levels are shown in Table 1.

The top categories of the recorded primary professional discipline were physician (n=257, 13.01%), nurse (n=229, 11.59%), case/care manager (n=219, 11.08%), nurse practitioner (n=148, 7.49%), and social worker (n=148, 7.49%). Regarding the practice years in the primary professional discipline, 124 (6.28%) indicated more than 30 years of experience, 224 (11.34%) between 21 and 30 years, 402 (20.34%) between 11 and 20 years, and 1182 (59.82%) 10 years or less. For clinicians' employment setting, the top categories recorded were community health center (n=379, 19.18%), hospital/hospital clinic (n=350, 17.71%), state/local health department/clinic (n=190, 9.62%), private/group practice (n=169, 8.55%), managed care organization (127, 6.43%), and professional organization (n=108, 5.47%). Among these, 1257 (63.61%) were in urban settings, 439 (22.22%) were in the suburbs, and 280 (14.17%) were in rural areas. Details of the clinicians' primary professional disciplines, years in practice, and employment settings are provided in Table 2.

For the caseload, 171 (8.65%) clinicians reported seeing more than 100 HIV patients per month, 82 (4.15%) reported seeing more than 100 HCV patients per month, and 108 (5.47%) reported seeing more than 100 STD patients per month. The caseload category of 1-10 patients per month recorded the largest number of clinicians (n=515, 26.06% for HIV; n=466, 23.58% for HCV; and n=454, 22.98% for STD). The top clinical services provided for HIV patients were risk reduction intervention (n=617, 31.22%), case management (n=456, 23.08%), and HIV screening/testing (n=447, 22.62%). The top services for HCV patients were risk reduction intervention (n=538, 27.23%), HCV screening/testing (n=381, 19.28%), and HCV treatment (n=179, 9.06%). The most popular services for STD patients were risk reduction intervention (n=623, 31.53%), STD screening/testing (n=359, 18.17%), and STD treatment (n=289, 14.63%). The details of the clinicians' caseloads and clinical services are provided in Table 3.

Regarding the number of online CME/CNE courses taken by the health care providers, 1454 (73.58%) clinicians completed only one course, 182 (9.21%) completed two, and the remaining 340 (17.21%) clinicians completed three or more. Excluding a CEI staff who worked as a system tester, the largest recorded number of online CME/CNE courses completed by a single clinician was 47, and the average number of courses taken was 2.17.

As a measurement of course popularity, we recorded a list of courses with the most numbers of completions. The top three on the list were: (1) *HIV/AIDS Confidentiality Law Overview*, with 1379 completions; (2) *Street Drugs & HIV*, with 195 completions; and (3) *STD-HIV Inter-Relationship*, with 158 completions. A complete list of the top 20 most popular online CME/CNE courses is shown in Table 4.

In terms of course evaluation, the overall responses from the clinicians were very positive. With the 4363 completed courses, 3974 responses (91.08%) indicated that the information presented was useful and relevant, 3887 (89.09%) indicated that the course was easy to comprehend, 4014 (92.00%) indicated that the trainer was knowledgeable, and 3680 (84.35%) indicated that the online training format was appropriate. With regard to the impact of the online training, 2117 of the 4363 responses (48.52%) indicated at least one level increase in knowledge, 3720 (85.26%) indicated intention to use the learned knowledge, and 959 (21.98%) indicated a plan to change clinical practice. Excluding those who did not provide direct patient services at the time, 39.43% (959/2432) of those who responded planned to change their clinical practice after the training. A summary of the course evaluation data is shown in Table 5.

Table 1. Participating clinicians' demographics and education levels.

Characteristics	n (%)
Gender	
Male	632 (31.98)
Female	1333 (67.46)
Transgender - male to female	4 (0.20)
Transgender - female to male	7 (0.35)
Racial background	
American Indian or Alaska Native	20 (1.01)
Asian	128 (6.48)
Black or African American	492 (24.90)
Native Hawaiian or Pacific Islander	7 (0.35)
White	1103 (55.82)
Other	226 (11.44)
Ethnic background	
Hispanic/Latino	436 (22.06)
Not Hispanic/Latino	1540 (77.94)
Highest level of education	
Doctoral degree	308 (15.59)
Master degree	486 (24.60)
Bachelor degree	575 (29.10)
College coursework	315 (15.94)
High school diploma	153 (7.74)
Other	139 (7.03)

Table 2. Participating clinicians' primary professional disciplines, years in practice, and employment settings.

Characteristics	n (%)
Primary professional discipline/occupation	
Case/care manager	219 (11.08)
Counselor	95 (40.81)
Dental hygienist	2 (0.10)
Dentist	9 (0.46)
Health educator	80 (4.05)
Health profession student/trainee	56 (2.83)
Health program administrator/coordinator	97 (4.91)
Lab manager/technician	5 (0.25)
Medical/dental assistant	22 (1.11)
Nurse	229 (11.59)
Nurse practitioner	148 (7.49)
Nutritionist/dietician	11 (0.56)
Pharmacist	25 (1.27)
Pharmacy technician	8 (0.40)
Physician	257 (13.01)
Physician assistant	27 (1.37)
Psychiatrist	2 (0.10)
Psychologist	8 (0.40)
Public health professional	74 (3.74)
Social worker	148 (7.49)
Therapist/interventionist	8 (0.40)
Other	446 (22.57)
Years in primary profession/occupation	
>30 years	124 (6.28)
21-30 years	224 (11.34)
11-20 years	402 (20.34)
0-10 years	1182 (59.82)
Unknown	44 (2.23)
Employment setting	
Community health center	379 (19.18)
Hospital/hospital clinic	350 (17.71)
Emergency department	15 (0.76)
Private practice/group practice	169 (8.55)
Dental clinic	10 (0.51)
Managed care organization	127 (6.43)
Professional organization	108 (5.47)
Mental health center/program	75 (3.80)
Nursing/chronic care facility	44 (2.23)
Substance use center/program	16 (0.81)
Retail/commercial pharmacy	12 (0.61)
State/local health department/clinic	190 (9.62)

Characteristics	n (%)
Correctional facility	19 (0.96)
School/college-based clinic	25 (1.27)
Military/veterans affairs	7 (0.35)
Not employed	54 (2.73)
Other	376 (19.03)
Location of primary employment setting	
Rural	280 (14.17)
Suburban	439 (22.22)
Urban	1257 (63.61)

A total of 288 comments from the clinicians were collected during the study period. Review and analysis of these comments excluded 156 invalid or meaningless responses. For the remaining 132 comments, we further categorized them into five themes: information/content, format, trainer, technical issues, and general positive feedback, with 4 belonging to two separate themes. Among these, 39 indicated that the clinicians learned a lot from the presentation and found it very informative. For example, a comment under this theme was "the information is useful for updating agency policy," indicating that the clinician planned to utilize the learned information in their facility. The 53 general positive feedbacks such as "I like it" and "excellent program" only expressed clinicians' overall positive experiences but without details. Additional positive comments were recorded on knowledgeable trainer (n=3) and appropriate online format (n=1). We recorded 25 comments about technical issues encountered by the clinicians, for example, "video was cut off at 40 minutes' mid-sentence." Other negative comments included challenging materials or other information issues (n=4), problem with the trainer (n=5), and request for improvement of the format (n=6).

Table 3. Participating clinicians' caseloads and clinical services.

Characteristics	n (%)
Number of patients per month - HIV/AIDS	
0	778 (39.37)
1-10	515 (26.06)
11-20	127 (6.43)
21-40	146 (7.39)
41-60	117 (5.92)
61-100	122 (6.17)
>100	171 (8.65)
Number of patients per month - HCV[a]	
0	1071 (54.20)
1-10	466 (23.58)
11-20	127 (6.43)
21-40	109 (5.52)
41-60	70 (3.54)
61-100	51 (2.58)
>100	82 (4.15)
Number of patients per month - STD[b]	
0	1019 (51.57)
1-10	454 (22.98)
11-20	146 (7.39)
21-40	104 (5.26)
41-60	85 (4.30)
61-100	60 (3.04)
>100	108 (5.47)
Clinical services - HIV/AIDS	
Adherence counseling	340 (17.21)
Case management	456 (23.08)
Medication management	300 (15.18)
Postexposure prophylaxis	191 (9.67)
Pre-exposure prophylaxis	234 (11.84)
HIV screening/testing	447 (22.62)
Mental health management	237 (11.99)
Partner services	180 (9.11)
Peer education	282 (14.27)
Resistance testing	163 (8.25)
Risk reduction intervention	617 (31.22)
Screening for opportunistic infections	141 (7.14)
Other	162 (8.20)
None	824 (41.70)
Clinical services - HCV	
HCV screening/testing	381 (19.28)

Characteristics	n (%)
HCV treatment	179 (9.06)
Risk reduction intervention	538 (27.23)
Other	94 (4.76)
None	1175 (59.46)
Clinical services - STD	
Partner services	190 (9.62)
Physical assessment	217 (10.98)
Risk reduction intervention	623 (31.53)
Screening/testing	359 (18.17)
Treatment	289 (14.63)
Vaccination	200 (10.12)
Other	96 (4.86)
None	1119 (56.63)

[a]HCV: hepatitis C virus.

[b]STD: sexually transmitted disease.

Table 4. The top 20 most popular online continuing medical education/continuing nursing education courses.

Course	Completions, n (%)
HIV/AIDS Confidentiality Law Overview	1379 (31.61)
Street Drugs & HIV	195 (4.47)
STD[a]-HIV Inter-Relationship	158 (3.62)
The Clinical Diagnosis and Treatment of Gonorrhea, Chlamydia, and Genital Herpes	114 (2.61)
Sexual Assault Evaluation: What Health Professionals Need to Know	101 (2.31)
HIV Pre-Exposure Prophylaxis in the Real World	92 (2.11)
HIV and Aging	90 (2.06)
The Clinical Diagnosis and Treatment of Syphilis	84 (1.93)
Diagnosis and Treatment of Acute HIV: A Stitch in Time?	77 (1.76)
Smoking Cessation in the HIV Patient	70 (1.60)
HIV Prevention and Care in Transgender People	65 (1.49)
Vaginitis	61 (1.40)
Advances in the Treatment and Prevention of HIV Infection: CROI[b] 2015, Focus on ART[c]	60 (1.38)
HIV Sexual Networks: Transmission Dynamics, and Drug Resistance	59 (1.35)
The Patient Protection and Affordable Care Act: What It Means to Patients	56 (1.28)
Drug-drug Interactions in HIV and HCV[d] in an Aging Population	55 (1.26)
Management of HIV/HCV Co-infection in 2014: Cure for All?	55 (1.26)
The Good, the Bad and the Ugly of Inflammation in HIV Infection	53 (1.21)
Clinical Management of Alcohol Use & Abuse in HIV-Infected Patients	50 (1.15)
What Is It with HIV-2?	48 (1.10)

[a]STD: sexually transmitted disease.

[b]CROI: Conference on Retroviruses and Opportunistic Infections.

[c]ART: antiretroviral therapy.

[d]HCV: hepatitis C virus.

Table 5. Clinicians' evaluation of the online continuing medical education/continuing nursing education courses.

Measures and responses	n (%)
Information useful and relevant (n=4363)	
Positive	3974 (91.08)
Strongly agree	2358 (54.05)
Agree	1616 (37.04)
Nonpositive	389 (8.92)
Neutral	339 (7.77)
Disagree	19 (0.44)
Strongly disagree	15 (0.34)
Not applicable	16 (0.37)
Easy to comprehend (n=4363)	
Positive	3887 (89.09)
Strongly agree	2190 (50.19)
Agree	1697 (38.90)
Nonpositive	476 (10.91)
Neutral	420 (9.63)
Disagree	34 (0.78)
Strongly disagree	13 (0.30)
Not applicable	9 (0.21)
Knowledgeable trainer (n=4363)	
Positive	4014 (92.00)
Strongly agree	2495 (57.19)
Agree	1519 (34.82)
Nonpositive	349 (8.00)
Neutral	304 (6.97)
Disagree	16 (0.37)
Strongly disagree	11 (0.25)
Not applicable	18 (0.41)
Format appropriate (n=4363)	
Positive	3680 (84.35)
Format appropriate, no change needed	3680 (84.35)
Nonpositive	683 (15.65)
I would like the following format changes	683 (15.65)
Include more case-based presentations (n=683)	382 (55.93)
Add breakouts for subtopics (n=683)	96 (14.06)
Increase interactions with attendees (n=683)	112 (16.40)
Schedule more time for Q&A (n=683)	61 (8.93)
Intend to use knowledge (n=4363)	
Positive	3720 (85.26)
Strongly agree	2155 (49.39)
Agree	1565 (35.87)
Nonpositive	643 (14.74)
Neutral	440 (10.08)

Measures and responses	n (%)
Disagree	15 (0.34)
Strongly disagree	16 (0.37)
Not applicable	172 (3.94)
Change of knowledge level after the training (n=4363)	
Positive	2117 (48.52)
4	28 (0.64)
3	35 (0.80)
2	422 (9.67)
1	1632 (37.41)
Nonpositive	2246 (51.48)
0	2160 (49.51)
–1	68 (1.56)
–2	13 (0.30)
–3	3 (0.07)
–4	2 (0.05)
Will change practice (n=4363)	
Positive	959 (21.98)
I will make the following changes to my practice	959 (21.98)
Create/revise protocols or policies (n=959)	448 (46.72)
Create/revise procedures in my practice (n=959)	232 (24.19)
Change the management of my patients (n=959)	187 (19.50)
Nonpositive	3404 (78.02)
I will not make changes to practice because	1473 (33.76)
This training validated my current practice (n=1473)	415 (28.17)
Other reasons (n=1473)	1289 (87.51)
Not applicable - no current patient service	1931 (44.26)

Discussion

In this study, for the first time, we reported a detailed profile of health care professionals participating in a statewide online HIV-HCV-STD knowledge dissemination program. Although there were limited reference data, we had a few interesting findings. First, compared to the data of general health care workforce in New York State [37], the proportion of the CEI program participants working in nonhospital community settings was much higher (82% vs 58%). Comparison to the data of active registered nurse in New York State [38] showed similar results (82% vs 29%). These data demonstrated that the CEI online program successfully reached out to the primary care communities, as defined by its missions. Second, 14% of the CEI program participants were from rural areas, similar to the active registered nurse data in New York State (14%) [38]. Further research is required to assess the detailed geographical distribution of the participants and the potential changes over time. Third, the demographics of the CEI program participants indicated a slightly more racially/ethnically diversified workforce (56% white, 25% black, 6% Asian, and 22% Hispanic) as compared to the data of active registered nurses in New York State (61% white, 18% black, 12% Asian, and 6% Hispanic) [38]. This perhaps reflected the higher incidence and prevalence of HIV, HCV, and STD infections in minority groups and therefore the need for more racial/ethnic diversity in health care provider teams. Future research is required to explore race and ethnicity as co-variates for clinician's course evaluation.

To relieve the potential concern on privacy, we did not collect CEI participant's date of birth. Instead, we used years of practice as an alternative measure, which we believed could roughly estimate a health care provider's age in most cases. The data showed that a majority (60%) of the CEI audience had 10 years or less of experience in practice. This result was consistent with previous finding that an online program tended to attract younger clinicians [14]. In addition, 18% of clinicians in the program had more than 20 years of working experience, indicating that this group of health care providers was actively engaged in the CEI online program.

Similar to a previous pilot study [39], we recorded data of clinicians from a variety of professional disciplines participating in the CEI online program. As increasingly recognized and advocated by the research community [40], the interprofessional approach for knowledge dissemination defined another contribution of our study. Related to that, we identified a comprehensive set of clinical services provided by the professionals participating in the CEI online program. Future research is required to assess potential interactions among professional disciplines, clinical services, training topics, and course evaluations.

With regard to caseload, our data indicated a wide range of distribution, from 0 to 100+ HIV, HCV, and STD patients per month. The largest category of the participating clinicians had 1-10 patients per month, a typical scenario in the primary care setting. It is interesting to note that 4%-9% of the clinicians had 100+ patients per month, indicating that the CEI online program also attracted HIV, HCV, and STD specialists, as suggested by anecdotal evidence. In addition, 39%-54% of the clinicians had no patients at the time—they likely were those: (1) in the HIV, HCV, and STD clinical care and public health teams but with no direct interactions with patients; or (2) new practitioners preparing to engage in HIV, HCV, and STD patient care.

According to the Accreditation Council for Continuing Medical Education 2015 Annual Report, there were close to 37,000 enduring internet material activities that provided more than 74,000 hours of instruction to 4.8 million physicians and over 6.8 million other learners [41]. Nevertheless, just posting materials online for reading is not enough. Studies showed that multimedia materials and interactivity would increase the satisfaction of health care professionals for their participations in online learning [42]. Other important factors used by clinicians in the selection of an online course included the quality of content, flexibility of access, ease of use, and convenience of obtaining continuing professional development credits [42]. We believe that effectively addressing these issues has led to the initial success of the CEI online program.

The data from a recent national survey called for a central repository for listing educational opportunities and tracking continuing education credits [43]. Nonetheless, another study found that online materials from open public sources such as YouTube had overall low quality [44]. A large repository of centrally managed, high-quality online courses with a student portal to track the progress of learning and CME/CNE credits is likely an important contributing factor for the success of the CEI online program in engaging a core group of clinicians. Our data showed that this core group of clinicians kept coming back to the CEI online program to take new courses.

This study has a few limitations. First, we focused only on a specific category of online resource, multimedia CME/CNE course, while many other types of resources such as case simulation, InfoButton, and clinical decision support could also be leveraged for dissemination of clinical evidence [20,43,45]. As advocated by others, multi-faceted interventions will likely be more effective for knowledge dissemination [20]. The CEI online program has already developed a few other types of resources and communication channels [9-11]. Future research is required to assess the effectiveness to use multiple categories of online resources for knowledge dissemination. Second, this research was based on a cross-sectional descriptive study design without comparative groups (except for the measure of clinicians' knowledge level, which involved a before-after comparison). Future research is required to compare the effectiveness of the interventions delivered through the online resources with specific types of controls in order to demonstrate that the benefits of online courses outweigh the disadvantages [42-43]. Third, we relied on self-reported data [46] to measure clinicians' satisfaction on content, format, knowledge change, and potential improvement in clinical practice. Given that CEI is a statewide program, this is perhaps the best we could do. Future research should include direct measures on health care processes and patient outcomes [47]. Finally, since the CEI online program was newly developed at the time, there were still technical issues (as shown in the clinicians' comments) during the study period. The CEI program staff were actively working to address those issues found by the clinician students. Ideally, a system should be frozen during evaluation [48]. However, considering a large program such as CEI that serves thousands of clinicians, it is unrealistic to freeze the system and ignore the identified issues for a long study period. We therefore decided to evaluate the system along the normal process of system maintenance, which reflected the real status of its performance.

In conclusion, we have successfully characterized the profiles of clinicians participating in the New York State CEI online CME/CNE program for dissemination of the latest HIV, HCV, and STD clinical evidence. We have identified a diverse group of health care providers in terms of the demographics, education levels, professional disciplines, practice years, employment settings, caseloads, and clinical services. The participating clinicians' evaluation of the CEI online CME/CNE courses was very positive with regard to the content, format, and knowledge increase. A significant portion of the participating clinicians planned to adopt the learned knowledge and skills in their practice. These initial set of evaluation data have demonstrated the effectiveness of using online resources for dissemination of HIV, HCV, and STD clinical evidence to primary care clinicians. Future research is required: (1) to assess the effectiveness of knowledge dissemination with multiple types of online resources and using direct measures on health care processes and patient outcomes; (2) to examine the comparative effectiveness with control groups; and (3) to analyze the co-variates through development of a predictive model for effective online training.

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Conflicts of Interest

None declared.

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Abbreviations

AHRQ: Agency for Healthcare Research and Quality
CDC: Center for Disease Control and Prevention
CEI: Clinical Education Initiative
CME: continuing medical education
CNE: continuing nursing education
HCV: hepatitis C virus
STD: sexually transmitted disease

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Original Paper

Motivating HIV Providers in Vietnam to Learn: A Mixed-Methods Analysis of a Mobile Health Continuing Medical Education Intervention

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Abstract

Background: The Mobile Continuing Medical Education Project (mCME V.2.0) was a randomized controlled trial designed to test the efficacy of a text messaging (short message service [SMS])–based distance learning program in Vietnam that included daily quiz questions, links to readings and online courses, and performance feedback. The trial resulted in significant increases in self-study behaviors and higher examination scores for intervention versus control participants.

Objective: The objective of this mixed-methods study was to conduct qualitative and quantitative investigations to understand participants' views of the intervention. We also developed an explanatory framework for future trial replication.

Methods: At the endline examination, all intervention participants completed a survey on their perspectives of mCME and self-study behaviors. We convened focus group discussions to assess their experiences with the intervention and attitudes toward continuing medical education.

Results: A total of 48 HIV specialists in the intervention group completed the endline survey, and 30 participated in the focus group discussions. Survey and focus group data suggested that most clinicians liked the daily quizzes, citing them as convenient mechanisms to convey information in a relevant manner. A total of 43 of the 48 (90%) participants reported that the daily quizzes provided motivation to study for continuing medical education purposes. Additionally, 83% (40/48) of intervention participants expressed that they were better prepared to care for patients with HIV in their communities, compared with 67% (32/48) at baseline. Participation in the online coursework component was low (only 32/48, 67% of intervention participants ever accessed the courses), but most of those who did participate thought the lectures were engaging (26/32, 81%) and relevant (29/32, 91%). Focus group discussions revealed that various factors influenced the clinicians' decision to engage in higher learning, or "lateral learning," including the participant's availability to study, professional relevance of the topic area, and feedback. These variables serve as modifying factors that fit within an adapted version of the health belief model, which can explain behavior change in this context.

Conclusions: Qualitative and quantitative endline data suggested that mCME V.2.0 was highly acceptable. Participant behaviors during the trial fit within the health belief model and can explain the intervention's impact on improving self-study behaviors. The mCME platform is an evidence-based approach with the potential for adoption at a national scale as a method for promoting continuing medical education.

Trial Registration: ClinicalTrials.gov NCT02381743; https://clinicaltrials.gov/ct2/show/NCT02381743

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KEYWORDS

continuing medical education; HIV/AIDS; mHealth; Vietnam; health education; SMS intervention; telemedicine; text messaging

Introduction

Background

Continuing medical education (CME) is essential to maintaining the competence of a clinical workforce, but the complexity of managing CME programs and the resources required can be barriers to implementation. This may be particularly true in low- and middle-income countries. In November 2009, Vietnam passed the Law on Medical Examination and Treatment, which mandated that all clinicians participate in yearly CME activities to maintain licensure [1-3]. There has been increasing enthusiasm for mobile health (mHealth) in Vietnam, with 20 initiatives identified in a recent landscape analysis [4]. While this indicates an interest in using mHealth to improve the quality of health care through provider education, a lack of sustainability for current initiatives and absence of technological infrastructure pose challenges to mHealth programs across the country [4]. Since there is little infrastructure in the country to support such a national CME program, health officials may want to consider developing a feasible, scalable, and cost-effective platform that provides medical professionals with evidence-based training. Previous research in other contexts suggests that CME delivered at a distance is acceptable and can be effective at improving medical knowledge, changing behavior, and advancing clinical practice [5-15]. Distance learning is an attractive alternative to in-person CME, but evidence of its effectiveness is needed prior to program implementation at a national level.

Beginning in 2014, researchers at the Boston University School of Public Health, in Boston, MA, USA, collaborated with the Vietnamese Ministry of Health and the Vietnamese nongovernmental organization Consulting, Researching on Community Development to create the Mobile Continuing Medical Education Project (mCME). mCME was a short message service (SMS) text messaging–based mHealth education strategy that delivered CME via cell phones. Over 2 consecutive randomized controlled trials, we demonstrated that the mCME strategy was technically feasible, acceptable, and effective at motivating self-study behaviors, and it led to improved medical knowledge on a standardized examination [16-19].

Analysis of qualitative findings from the first mCME trial (V.1.0), which demonstrated feasibility and acceptability but not improved medical knowledge, influenced the design of V.2.0, which did demonstrate improved medical knowledge. During the design of V.2.0, mCME was considered a behavioral change intervention, and not a knowledge transfer intervention, with the emphasis on self-study behaviors. We enhanced the design to maximize study participation and engagement with the different intervention components. As we analyzed the results of mCME V.2.0, we noted that the fundamental components of the intervention were a pedagogical analog to the health belief model (HBM), a sociobehavioral theory that explains individual motivation to change behavior [20]. The HBM employs perceived susceptibility and perceived severity to rely on cues to action to encourage behavior change [20,21]. We posit that the intervention is aligned with the HBM because of the way that mCME spurred increased self-study, acquisition of evidence-based resources, and professional collaboration during its implementation.

Objective

We aimed to analyze both qualitative and quantitative data obtained from participants randomly assigned to the mCME V.2.0 intervention to better understand the underlying mechanisms that led to successful increases in self-study behaviors and medical knowledge. We propose that understanding how the program worked will be critical to replicating its success at a national scale. We sought to understand how a digital education framework corresponding to the sociobehavioral HBM and designed to stimulate deeper learning could explain the success of the mCME approach. From within this framework, we used qualitative and quantitative data to evaluate (1) how medical professionals felt about the principal components in the intervention, and (2) the impacts that the intervention had on participants' self-study, knowledge, and self-efficacy.

Methods

Study Site and Participants

Full details of the mCME V.2.0 project methodology are published in the main effects article [18]. Briefly, mCME V.2.0 was a randomized controlled trial conducted in 2016-2017 that aimed to test whether an integrative model of SMS text messaging and Web-based learning could improve medical knowledge among Vietnamese HIV clinicians. HIV health professionals from 3 provinces in northern Vietnam (Thái Nguyên, H i Phòng, and Qu ng Ninh) were enrolled in the study and took a baseline examination (1 held in each province) to assess medical knowledge and then randomly assigned into intervention and control groups. The intervention group received the following: a daily multiple-choice quiz question pertaining to a specific module within the Hanoi Medical University (HMU) online courses, daily linked readings to additional information, regular reminders to access the HMU online courses, and feedback on their individual performance versus their peers' performance. The control group had access to the HMU courses and received nonmedical SMS text messages, but did not receive the daily medical quizzes, linked readings, feedback, or reminders to take the HMU courses. Multimedia Appendix 1 depicts the study design.

Data Collection

At the end of 6 months, both intervention and control groups took an endline examination to test for improvement in medical knowledge and completed a survey on their study behaviors and experiences with the trial. The 50-question survey covered topics such as study behaviors, experiences with each of the intervention components, attitudes toward CME, job satisfaction, and perception of HIV knowledge and skills. After the endline examination workshops at each of the 3 sites, study investigators in Vietnam scanned the quantitative surveys with an optical scanning device (Scantron, Inc, Eagan, MN, USA).

After the endline examination, we invited a subset of intervention participants from each of the 3 provinces to participate in focus group discussions (FGDs) to learn about their experiences with the intervention. Within each group, we attempted to include a balanced representation of experiences with the intervention, with roughly equal numbers of participants whose response rates of the daily quiz questions were above the median, and those whose response rates were below the median. We used quiz response rates for this stratification because the daily quizzes were the most fundamental core element of the mCME intervention. Following a semistructured FGD guide, we asked participants about their experiences with the intervention, the impact the intervention had on their learning, and their suggestions for how to improve the mCME approach. All 3 FGDs were recorded in Vietnamese and translated and transcribed into English.

Data Analysis

Boston University researchers analyzed the FGD transcripts in NVivo version 11 (QSR International). Themes and subthemes were individually identified and cross-checked by 2 qualitative analysts to test for variability, and then a consensus of key themes was reached prior to analysis. Responses were grouped and prioritized by frequency. We also compared responses by study site. Boston University researchers analyzed the survey data with various descriptive data analysis techniques using SAS version 9.4 (SAS Institute). As a secondary analysis, we analyzed qualitative and quantitative responses based on use of the intervention components (eg, we included survey results data on perspectives on the HMU courses only if the participant ever accessed the HMU courses). We include those results in this paper, to account for social desirability bias.

Developing the Theoretical Framework to Understand Views on and Impact of the Intervention

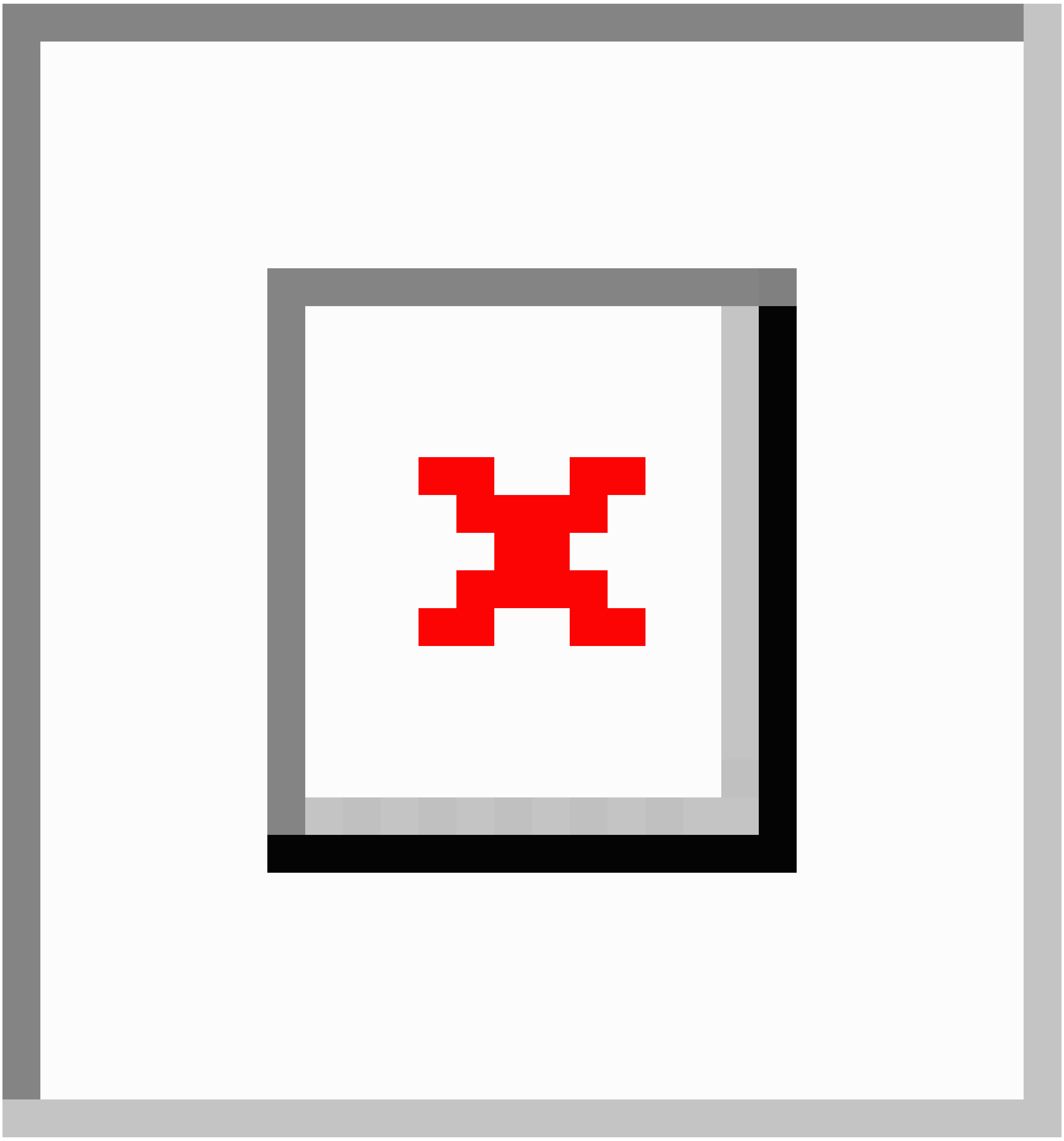
In a preliminary review of the data, we realized that there were several themes from the qualitative data that paralleled the HBM. The first component of both the HBM and our intervention is cues to action, which the HBM states provide a stimulus to trigger a decision or behavior change [20,21]. Another way in which this intervention mirrors HBM is through the idea of perceived severity and susceptibility; the HBM defines these as the individual's own perceptions of the likelihood of getting a disease or having a severe form of the disease [20,21]. We have applied this concept beyond the context of disease; in this intervention, perceived severity and susceptibility correspond to the perceived importance and level of need to take CME to provide high-quality medical care. In our intervention, these views were informed by several modifying variables that affected quality and intensity of learning among the participants. We analyzed how participants chose to access and use high-quality educational materials beyond the daily SMS text messages, which we termed lateral learning. We then developed a framework to explain the clinician's decision to learn through a behavioral lens (Figure 1 [20,21]). We analyzed the qualitative data within the context of this framework to explore how clinicians interacted with the intervention and to understand how lateral learning could be achieved.

The cues to action in mCME are the various text message interactions that the user has with the mCME program: the daily SMS quizzes, which prompt the user to seek an answer to a medical question; the HMU course reminders, which come at the beginning and end of each module; and individual and peer feedback, which comes in the form of a correct versus incorrect response per daily quiz question and an end-of-module final score comparing the individual's percentage correct responses compared with the rest of the cohort. Whether the cues to action led to lateral learning depended on the individual's weighing of the perceived susceptibility and perceived severity, which are modified by factors such as professional relevance, convenience of CME, perceived quality of resources, subject matter expertise, motivation and self-efficacy, technical literacy, and the participant's time and availability. These factors should be considered together with the HBM's concept of perceived susceptibility, or in this case, the perceived level of need for the individual to have CME, and the perceived severity, or in this context, the level of importance the individual places on CME. The individual then weighs the perceived prohibitive and supportive factors and determines whether to engage in lateral learning. Because a participant might choose to access vetted materials or additional resources of varying quality, we hypothesize that the educational value of outside resources is an additional moderating variable for lateral learning.

Ethical Review

This study was registered on ClinicalTrials.gov (NCT02381743) with ethical oversight by Boston University Medical Center, Boston, MA, USA, and Hanoi University of Public Health, Hanoi, Vietnam. All participants in this trial provided written informed consent prior to participation in the trial, with additional consent provided for participation in the FGDs.

Figure 1. Framework for the decision to engage in lateral learning. Elements of the Mobile Continuing Medical Education Project are analogous to the health belief model. The figure illustrates the underlying behavioral mechanisms that lead a clinician to decide whether to engage in lateral learning, defined as accessing and using high-quality educational materials beyond daily short message service (SMS) text messages. CME: continuing medical education; HMU: Hanoi Medical University.



Results

Background Characteristics of mCME V.2.0 Trial Participants

Endline examinations with postintervention surveys and FGDs took place in May 2017. All HIV clinicians who participated in the intervention and returned for the endline examination were asked to complete the survey (n=48). We asked 10 clinicians assigned to the intervention group at each of the 3 sites to participate in the FGDs (n=30), all of whom signed a separate consent form specific to the qualitative research. Here, the term "intervention participants" includes all intervention participants, and "FGD participants" includes only the views of intervention participants who also participated in a focus group. Each FGD lasted 1 to 1.5 hours. The average age of all intervention participants was 41 years, and they had spent an average of 4 years in the HIV/AIDS field. As Table 1 shows, the demographic characteristics of the FGD subset and the full intervention cohort were generally similar, suggesting that the FGD subset was broadly representative of the larger group.

Below we first explore the various themes from the survey and the FGDs, including participant attitudes toward the major components of the intervention. We then describe the impact on self-study in relation to the modifying factors that influence learning behaviors, one of the key components to the lateral learning framework. Finally, we analyze the impact the intervention had on knowledge and self-efficacy.

Views of the Intervention

Similar to the results of mCME V.1.0, participants reported positive views of the intervention and of CME in general for mCME V.2.0 [17]. Of the 48 intervention participants, 45 (94%) agreed or strongly agreed with the statement “I believe CME is important” and 43 (90%) agreed or strongly agreed that text messages can provide motivation to study for CME accreditation (Figure 2). Additionally, 41 of the 48 (85%) intervention participants who accessed all 3 components of the intervention rated their experience as “very satisfying” or “somewhat satisfying.”

Intervention participants commented on their experiences with the 3 main components of the intervention: the daily quizzes, the daily readings that corresponded to the quiz question, and the HMU courses. Figure 2 shows additional survey data indicating the percentage of participants who agreed or strongly agreed with Likert-scale questions from the endline survey.

Table 1. Demographic characteristics and intervention behaviors of Mobile Continuing Medical Education Project (mCME V.2.0) trial participants.

Characteristics	Intervention participants (n=48)	Focus group participants (n=30)
Sex, n (%)		
Male	19 (40)	11 (37)
Female	29 (60)	19 (63)
Research site, n (%)		
Thái Nguyên	18 (38)	10 (33)
H i Phòng	17 (35)	10 (33)
Qu ng Ninh	13 (27)	10 (33)
Age (years), mean (SD)	41.1 (8.8)	40.43 (8.7)
Years working in HIV/AIDS health sector, mean (SD)	4.3 (4.8)	5.20 (5.2)
Clinical degree, n (%)		
MD	20 (42)	13 (43)
Mid-level provider	28 (58)	17 (57)
Text message response rate[a] during study, by location, n (%)		
Thái Nguyên		
High	13 (72)	5 (50)
Low	5 (28)	5 (50)
H i Phòng		
High	11 (65)	5 (50)
Low	6 (35)	5 (50)
Qu ng Ninh		
High	10 (77)	7 (70)
Low	3 (23)	3 (30)
Hanoi Medical University course use during study, n (%)		
Ever	32 (67)	19 (63)
Never	16 (33)	11 (37)
Daily readings access during study, n (%)		
Ever	41 (85)	22 (73)
Never	7 (15)	8 (27)
Hours per week spent on medical self-education, n (%)		
0	1 (2)	1 (3)
1-2	26 (54)	17 (57)
2-4	9 (19)	6 (20)
4-7	7 (15)	3 (10)
≥8	5 (10)	3 (10)
Number of patients seen per day on average, n (%)		
0-9	23 (48)	15 (50)
10-19	7 (15)	5 (17)
20-29	8 (17)	4 (13)
30-39	4 (8)	2 (7)
≥40	6 (12)	4 (13)

[a]For response rates, high refers to those ≥85% for Thái Nguyên, ≥82% for H i Phòng, and ≥77% for Qu ng Ninh.

Figure 2. Sample of Likert-scale responses from Mobile Continuing Medical Education Project (mCME V.2.0) trial intervention participants in the endline survey showing the proportion of those who agreed or strongly agreed with the statements shown (standard error bars with 95% CI). Importantly, for questions pertaining to the daily readings and the Hanoi Medical University (HMU) courses, we excluded the responses from participants who never accessed those intervention components. CME: continuing medical education; SMS: short message service.

Daily Quizzes

Most FGD participants liked the daily quizzes, finding them to be convenient, relevant, and informative. This is consistent with daily quiz response rates during the intervention, which averaged 81.9% (118/144 daily quizzes) across 3 sites [19]. A few participants even wished that the intervention would continue; one commented that, "I quite miss the daily quizzes now that the intervention is over" (participant in H i Phòng) and another said, "There have been no quizzes in the last 2 weeks and I miss them" (participant in Qu ng Ninh). Remarking on the convenience of the daily quizzes, one participant said, "I feel satisfied because it is clear whether I have answered right or wrong" (participant in Qu ng Ninh). Several participants reported that the daily quizzes led them to access educational materials to learn more about the topic area; 1 participant noted that they "encourage us to search for knowledge to be able to answer the questions—we had to read books or access online materials" (participant in Thái Nguyên).

Although most liked the quizzes, FGD participants commented that the two main drawbacks of the daily quiz were the formatting and system errors. Referring to phonetic markings and clarity, one person said, "I think the contents of the messages were not clear: choice a and b were sometimes put together in one line with no punctuation" (participant in Thái Nguyên). All participants in the FGD in Qu ng Ninh agreed that the texts on the phone were too short, which affected their ability to understand what was being asked. Finally, participants at all 3 sites mentioned that there were sometimes system errors with the messages. One participant said, "Sometimes I chose the right answer but the system said I was wrong" (participant in H i Phòng) and another said, "Some questions are vague, for example a question has many [correct] answers" (participant in Qu ng Ninh). In this particular case, there was indeed one instance in which the programmers listed the wrong answer for a daily quiz; however, the claim that some quizzes had multiple correct answers was untrue.

Notably, most participants suggested that texts be sent in the morning and 24 hours be allotted to answer each SMS text message. One participant said that:

> *The timing of the messages in the afternoon is not reasonable. I had no time to search for more knowledge, since we were often busy in the afternoon at work, and at home we were too tired to research more.* [participant in Thái Nguyên]

We intentionally changed the timing of when the daily quiz was sent each day about halfway through the trial to test the impact of timing on the response rate. Most participants agreed that the timing of the messages (1:00 PM) negatively affected their ability to respond or seek out answers from provided resources. Importantly, although participants strongly protested against afternoon daily messages as opposed to morning messages, the response rate and correct answer rate was not significantly different between the 2 time points (Multimedia Appendix 2).

Daily Readings

Of the 3 intervention components, the daily readings had the lowest rates of utilization. The intervention participants accessed, on average, 18.1% (26/144) of the daily readings that they had received over the course of the intervention [19]. Many explained that the daily readings didn't have enough in-depth information to cover complex topics. One participant elaborated:

> *I also think the contents in the links were not enough...when I accessed the links I didn't understand completely. I still had questions and had to find other resources. If one doesn't have enough knowledge on HIV then it would be difficult to understand contents of the link only.* [participant in Thái Nguyên]

For some, the length of the readings was sufficient and time efficient, but other participants sought more in-depth knowledge to gain deeper insight into the topic area.

Some participants found the daily readings to be a quick way to access information related to the daily quizzes. One participant noted that the daily readings in concert with the daily quizzes improved understanding:

> *Receiving daily messages probably helps me a lot, since I've just started [providing] ARV treatment for 3 months. It helps me in reading materials and providing information, thus enabling my self-study.* [participant in Thái Nguyên]

Another said that:

> *The links to the daily readings are great because they provide immediate answers.* [participant in Qu ng Ninh]

Of the participants who accessed the daily readings, 88% (35/41) said that they were satisfied or very satisfied with the relevance of the daily readings to their medical practice (Figure 2). Despite these noted benefits, many participants complained that the daily readings were insufficient to improving their medical knowledge. One participant said simply that:

> *The contents of the daily readings are insufficient, especially for case questions.* [participant in Qu ng Ninh]

Hanoi Medical University Courses

For the primary end point of this study, we observed that the intervention participants accounted for 83.2% of the total course use across intervention and control groups (134/161 total times accessed by all users), and intervention participants were significantly more likely than the control participants to ever access the HMU courses (relative risk 2.3, 95% CI 1.4-3.8) [18]. Few participants regularly accessed the HMU courses, but most of the intervention participants who ever accessed the courses thought the lectures were engaging (26/32, 81%) and relevant (29/32, 91%). One participant commented that:

> *If it was a topic I'm interested in then I'd watch it carefully. Some contents were very in-depth...[and the] assessment was very interesting, since it allowed me to see how much I could do, if I am progressing or not.* [participant in Thái Nguyên]

Most approved of the quality of the courses in terms of content, sound, visual elements, and navigation, according to the endline survey (Figure 2).

Reasons for not using the HMU courses included the participant's lack of availability, topic relevance, and motivation. Speaking to why someone wouldn't take the course, one person noted that:

> *Some knowledge I have already owned and have been directly trained, which makes it boring although I really like studying....Also, for the same lectures, reading documents only takes me 15-20 minutes, while listening to lecturer is too time consuming and I am sometimes busy, although it helps me gain more knowledge.* [participant in Qu ng Ninh]

Another noted availability and course quality as deterrents:

> *I rarely use the HMU courses because the lectures are lengthy and unattractive despite being useful. First, they are just speeches or slides. Second, although they are beneficial, sometimes I am busy for 1, 2 days or even a week so I may forget to answer and there is no reminder from the system.* [participant in Qu ng Ninh]

Many also suggested in the FGDs that the HMU lectures be updated to reflect current treatment guidelines; as one participant commented:

> *I hoped the knowledge would be updated according to the current treatment knowledge. At least we should be able to know the current possibility in treatment so we could give suitable consultation for patients.* [participant in Thái Nguyên]

Accessing the lectures on their mobile phones was also challenging. One person said, "The speed of loading links is quite slow for phones with low configuration, making it difficult to access" (participant in Qu ng Ninh) and another noted that, "The online training provided by HMU loaded slowly on mobile phones despite a good Wi-Fi connection" (participant in Thái Nguyên).

Finally, several noted the limitations of mCME versus traditional CME when discussing the online courses. Many participants agreed that e-learning is the most convenient method. One participant said that:

> *This approach is very convenient, aiming to the majority of learners, any type of individual and convenient for community-based health staff.* [participant in Thái Nguyên]

However, several participants expressed more ambivalence toward online training:

> *This method does not have interaction between teachers and students so I feel unsatisfied because I cannot ask questions. But this method enables me to choose whichever part I like to study.* [participant in Qu ng Ninh]

Others suggested that direct training be combined with mCME:

> *[With mCME], we get the convenience and can get access to it anytime, but especially in the treatment aspect, direct training with feedback would be more efficient and help keep a longer memory. Therefore,*

I suggest that online learning and direct training should be combined. [participant in Thái Nguyên]

Impact on Self-Study: Modifying Factors That Influenced Learning Behaviors

Our study results indicate that, compared with pretrial surveys, participants in the intervention group at endline reported higher levels of self-study through reference to medical textbooks, colleagues, online research, medical specialty websites, Vietnamese treatment guidelines, and scientific literature than their control group counterparts [18]. In the focus groups, participants raised several factors that influenced their decision to engage in self-study beyond memorizing the answer from the daily multiple-choice quiz. Among these factors were their time or availability, relevance of the subject matter to their profession, convenience of the intervention, perceived quality of the HMU and daily readings resources, individual-level subject matter expertise, technological literacy, and motivation to learn (Table 2).

Each of these factors fits within the lateral learning framework outlined in Figure 1. Table 2 provides exemplar quotes detailing the various factors that influenced participants' decisions to engage in this lateral learning, or learning beyond rote memorization of the SMS text message.

Participant responses to the cues to action (SMS text message quizzes, course reminders, and performance feedback) were contextual, and the modifying factors listed in Figure 1 either aided in self-study or inhibited it. For example, participants studied more if they found the material to be professionally relevant, and did not study if they found the inverse.

Table 2. Quote excerpts from focus group discussions illustrating modifying factors in the decision to engage in lateral learning, May 2017.

Factor	Quote	Participant location
Time or availability	Honestly I don't have much time so I would not access [additional materials].	Thái Nguyên
	Q: Is there anybody who answered without checking any source? All: Yes, when we are too busy.	H i Phòng
	There are other things to do apart from studying. Actually, there are very few people who have time to participate in the courses at home, and studying when working often gets interrupted.	Qu ng Ninh
Professional relevance	I would spend more time studying work-related topics, I researched more and often got a high score; other than that I would skip.	Thái Nguyên
	The [materials] are directly related to my work, so I need to study to improve my knowledge.	Thái Nguyên
	I believe that people directly treating patients would know more than us, so for those who do not know much about HIV/AIDS like us, reading is very important.	Thái Nguyên
Convenience	I could study at home. There is no need to go to class, so it is time and cost effective.	H i Phòng
	All: Studying on our phones is more convenient because it is not possible to bring our laptops along all of the time.	Qu ng Ninh
	The most beneficial thing for us working at medical centers is that we can study anywhere, without having to attend classes; it is suitable for those who live far away from the training centers.	Thái Nguyên
Perceived quality of resources	The links provide more information from research, which is very useful.	Qu ng Ninh
	Some lectures were not updated, although the official documents and national treatment guides are changed frequently.	Thái Nguyên
	The current explanation in the links was short and insufficient; there should be more information so we wouldn't have to access other sites.	Thái Nguyên
Subject matter expertise	Unlike those of you who have been in this program for one year and have experience and knowledge, I am totally new to this field and I need to search for information.	Qu ng Ninh
	People who are new to this information will be more motivated to study. I have already been trained about this before so I don't actively participate in the courses, although I think they are useful for me.	Qu ng Ninh
Technology literacy or accessibility	The password is hard to remember. Sometimes I have to type it from the beginning.	Qu ng Ninh
	My limitation would be my bad eyesight. I would only read the links if I was on the computer.	Thái Nguyên
	It may take 1 or 2 weeks for us to remember the phone number [text message] of the program.	H i Phòng
Motivation	I like it best when having group discussion, sending the answer, and then receiving "Congratulations" on giving the right answer.	Qu ng Ninh
	If studying time is taken into account to decide whether or not one could receive a certificate, I will have a purpose and be more motivated to study.	Qu ng Ninh
	When I have answered too many quizzes and my score is low compared to the group average, I will read the daily readings to gain more knowledge.	H i Phòng

One participant said, “If I need the knowledge at that moment, I will be more motivated to study” (participant in Qu ng Ninh), but another commented that, “I would spend more time studying work-related topics, I researched more and often got high score; other than that I would skip [questions]” (participant in Thái Nguyên). Similarly, whether they viewed mCME as convenient affected their study behaviors. One participant said that:

> *The most beneficial thing for us working at medical centers I think is that it can be studied anywhere, without having to attend classes, and it is suitable for those who live far away from the training center.* [participant in Thái Nguyên]

A counterpart said:

> *Actually, there are very few people who have time to participate in the courses at home, and studying when working often gets interrupted. Sometimes it is possible to read the entire lectures but sometimes I have to turn it off after having read for only 1 or 2 minutes.* [participant in Qu ng Ninh]

Ultimately, these modifying factors boil down to the individual participant. One health professional from Thái Nguyên succinctly summarized, noting that “Compared to direct training, I think online learning is very good, with the condition that the learner has the will to learn.”

Impacts of the Intervention on Self-Study and Medical Knowledge

The mCME V.2.0 intervention significantly increased self-study behaviors, leading to improved HIV medical knowledge and perceived skills, and high levels of job satisfaction [18]. In particular, it was the unique combination of these multiple components of the intervention—the cues to action (daily quizzes and individual or peer feedback) and links to self-study resources (daily readings and HMU courses)—that was appealing to participants. When asked which of the components was most useful, nearly half chose all 3, rather than selecting only one.

Impact on HIV Knowledge

In mCME V.2.0, intervention participants accessed HMU courses and daily readings significantly more than the control group did, and response rates to the daily quizzes remained high throughout the trial. This resulted in a significant difference in examination scores between intervention and control participants [18]. Of the 48 intervention participants, 83% (n=40) felt that they were better prepared to care for patients with HIV in their communities, compared with 67% (n=32) at baseline. In the FGDs, participants reported similarly that the intervention improved their knowledge of HIV. One participant said that, “At first I didn’t know much, but after that I still needed to read more materials and use the internet to improve my knowledge” (participant in Thái Nguyên). Another noted that, “The benefit is that [the quizzes] motivated me to search for information in order to answer questions in the field that I do not have much knowledge about” (participant in H i Phòng).

Impact on HIV Feelings of Self-Efficacy

Our intervention did not evaluate clinical skills, but we did ask participants to comment on their own abilities pertaining to HIV care. Figure 2 illustrates additional self-assessment data of HIV knowledge and self-efficacy. Of particular note, 85% (41/48) of intervention participants reported that they either agreed or strongly agreed with the statement “I feel confident providing clinically accurate HIV diagnoses and counseling to patients,” and 94% (45/48) agreed or strongly agreed with the statement “I feel confident in my ability to educate patients about HIV prevention” (Figure 2). However, none of these self-assessments different significantly from the control group, with the exception of the statement “I feel confident in my ability to appropriately identify patients who require methadone treatment.” One FGD participant summed up these views, saying that, “The most important benefit is that [the courses] increase our knowledge and help us become more confident” (participant in H i Phòng).

Discussion

Principal Findings

Data from this randomized controlled trial among HIV clinicians in Vietnam may suggest that a mobile CME intervention is both effective at improving medical knowledge and self-study behaviors, and acceptable by trial participants. Participants reported in our postintervention survey and FGDs that they liked the 3 components of the intervention: the daily quizzes, the daily readings, and the HMU online courses. FGD participants noted that the daily quizzes encouraged them to seek out answers and learn on a daily basis, but also commented that clarity of the messaging and the timing of the messages were sometimes an issue. HMU course utilization rates were significantly higher in the intervention group, but participants noted that the quality, format, and loading time of the HMU courses precluded additional use. The HMU courses themselves were unpopular; participants’ use of this resource was low, and public health officials should address feedback on these resources when developing new content for their platforms. The daily readings were not well used during the intervention; some participants found them to be too short to provide sufficient information. However, in the context of mCME, many noted that the readings were helpful in that they provided immediate and accurate answers to the daily quiz questions. We conclude that the intervention was acceptable, was convenient, and helped improve health professionals’ knowledge of HIV treatment and care in Vietnam within this population of HIV providers.

Although we showed the intervention to improve medical knowledge, disaggregating the 3 components of the intervention to understand which was the most influential remains a challenge. A medical degree, or even CME, given over SMS text messaging is not sufficient, and content without practical training is not sufficient for health professionals. We posit that it was not the SMS text messages, but rather the stimulus that they provided to seek out answers and improve their self-study via digital and interprofessional resources, that was responsible for the improvement in medical knowledge. The survey and FGD data presented in this analysis supports this hypothesis, and we also explored this further in a separate quantitative analysis of the factors that led participants to engage in self-study behaviors [19].

Many factors interrelated to facilitate or prevent self-study in this population, as outlined in Figure 1 and Table 2. For example, the convenience of mCME, combined with the feeling that the topic area was professionally relevant, could have motivated a participant to study. Inversely, lack of free time coupled with the feeling that the participant was already an expert in the subject matter could have discourage one from doing so. These factors, considered both individually and with others, may have been important influencers in a participant's decision to engage in lateral learning during the intervention period.

When considering the variables that influence a clinician's decision to seek out in-depth information, we must consider these aforementioned variables, as well as the larger framework of the HBM. This model posits that an individual's perceived severity of disease and perceived susceptibility to disease, along with cues to action and moderating variables, all contribute to the decision-making process of whether to engage in a health behavior [20,21]. Applied to our research setting, the HBM can be used to consider the different factors that influence a clinician's decision to engage in lateral learning (Figure 1). Following this framework, intervention participants chose to both engage and not engage in lateral learning, based on the personal value placed on the modifying factors and their perspectives on the need and importance of CME. In this research study, the intervention group had a larger change in performance between baseline and endline examinations than did controls, who did not have any of the cues to action listed in this model [18]. Past research is consistent with the findings of this analysis, which postulate that, ultimately, medical professionals must find the internal motivation to learn and must view learning both as beneficial to their practice and as something they are capable of doing [22,23].

Multiple theories have been put forward in the field of CME to enhance learning, and these theories need to be applied when developing distance CME programs in the future [24]. This research intervention attempted to answer the question of whether CME might be delivered at a distance, and our conclusion is that this is a viable method, provided that we employ behavior change learning models rather than purely educational ones. Our research framework considered the HBM but adapted it to a pedagogical setting, providing public health professionals with the successful structure that could be repeated and adapted to future iterations of this program at a national scale. Additional quantitative research is recommended in this area to support generalizability to other settings and populations, and to further explore the modifying factors that ultimately influence access, use, and learning.

Limitations

Our study had several limitations. With only 106 health professionals enrolled, our sample size was relatively small, which suggests that this research should be repeated at a larger scale to further inform precise impact measures. However, it is important to note that we selected participants via rigorous sampling and randomization methods, and we were able to capture nearly all eligible participants across the 3 provinces. Additionally, participants in qualitative research are always subjected to social desirability bias, which could mean that the statements made may not accurately reflect their actions so much as their desire to appear to be good students. We mitigated this by triangulating our quantitative and qualitative results and including opinions of only those who ever accessed the components of the intervention when reporting on their views of the intervention. And lastly, our research measured HIV medical knowledge, which is related to but not the same as clinical practice. Future research should explore the modifying factors that affect learning and measure whether CME programs improve clinical diagnoses, treatment, and general performance.

Conclusion

In this randomized controlled trial, we have proven that the intervention (1) improved self-study behaviors, (2) improved medical knowledge, and (3) was acceptable to the target population. This mixed-methods analysis demonstrated that the intervention was easy to use, convenient, and relevant to the participants' work. Factors such as topic relevance, subject matter expertise, and availability of high-quality resources affected participants' decisions to access additional resources. If public health officials choose to scale up this platform to the national level, future programs may consider the lateral learning framework as part of a successful strategy to engage in higher learning and truly improve medical knowledge. mCME was well liked, inexpensive, and cost effective, and thus merits consideration for nationwide scale-up. If implemented, mCME has the potential to improve the medical knowledge of health professionals across multiple disciplines.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Study design of mCME V.2.0 (November 2016 to May 2017).

[PNG File, 628KB - mededu_v5i1e12058_app1.png]

Multimedia Appendix 2

Impact of timing of daily quiz on response rate, correct answer rate, and use of daily readings.

[PNG File, 12KB - mededu_v5i1e12058_app2.PNG]

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Abbreviations

CME: continuing medical education
FGD: focus group discussion
HBM: health belief model
HMU: Hanoi Medical University
mCME: Mobile Continuing Medical Education Project
mHealth: mobile health
SMS: short message service

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Original Paper

Exploring Care Providers' Perceptions and Current Use of Telehealth Technology at Work, in Daily Life, and in Education: Qualitative and Quantitative Study

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Abstract

Background: A telehealth technology education curriculum designed to integrate information technology and telecommunication well has great potential to prepare care providers for health care delivery across space, time, and social and cultural barriers. It is important to assess the readiness level of care providers to use and maximize the benefits of telehealth technology in the health care delivery process. Therefore, this study explored care providers' existing experience using technology in various use contexts and compared their familiarity with telehealth technology's relevant features.

Objective: This study's objective was to explore care providers' familiarity with using technology in different settings and their perceptions of telehealth-driven care performance to lay a foundation for the design of an effective telehealth education program.

Methods: The study used quantitative and qualitative analyses. The online survey included four items that measured care providers' perceptions of care performance when using telehealth technology. Advanced practice registered nurse students rated each item on a 7-point Likert scale, ranging from 1 ("strongly disagree") to 7 ("strongly agree"). They also responded to three open-ended questions about what kinds of health information technology they use at work, after work, and in their current educational program.

Results: A total of 109 advanced practice registered nurse students responded to the online survey and open-ended questionnaire. Most indicated that using telehealth technology enhances care performance (mean 5.67, median 6.0, SD 1.36), helps make their care tasks more effective (mean 5.73, median 6.0, SD 1.30), improves the quality of performing care tasks (mean 5.71, median 6.0, SD 1.30), and decreases error in communicating and sharing information with others (mean 5.35, median 6.0, SD 1.53). In addition, our qualitative analyses revealed that the students used the electronic health records technology primarily at work, combined with clinical decision support tools for medication and treatment management. Outside work, they primarily used video-text communication tools and were exposed to some telehealth technology in their education setting. Further, they believe that use of nonhealth technology helps them use health information technology to access health information, confirm their diagnoses, and ensure patient safety.

Conclusions: This research highlights the importance of identifying care providers' existing experience of using technology to better design a telehealth technology education program. By focusing explicitly on the characteristics of care providers' existing technology use in work, nonwork, and educational settings, we found a potential consistency between practice and education programs in care providers' requirements for technology use, as well as areas of focus to complement their frequent use of nonhealth technologies that resemble telehealth technology. Health policymakers and practitioners need to provide compatible telehealth education programs tailored to the level of care providers' technological familiarity in both their work and nonwork environments.

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KEYWORDS
telehealth technology; nurse practitioners; daily technology use; telehealth care performance; nursing education

Introduction

Digital health is known widely for its potential to bring modern health care to the nontraditional, virtual care horizon using mobile health technologies. As one among the medical technology frontiers, telehealth technology "…provides access to health assessment, diagnosis, intervention, consultation, supervision and information across" [1] by allowing users to involve diverse interactions among patients, providers, and specialists over a virtual care platform. Ranging from telephones, facsimile machines, and electronic mail systems to remote patient monitoring devices, users on each end of telehealth technology need to exchange various forms of data and communicate on the mobile platform for virtual care processes. Accordingly, these virtual services require skilled care providers who can manage and analyze multimedia data, make real-time decisions via video or audio communication, and relay such information to other related care provider(s) or team(s).

As telehealth technology is changing modalities of care delivery rapidly, there is a growing expectation that care providers' use of telehealth technology can play a pivotal role in realizing its benefits and improving the quality of care. As the health care sector is embracing a variety of health technologies and reaching its maturity (eg, electronic health records), more than 70% of health care providers have adopted telehealth technology for their inpatient and ambulatory patient care services [2]. In fact, these providers often have to use new telehealth technology in addition to other technological priorities and responsibilities in care environments, which can be challenging and disruptive. Given how quickly telehealth care services are developing with multiple care modalities [3], care providers need to understand two components of telehealth technology: exchanging electronic information from one site to another [4] and using a wide variety of modalities in telecommunications technologies. Although existing information technology infrastructure facilitates electronic information exchange within health care organizations [5], telehealth telecommunications are more complex, featuring *live conferencing* for interactive two-way communication, *store-and-forward* systems to exchange health information recorded, and *hybrid* mechanisms that feature both live and recorded information care modes [6]. Therefore, it is imperative that care providers are familiar with new technological dynamics, so that they can diagnose and consult with patients by using new telehealth-driven care modalities [7,8].

Under these circumstances, a clinical educational program can nurture care providers' familiarity with telehealth technology. Advanced practice registered nurses (APRNs) are one of the largest groups of health care providers at the forefront, as their responsibilities involve direct patient care in rapidly changing health care systems. As telehealth technology-driven care services shift the way care is delivered and affect online health care communication between providers and patients and among providers directly, it is critical that future health care providers are educated with well-designed, technologically advanced curriculums [9]. Further, clinical educators should consider the effect technology can have on students' performance within and beyond the educational settings. Similarly, health profession students should take an active role by expanding their knowledge of health care technology to increase their awareness of its influence in the process of patient care.

Prior studies of provider technology education have focused on incorporating telehealth technology within the curriculum. For example, various factors facilitate and provide barriers to the adoption of telehealth technology [8]. As an education tool, mobile telehealth technology has been shown to help enhance medical students' virtual communication skills and raise awareness of patient data protection [10]. A recent systematic review showed that although using information and communication technology can help health professionals share clinical practice standards, their perceptions of and behaviors toward the technology vary by the types of technologies they use in different settings [11] and among different care provider groups such as nurse practitioners [12,13]. Given that care providers are using a variety of technologies outside educational settings, it might be possible that their existing experience with similar functions and characteristics of technologies may provide information necessary to design an effective telehealth technology education curriculum, all of which calls for more attention on the subject.

Taken together, we consider the assessment of telehealth technology's characteristics as a starting point. Telehealth technology resembles other health information technologies, in practice, and daily nonhealth-related technologies. For example, during a live conference with patients, care providers need to diagnose them over a computer screen while scanning the patients' electronic health information, staring at a computer camera, and answering patients' text queries. Because nontraditional telehealth care services require providers to use this technology skillfully while seeing and treating patients online, the extent to which they are familiar with similar features of telehealth technology may predict their proper use of telehealth technology in virtual patient encounters. Thus, we examined two important components of a telehealth technology curriculum—experience of using both "focal" and "related" technologies across life-work-education settings—and proposed ways to incorporate this information in designing a tailored telehealth curriculum.

Methods

Recruitment

To explore care providers' level of familiarity with telehealth technology, APRN students in a Graduate Nursing Program at a Southeastern US university were recruited as a study sample. All students in this study are registered nurses pursuing advanced degrees in Nursing Practice, who were recruited because they deliver health care throughout the community currently in various practice settings and using various technological modalities. Specifically, these APRN students have been exposed to telehealth technology in their current education setting. After a Nursing Program leader agreed to participate in the study, a preliminary interview was conducted to contextualize the survey. We interviewed three nursing faculty members and refined the survey questions about technology use in three major domains—daily life, work, and the education program. Final consensus was reached on the number of open-ended questions and refinement of survey instruments. In the process, internal review board approval was obtained to contact and survey the graduate nursing students. As one of the coauthors had a conflict of interests due to her position as a nursing faculty member, the nonnursing author alone was involved in data collection and analyses. Two cohorts of APRN students were then invited to participate in a voluntary online survey during the Spring and Summer semesters in 2018. One cohort started the program in the Spring (primarily in the family program), while the summer cohort was in their final semester of the program across disciplines such as Family Medicine, Psychiatric/Mental Health, Pediatric Medicine, and Adult Geriatric Medicine.

Survey Instruments

To assess the survey instruments' face validity, researchers, nurse practitioners, and technologists evaluated and refined our items before pretesting. During the pretest, we collected 20 responses and revised our items for the final survey accordingly. Table 1 presents the questions that the participants responded to using a 7-point Likert scale (1: strongly disagree to 7: strongly agree).

The survey also included open-ended questions that explored individual APRN students' use of health and nonhealth information technology at work, in their education programs, and for personal use. Participants were asked to name the types of health information technologies that they have used frequently in the three different settings (eg, "Which health information technology do you use in your work setting?").

Statistical Analysis

The study generated both quantitative and qualitative results. We sent an online, cross-sectional survey to the two cohorts enrolled in the Graduate Nursing program (a total of 155 students) during the Spring and Summer semesters and had been exposed to telehealth technology in a simulation laboratory. A total of 109 responses were collected from the Spring cohort (n=71) and Summer cohort (n=38), with a 70.32% response rate. All the data were self-reported, so the researchers carefully evaluated nonresponse bias [14,15] and the common method bias [16]. Nonresponse bias occurs when there is a systematic difference between respondents and nonrespondents. We checked nonresponse bias by comparing the difference between early and late responses for each cohort in the Spring and Summer semesters and confirmed that there was no mean difference between them. Second, as we collected independent variable and dependent variable data in the same survey, we further performed the Harman single-factor analysis to assess common method bias. The results showed that one factor explained 35.24% of the variance, confirming no threat of the common method bias. However, not all students answered the demographic or key research questions, resulting in smaller sample sizes.

Table 1. Questions used to survey advanced practice registered nursing students' perceptions of care performance using telehealth technology.

Question #	Survey question
1	I believe that telehealth technology can increase my overall performance on care tasks.
2	I believe that telehealth technology can increase my effectiveness with care tasks.
3	I believe that telehealth technology can increase the quality of dealing with care tasks.
4	I believe that telehealth technology systems can decrease error rates in communicating and sharing information with others.

Results

User Statistics

A total of 86 students responded to the demographic questions. As shown in Table 2, 70.9% of these students were female and most (67.4%) were between the ages of 26 and 40 years. Approximately half of the students (49%) were working full-time at a health care organization at the time of the survey, and 32.6% had obtained a master's degree already.

Inclusion of Telehealth Technology Use in the Curriculum

Exploring Care Providers' Experience of Using Telehealth-Related Technologies

First, we explored the possibility of including telehealth technology use in the curriculum by looking at care providers' perceptions of telehealth technology overall. Specifically, we asked whether APRN students believe that using telehealth technology can enhance their care performance at work. Because all respondents had experience with a telehealth technology (ie, doxy.me) in the school's simulation laboratory, this question was used to ask the students about their existing experience of using telehealth technology and their perceptions of care performance using the technology in the future. Of the 109 students recruited, 100 responded to these questions, and our descriptive statistics showed that most respondents perceive using telehealth technology positively (Table 3). More specifically, APRN students thought that telehealth technology could improve their care performance overall (Question 1: mean 5.67, median 6.0, SD 1.36). In addition, our respondents perceived that technology helped make their care tasks more effective (Question 2: mean 5.73, median 6.0, SD 1.30) and improved the quality of performing care tasks (Question 3: mean 5.71, median 6.0, SD 1.30). Lastly, they also believed that using telehealth at work decreased errors in communicating and sharing information with others (Question 4: mean 5.35, median 6.0, SD 1.53).

Table 2. Descriptive statistics of survey respondents.

Variable	n (%)
Gender	
Male	25 (29.1)
Female	61 (70.9)
Age (years)	
18-25	10 (11.6)
26-40	58 (67.4)
41-55	17 (19.8)
56-65	1 (1.2)
Education	
Bachelor's degree	51 (59.3)
Master's degree	28 (32.6)
Doctoral degree	2 (2.3)
Others	5 (5.8)
Income status (US$ per annum)	
25,000-49,999	19 (22.1)
50,000-74,999	34 (39.5)
75,000-99,999	8 (9.3)
≥100,000	9 (10.5)
Prefer not to answer	16 (18.6)
Occupational status	
Working full-time	49 (57.0)
Working part-time	31 (36.0)
Unemployed	4 (4.7)
Unable to work	1 (1.2)
Other	1 (1.2)

Existing Experience of Using Technology via Qualitative Textual Analysis

Next, we delved further into the types of technologies that care providers have used across multiple domains to identify their similarities and differences. In our survey, each respondent was asked to list the names of technology they have used at work, in daily life, and in educational contexts (Tables 4-6).

According to the 78 respondents who answered this question completely (Table 4), the technology they used most frequently in their work was electronic health record systems from different vendors (24.36%) such as Epic, Cerner, and eClinical Works. Furthermore, they used evidence-based clinical decision support tools: 17% reported using Epocrates and 14% used Wikipedia-type reference tools such as UpToDate. Interestingly, 2% of respondents used a telehealth app (eg, Care on Demand). Other categories included diverse responses such as Sanford guide and health4 me.

During their educational program, respondents seemingly used a similar variety of health information technologies from their work place (Table 5).

In our last open-ended question, APRN students were asked to name nonhealth care technologies that they use in their daily lives, such as the internet, Facebook, Twitter, YouTube, and text messages. As respondents did not specify the names of apps that they use after work hours, we reported their frequency of using technology across broad categories of nonhealth technologies. As shown in Table 6, 88 APRN students used social network and chatting apps most frequently (72% for daily use), followed by internet banking (43% for weekly use) and transportation apps (44% for monthly use).

Table 3. Descriptive statistics of survey questions and responses.

Questions and responses	n
Question 1	
Strongly disagree	4
Disagree	1
Somewhat disagree	1
Neither agree nor disagree	5
Somewhat agree	22
Agree	41
Strongly agree	26
Question 2	
Strongly disagree	4
Disagree	2
Somewhat disagree	2
Neither agree nor disagree	22
Somewhat agree	45
Agree	25
Question 3	
Strongly disagree	3
Disagree	1
Somewhat disagree	2
Neither agree nor disagree	4
Somewhat agree	23
Agree	40
Strongly agree	27
Question 4	
Strongly disagree	3
Disagree	3
Somewhat disagree	7
Neither agree nor disagree	10
Somewhat agree	22
Agree	30
Strongly agree	25

Table 4. Summary of health technology types used in the workplace.

Technology	Tool	n (%)
Electronic Health Records	Epic, Cerner, Allscripts, mychart	19 (24.35)
Epocrates	Clinical Decision Support	13 (16.67)
Medscape	Clinical Portal	4 (5.12)
UpToDate	Drug Reference	11 (14.10)
CDC[a] Vaccine Schedules	Vaccine Reference	4 (5.12)
Care on Demand	Telehealth App	2 (2.56)
Other	Sanford guide, health 4 me, etc	25 (32.05)

[a]CDC: Centers for Diseases Control and Prevention.

Table 5. Summary of the health technology types used in the education program.

Technology	Tool	n (%)
Electronic Health Records	Epic, Cerner, etc	14 (25.00)
Epocrates	Clinical Decision Support	8 (14.29)
Uptodate	Drug Reference	3 (5.36)
School websites	None	7 (12.50)
Simulation laboratory technology	School Technology including Telehealth Technology	4 (7.14)
Typhon	Student Tracking System	6 (10.71)
Others	Familydoctor.org, PharmaxSoft, np notes, etc	14 (25.00)

Table 6. Summary of health technology types used in daily life.

Technology category	Daily, n (%)	Weekly, n (%)	Monthly, n (%)	Never, n (%)
Internet banking	39 (44.32)	38 (43.18)	10 (11.36)	1 (1.14)
Online shopping	21 (23.86)	34 (38.64)	28 (31.82)	5 (5.68)
Social network	63 (71.59)	16 (18.18)	5 (5.68)	4 (4.55)
Entertainment	40 (45.45)	26 (29.55)	11(12.50)	11 (12.50)
Chatting	63 (71.59)	8(9.09)	7 (7.95)	10 (11.36)
Transportation	14 (15.91)	19 (21.59)	39 (44.32)	16 (18.18)

Lastly, to explore the students' perceptions of the effect of using nonhealth technology daily on the use of health technology at work, we sent the students a follow-up question in an email survey, in which each respondent was asked, "When you recall using apps such as banking apps, social media apps, entertainment apps, communication apps, transportation apps, or chatting apps in your daily lives, do you believe such non-health technology use influences health information technology (HIT) use at your current work place? If the answer is yes, how specifically does using apps in your personal life influence your patient care performance at work?" Of the 109 students, 14 answered this question. Of them, 3 responded that using apps outside the classroom helped them feel comfortable and more confident in caring for patients:

> *I would learn more through using apps to help my patients.*
>
> *It helps with everything.*
>
> *I am young and using apps is comfortable to me.*

To the second follow-up question, 9 students answered that the use of apps in multiple domains enables them to access health information, confirm diagnoses and tests, and maintain patient care safety easily (Textbox 1).

Taken together, our quantitative and qualitative results indicated that (1) APRN students believe the use of telehealth technology can increase their care performance, (2) they are familiar with features of recording/managing patient information via EMR as well as decision-support tools to identify medical symptoms and treatment for clinical decision making at work, (3) they use similar technologies in their education setting, and (4) most students use social network and chatting apps on a daily basis (72% for both categories) in daily life and believe that using apps in daily life makes them feel confident about accessing health information by using the workplace health technology at the time of care. In the next section, we discuss how a new technology curriculum can integrate this information.

Textbox 1. Quotes from the responses of 9 students to the second follow-up question.

"It advantages since the information is accessible."

"More access than my head can hold."

"Helps to confirm your recall especially a test and confirm what you are doing."

"To check pharm is for safer for patients…"

"My comfort level makes it easier for me to use apps."

"I am comfortable to search for things at work."

"Provide safer care…"

"Confirm diagnosis and tests…"

"I can be more accurate with medications and check for safety interactions."

"My head cannot hold all the information I need so it helps me to help the patient."

"To look for information to diagnose and look for medications, to do everything."

Discussion

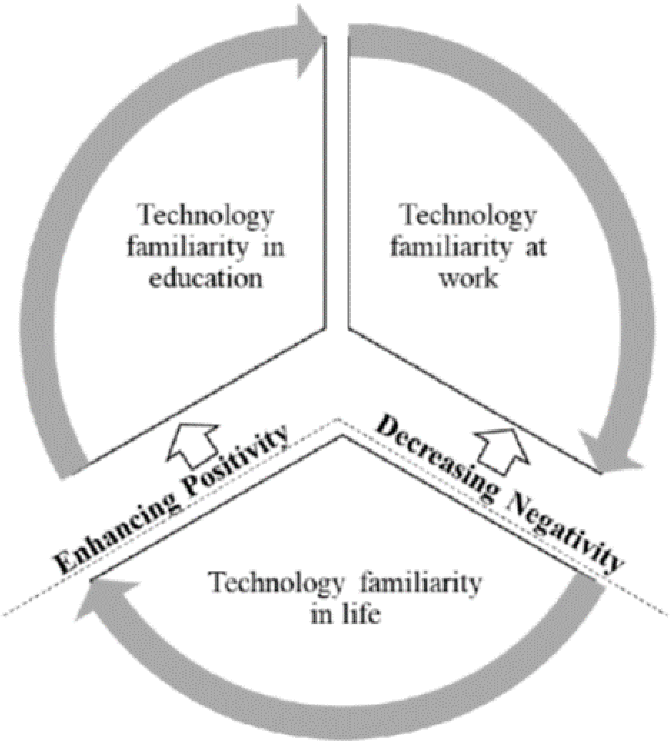
Principal Results

As the first step in designing a technology education curriculum, this research explored care providers' familiarity with telehealth technology by considering their level of exposure to using various features of both health- and nonhealth-related technologies in different settings. Acknowledging the scarcity of research in this domain, our study focused particularly on the characteristics of telehealth technology, which combines various technological features such as electronic health data management, real-time communication using multimedia, and chatting without hybrid formats, and further traced the system types that care providers have used across different settings. The results from both the quantitative and qualitative analyses showed that care providers have positive attitudes about telehealth technology's ability to enhance their care performance with respect to overall task performance, effectiveness of care, quality of care tasks, and sharing information. Further, technologies for personal use shared similarities with the focal telehealth technology, nurturing their abilities to communicate virtually and manage multimedia images, as well as highlighted the benefits of using nonhealth technology in life when using telehealth technology at work.

Although the study was exploratory, our explicit focus on care providers' use of technology in the three domains suggests that a telehealth education curriculum can be complemented by the use of other similar technology. In summary, our findings showed that (Figure 1): (1) there is strong overlap in technology familiarity between workplace and education programs and (2) daily experience of using nonhealth technology does not mesh with the existing nursing education, although care providers use mobile technology features daily that share commonalities with telehealth technology features. Thus, we propose that a telehealth curriculum needs to incorporate the existing experience of using technology, promoting similarity between telehealth technology and daily technology use. More specifically, adding components of social media and virtual communication to the existing nursing education may enhance the familiarity with a telehealth technology. For example, including social media channels to promote communication among students and between faculty members and students may promote their positive experiences with the similar features of telehealth technology [17]. As another example, to alleviate any negative perceptions such as frustration with technology about using technology overall, adding YouTube-based instructions on trouble shooting for telehealth can help enhance care providers' autonomy in processing necessary information about a new technology [18].

From a practical standpoint, it is timely to assess care providers' technology experience about their increasing role at the forefront of using virtual patient care modalities, particularly with rural or underserved populations [12]. It is important to understand APRN students' use of technology in the workplace, daily life, and educational programs to gain an understanding of their ability to adapt to the health care arena, as this arena will require them to use and be increasingly adaptable to technology in order to facilitate patient communication and improve patient safety and practice outcomes. Many health technologies have transformed professional health care practices, which alters the educational requirements for future practitioners. A flexible education program employing new technologies in the market in a timely manner has helped care providers familiarize themselves with various features from such health technologies and increase their comfort level [19-21]. For example, many educators use personal digital assistants in clinical education to take advantage of the current technology to enhance care providers' learning outcomes [22-24]. More recently, a video-based education program was shown to increase nursing students' satisfaction and learning experiences [25]. Furthermore, the telehealth curriculum has suggested the inclusion of problem-based solving and telehealth site visits in the curriculum [26].

Figure 1. Incorporating technology familiarity at work, in life, and in education programs.



However, development of a new technology program is not an easy task. Considering the fast-moving technology advances in the health care arena [27], a technology curriculum for health profession students may not keep up with the speed and variety of the prevalent health technologies. Moreover, care providers' technological ability to combine technology use and health care services is still neither defined well nor instructed frequently. An alternative educational focus on "related" technology experience in daily life may allow health care educators to take a proactive approach to incorporating newly developed health technology into education settings. In particular, health care educators can identify similar, widely available technologies that provide similar technology experience in the education setting and encourage providers to use them in training, all of which can help care providers enter the workforce with positive attitudes about new workplace technology.

Health care information technology vendors should also consider care providers' familiarity and experience with health as well as nonhealth information technologies for the design of a new health technology in the market. This is closely related to system usability, and a well-designed telehealth technology providing additional care monitoring and decision support capabilities can reduce care providers' frustration toward the technology [28]. Addition of familiar features may encourage care providers to reduce the level of frustration about health technology and adopt a new health technology at work.

Limitations

This research was an initial pilot study for a grant proposal. First, given the time and resources available when the study was conducted, only APRN students (n=109) in limited specialties such as Family Medicine participated. Future researchers should consider recruiting more APRN students with diverse specialties. Second, to capture care providers' continuous use of various domain technologies, their technology use behaviors should be tracked over time and analyzed using a cross-sectional time-series analysis. Third, a more in-depth survey is necessary to capture providers' daily use of nonhealth technology to compare technology use in both work and nonwork contexts. As participants self-tracked their use of various technologies across three different settings based purely on their memory and willingness, more robust data collection will enhance this study's qualitative analysis findings. Finally, in this paper, we identified the importance of considering care providers' technology experience across contexts and their care performance using telehealth technology. Future research may examine whether and how experience can influence attitudes and behaviors related to using telehealth technology through robust statistical analysis.

Conclusions

This study provided insights to inform a new telehealth nursing education program by exploring nursing students' technology use characteristics at work, in daily life, and in an educational setting. These findings contribute to the health education literature and to health policy initiatives by demonstrating a new approach to incorporate care providers' existing experience of using cross-domain technologies to design a tailored telehealth technology curriculum.

Authors' Contributions

HH was involved in the creation and distribution of the survey, analysis of the results, and drafting of the manuscript. DG was involved in creation and distribution of the survey and revising the manuscript. All authors read and approved the final manuscript. We appreciate Gloria Deckard's valuable comments on an earlier version of the manuscript.

Conflicts of Interest

None declared.

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Abbreviations

APRN: advanced practice registered nurses
CDC: Centers for Diseases Control and Prevention

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Original Paper

Evidence-Based Physical Therapy Practice in the State of Kuwait: A Survey of Attitudes, Beliefs, Knowledge, Skills, and Barriers

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Abstract

Background: Evidence-based practice (EBP) is necessary to improve the practice of physical therapy. However, a lack of knowledge and skills among physical therapists and the presence of barriers may hinder the implementation of EBP in the State of Kuwait.

Objective: The objectives of this study were to extensively (1) investigate attitudes toward EBP, (2) assess the current level of knowledge and skills necessary for EBP, and (3) identify the barriers to EBP among physical therapists in the State of Kuwait.

Methods: The following methods were used: (1) a previously validated self-reported questionnaire and (2) a face-to-face semistructured interview. The questionnaire, which was distributed to 200 physical therapists, examined the attitudes and beliefs of physical therapists about EBP; the interest in and motivation to engage in EBP; educational background, knowledge, and skills related to accessing and interpreting information; the level of attention to and use of the literature; access to and availability of information to promote EBP; and the perceived barriers to using EBP. The interview explored the factors that promote or discourage EBP. Descriptive statistics and logistic regression analyses were used.

Results: Of the 200 nonrandomly distributed questionnaires, 92% (184/200) were completed and returned. In general, the physical therapists had positive attitudes, beliefs, and interests in EBP. Their educational background, knowledge, and skills related to assessing and interpreting information were well-founded. The top 3 barriers included insufficient time (59.2%, 109/184), lack of information resources (49.4%, 91/184), and inapplicability of the research findings to the patient population (40.7%, 75/184).

Conclusions: EBP lacks support from superiors at work. Thus, identifying methods and strategies to support physical therapists in adopting EBP in the State of Kuwait is necessary.

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KEYWORDS

physical therapy practice; evidence-based practice; attitudes; knowledge

Introduction

Background

There is no doubt that evidence-based practice (EBP) is essential to improve physical therapy (PT) practice, as this strategy ties high-quality research evidence with the clinical expertise of physical therapists (PTs) and patient preferences to achieve the best clinical decision and PT care. EBP can also minimize the misuse, overuse, and underuse of health care services [1].

Globally, numerous studies have investigated the attitudes, skills, knowledge, and barriers to practice based on evidence among health care providers [2-5] including PTs [6-17]. Generally, PTs had positive attitudes toward EBP [6-13], with the majority of PTs believing that the use of research evidence is necessary to their practice [6,8-10,15]. The required skills and knowledge included the ability to phrase and ask a clinical question; search the literature using Boolean operators; and find, read, and critically evaluate the research findings using statistical knowledge to select the best and up-to-date evidence at any stage of PT care [6-8,10,13-16]. Lack of time was the most commonly reported barrier [6-8,10,11,15-17]. Other barriers included the lack of skills in identifying and critically evaluating research evidence, insufficient administrative support, insufficient access to evidence, inability to apply research findings to specific patient populations, and insufficient teaching in previous education.

In the State of Kuwait, PT care is provided and financed primarily by the government through the Ministry of Health (MoH). Approximately, 700 PTs are working in various specialties in various general and specialized hospitals distributed in 6 health regions: Alahmadi, Alfarwaniya, Aljahra, Alsabah, Hawally, and Alasema [18]. The majority of PTs in the workforce are non-Kuwaiti and are foreign-trained [18]. Foreign-trained PTs sit for a licensure exam before registering with the Kuwait Medical Licensing Authority (KMLA), whereas Kuwait-trained PTs only register with KMLA. Access to PT care is not direct and patients are referred from primary or secondary care. Similar to the health services, PT education is offered mainly through the government university. This one and only university has been offering a bachelor’s degree since 1982.

Strong training in EBP is not included in the university curriculum nor is it practiced among PTs in the MoH. This was evident in the literature that examined the extent of using research evidence as the basis for PT practice in Kuwait [19]. The study included Kuwaiti musculoskeletal PTs only and found that the current PT practice was more reliant on the basic knowledge acquired during undergraduate education, with minimal use of research evidence to inform the choice of the therapy technique. Despite these findings, PTs in Kuwait are trying to shift toward EBP [20]. However, they apparently lack the knowledge and skills necessary to practice PT based on evidence.

On the basis of the literature, a comprehensive in-depth investigation of the attitudes, the current level of knowledge and skills, and the barriers related to EBP among PTs is lacking in the State of Kuwait. Previous studies [19,20] touched superficially and indirectly on this topic and did not include all practicing PTs, Kuwaiti and non-Kuwaiti in various PT specialties. Needless to say, the findings from this study might help to (1) encourage the use of EBP among PTs, (2) identify methods to support PTs in adopting EBP, and (3) develop guidelines and implementation strategies for EBP in the State of Kuwait.

Objectives

The objectives of this study were to (1) investigate attitudes toward EBP, (2) assess the current level of knowledge and skills related to EBP, and (3) identify the barriers to practicing EBP among PTs in the State of Kuwait.

Methods

Quantitative and qualitative methods were used to collect the data over a 3-month period (September to December 2016) to achieve the study objectives. The study was approved by the institutional review boards at both Kuwait University and the MoH in the State of Kuwait. The participants and instruments used for each method are described below.

Participants

For the quantitative analysis, a convenient sample of 200 PTs received an invitation to participate in this study from approximately 660 eligible PTs currently working in the government hospital located in all governorates of the State of Kuwait. Participants were recruited if they had at least 1 year of clinical experience and were currently working in government hospitals and clinics. In addition, participants were recruited if they could read and understand English, which was the questionnaire language.

For the qualitative analysis, the directors of 8 PT departments were interviewed from the following health regions: Alfarwaneya, Hawally, Alasema, Aljahraa, Alahmadi, and Alsabah. A total of 6 directors worked in general care and 2 directors worked in specialized care. In addition, the head director of the PT departments at the MoH was interviewed. Participants had at least 15 years of clinical experience and at least 5 years of administrative experience. Directors were included in the study to explore the liaisons between the higher management and the working PTs. In particular, the interviews with PT directors would provide a good understanding about the current situation of PT and EBP, including the facing difficulties, together with the ways to overcome them practically and administratively.

Instruments

Questionnaire

For the quantitative analysis, a self-reported questionnaire was used in this study. The questionnaire was previously developed, wherein the content validity and reliability (Intraclass Correlation Coefficient (1, K) ranged from .37 to .90) of the questionnaire were established [6]. The questionnaire comprised 32 items. These items examined the PTs’ (1) attitudes and beliefs about EBP (items 1, 2, 4, and 6 to 11); (2) interest in and motivation to engage in EBP (items 3 and 5); (3) educational background, knowledge, and skills related to accessing and interpreting information (items 25 to 31); (4) level of attention to and use of the literature (items 12 to 14); (5) access to and availability of information to promote EBP (items 18, 19, and 21 to 23); and (6) perceived barriers to using EBP (item 32). The participants rated their attitudes, beliefs, education, knowledge, and skills related to EBP using a 5-point Likert scale with responses varying from *strongly disagree* to *strongly agree*. Items related to access to information required *yes/no* responses. In addition, demographic and practice data were collected, including the age, gender, nationality, education degree, years of experience, area of specialty, work environment, and patient load of the participant, as well as their contribution to research.

Interview

For the qualitative analysis, face-to-face semistructured interviews were conducted with the PT directors. The interview used questions that were developed by the research team in a previous study [5]. The questions were reviewed for relevance to this study. No changes were made, and the questions focused on 3 main themes: (1) background on EBP; (2) opinions on implementing EBP; and (3) current barriers and facilitators to adopting EBP in the PT field. See Multimedia Appendix 1 for interview questions.

Procedures

The cross-sectional survey was conducted by distributing the questionnaires to PTs at their workplace using a convenience sampling technique. The questionnaire, as well as the invitation letter and consent form, was distributed and collected by the fifth author over the period of a week. The letter explained the purpose of the study and assured the participant confidentiality of their responses.

Separate interviews with the head director of the PT departments at the MoH and the director of each PT department were arranged in advance. The interviews were conducted by the second author. They were transcribed verbatim. File notes were taken during and after the interview. The notes were typed out directly after completion of the interviews to ensure accurate documentation of all information.

Data Analyses

Descriptive statistics, including number and percentage of the demographical data of all participants were calculated. Logistic regression tests were used to assess the association between the demographics and research-related items (attitudes and beliefs about EBP; interest in and motivation to engage in EBP; educational background, knowledge, and skills related to accessing and interpreting information; the level of attention to and use of the literature; access to and availability of information to promote EBP; and perceived barriers to using EBP). Odds ratios and 95% CIs were calculated if a significant association was found. Statistical significance was evaluated at alpha=.05; statistical analyses were conducted using SPSS (version 24, SPSS Inc).

A content analysis approach was followed to analyze the interview data. Data from the open- and close-ended questions were transcribed verbatim to enable qualitative data analysis. A list of codes was initially developed based on the content of the semistructured interviews. Additional codes and subcodes were then added as new issues were raised by the participants during the interviews. The coding process was done manually wherein the transcripts were read thoroughly and each text segment was assigned a code or subcode. All transcripts were systematically searched for similar codes or subcodes using an iterative approach, in which the constant comparison method was used throughout the data management [21]. By this method, the data were constantly revisited after initial coding until it was clear that no new codes or subcodes were emerging.

The coding was performed by 2 independent researchers who have expertise in qualitative data analysis. The codes and subcodes by both researchers were compared for similarities and differences for the first 2 transcripts, and no major differences were identified. Therefore, the interrater reliability was not calculated.

Results

Results From the Questionnaire

Participation Rate

A total of 184 PTs completed and returned the questionnaires. The return rate was 92% (184/200). No questionnaire was returned with no less than 95% of the total questions answered. The time taken to complete the questionnaire was 5 to 10 min.

Participant Description

The sociodemographic data of the PTs are shown in Table 1. The results show that the majority of the study population were non-Kuwaiti (58.8%, 106/180) and female (60%, 108/180). Almost 29% (51/180) of the PTs were ranked as PT specialists, with the majority (73.2%; 131/179) holding entry-level degrees. More than half of the participants (62.6%, 109/174) had more than 10 years of clinical experience (mean 14.0 years). More than one-third of the PTs worked in general hospitals (38.4%, 70/182) or in rehabilitation hospitals (37.9%, 69/182). Most of the respondents worked for a minimum of 30 hours per week.

Table 1. Study participant demographics.

Demographics	n[a] (%)
Gender	
Male	72 (40)
Female	108 (60)
Age (years)	
20-29	42 (23)
30-39	79 (43.2)
40-49	50 (27.3)
50+	12 (6.5)
Education	
Bachelor of Science degree	131 (73.2)
Master of Science degree	48 (26.8)
Professional rank	
Junior PTs[b] practitioner	28 (15.6)
PTs practitioner	19 (10.6)
Senior PTs practitioner	42 (23.3)
PTs specialist	51 (28.3)
Senior PTs specialist	30 (16.7)
Superintendent PTs	10 (5.6)
Working hours per week	
<10	22 (12.8)
10-19	5 (2.9)
20-29	38 (22.1)
30-39	62 (36)
40+	45 (26.2)
Work settings	
General hospital	70 (38.4)
Rehabilitation hospital	69 (37.9)
Specialized hospital	43 (23.6)
Participation in continuous education	
Yes	138 (75)
No	46 (25)
Nationality	
Kuwaiti	75 (41.4)
Unidentified	19 (10.5)
Egyptian	17 (9.4)
Filipino	3 (1.7)
Indian	55 (30.4)
Saudi	7 (3.9)
Iraqi	3 (1.7)
Lebanese	1 (0.6)
Palestinian	1 (0.6)

Demographics	n[a] (%)
Nature of work	
Patient care	58 (32.2)
Administration	177 (97.8)
Supervising students	58 (32)
Teaching	31 (17.1)
Professional experience (years)	
0-5	33 (19)
6-10	32 (18.4)
11-15	38 (21.8)
16-20	38 (21.8)
21+	33 (19)
Patient load per day	
1-7	92 (50.8)
8-12	69 (38.1)
12+	11 (11)
Areas of specialty	
Neurology	34 (19.1)
Cardiopulmonary	28 (15.7)
Pediatrics	29 (16.3)
Orthopedics	87 (48.9)

[a]Column values do not always add up to the total number of questionnaire respondents because of missing data.

[b]PTs: physical therapists.

Attitudes, Beliefs, and Interests

The distribution of the data on attitudes, beliefs, and interests of the PTs about EBP is shown in Figure 1. Most of the PTs strongly agreed that the application of EBP was necessary to their practice (77.2%); EBP can improve the quality of patient care (66.9%); the literature and research findings are useful in everyday practice (55.4%); EBP can help with decision making (51.1%); and more evidence should be used in daily practice (48.6%). The majority of PTs indicated that they were strongly interested in learning or improving the skills necessary to incorporate EBP into their practice (58.5%). Some believed that strong evidence is not available to support most of the interventions they used with their patients (37.2%); EBP does not take into account the limitations of their clinical setting (34.3%); the adaption of EBP may place unreasonable demands on them (27.0%); and it cannot account for patient preferences (27.4%).

Significant associations were identified between some demographic factors (age, working hours, and work settings) and attitude and beliefs of the PTs (Table 2). In particular, PTs working in general hospitals believed more than those working in rehabilitation or specialized hospitals that research evidence supporting most of the interventions they used was lacking. In addition, the PTs working for longer hours believed more strongly than the PTs working shorter hours that EBP places unreasonable demands on them. Furthermore, older respondents and male respondents were more likely to hold this belief.

Education, Knowledge, and Skills

The majority of PTs either agreed or strongly agreed that they learned the foundations of EBP as a part of their academic program (79%); they received formal training in search strategies (62.7%); they were familiar with Web-based search engines (73.8%); they received formal training in critical appraisal (56.8%); they were confident in their ability to critically review the professional literature (70.5%); and they were confident in their ability to find research relevant to their clinical questions (81.5%).

Figure 1. Self-reported attitudes and beliefs about evidence-based practice (EBP).

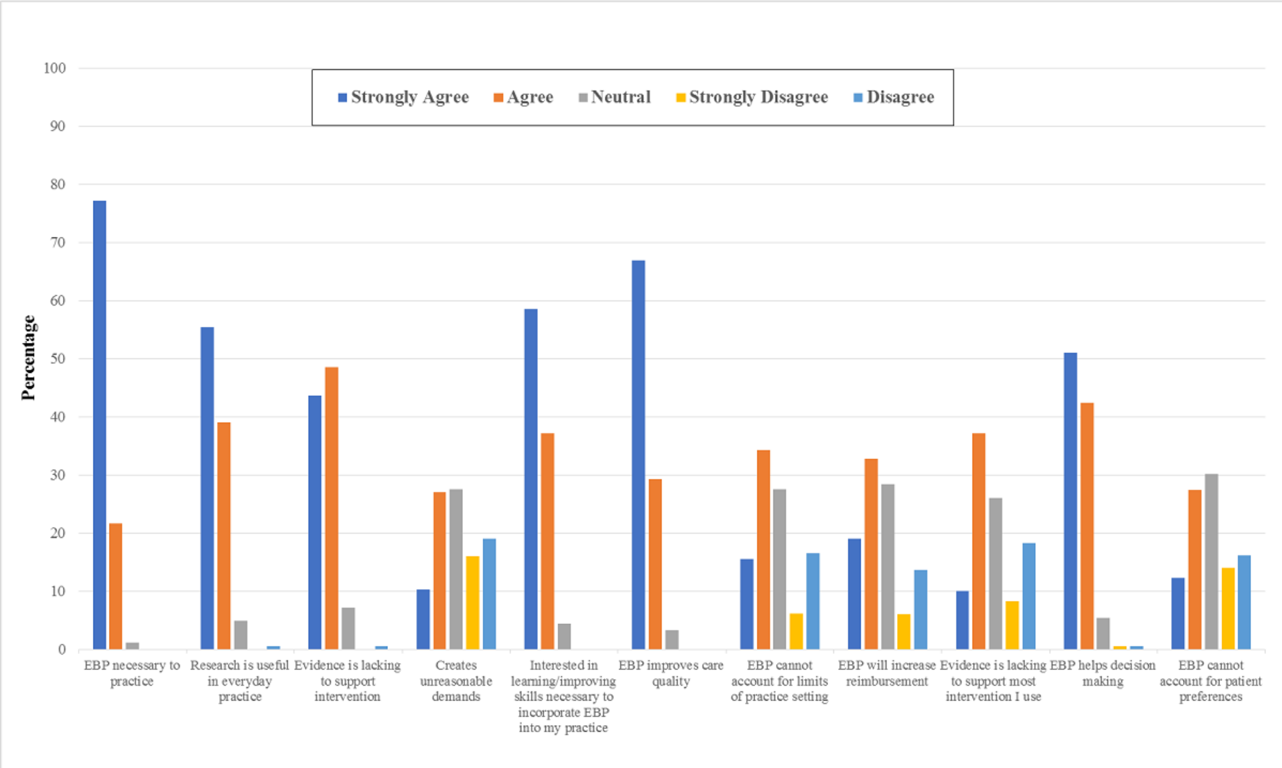


Table 2. Factors (demographics) associated with beliefs about evidence-based practice. The number of respondents varies because of missing data.

Attitude or belief and factor	Odds ratio (95% CI)	Model P[a] value	Model R^2[b]
Item #4: Creates unreasonable demands			
Age (years; n=173)		.004	.100
20-30	0.091 (0.02-0.422)		
31-40	0.194 (0.045-0.831)		
41-50	0.286 (0.07-1.164)		
51+	Reference		
Gender (n=170)		.004	.064
Male	2.517 (1.326-4.779)		
Female	Reference		
Working hours/week (n=162)		.045	.080
<10	0.596 (0.201-1.771)		
10-19	0.256 (0.088-0.746)		
20-29	1.917 (0.289-12.719)		
30-39	0.902 (0.402-2.024)		
40+	Reference		
Item #9: Evidence is lacking to support most intervention I use			
Work settings (n=178)		.003	.086
General hospital	1.034 (0.476-2.247)		
Rehabilitation hospital	0.342 (0.154-0.762)		
Specialized hospital	Reference		

[a]In logistic regression, one level of the independent variable serves as a reference against which the odds of the other levels occurring are determined.
[b]Nagelkerke R^2.

Figure 2 shows the distribution of the education, knowledge, and skills of the PTs about EBP. The results showed that the education, work settings, and area of specialty were significantly associated with the educational background of the PTs and their knowledge and skills related to accessing and interpreting information (Table 3). For example, PTs with Bachelor of Science (BSc) degrees had received more training in search strategies and critical appraisal and were more confident in search skills than PTs with Master of Science (MSc) degrees. In addition, participants with BSc degrees were more familiar with the medical search engines and had learned more about the foundations of EBP compared with those with MSc degrees. PTs working in general hospitals had received more training in search strategies and the critical appraisal of research and were more confident in their search skills than PTs working in rehabilitation or generalized hospitals. PTs working in general hospitals were also more familiar with the medical search engines. Finally, PTs practicing neuro-rehabilitation were more confident in their appraisal skills than PTs practicing other specialties.

The results reveal that PTs had diverse knowledge with regard to the terms related to EBP. The PTs largely understood the following terms: *relative risk* (59.4%), *absolute risk* (61.7%), and *systematic review* (52.5%). However, many PTs did not understand the following terms: *publication bias* (40%), *odds ratio* (40.6%), *meta-analysis* (38.3%), *confidence interval* (35.6%), and *heterogeneity* (36.7%; Figure 3). The PTs with BSc degrees were more likely to understand the terms *odds ratio*, *meta-analysis*, *confidence interval*, *heterogeneity*, and *publication bias* than the PTs with MSc degrees (Table 4).

Figure 2. Self-reported education, knowledge, and skills.

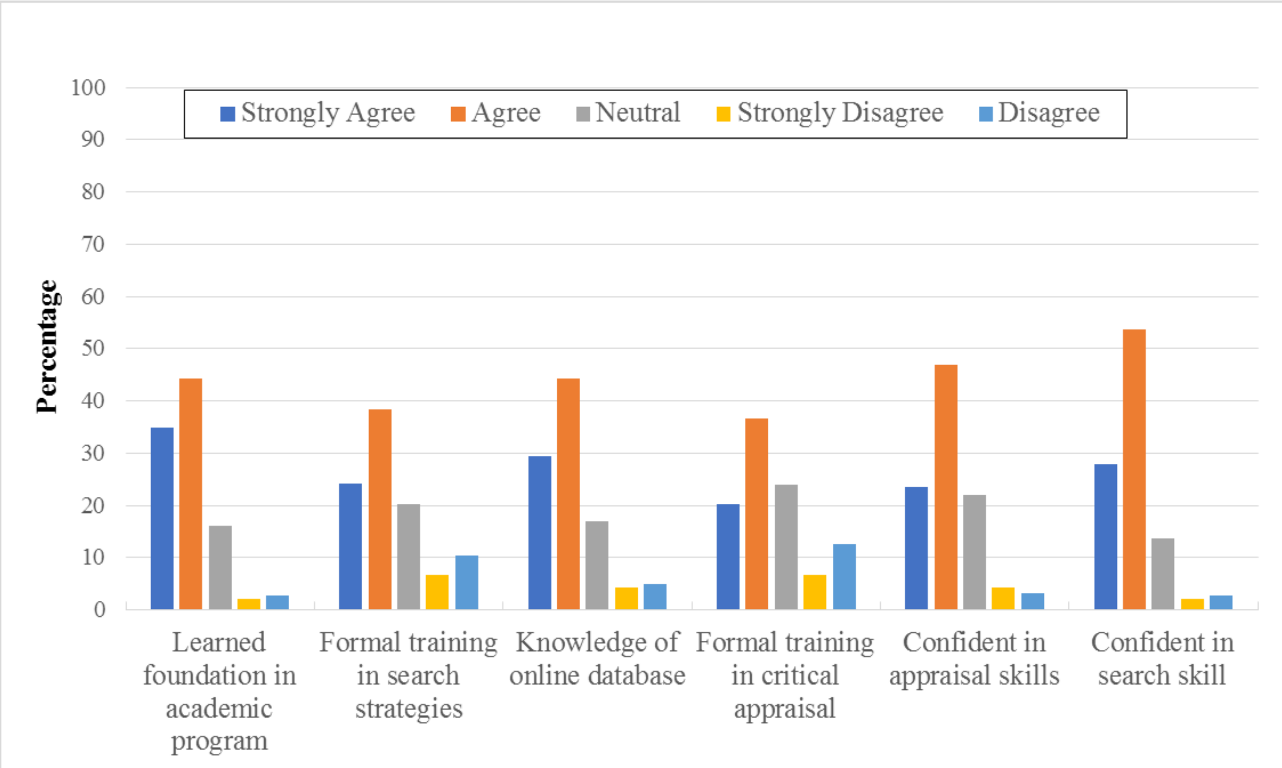


Table 3. Factors (demographics) associated with education, skills, and knowledge necessary for evidence-based practice. The number of respondents varies because of missing data.

Attitude or belief and factor	Odds ratio (95% CI)	Model *P*[a] value	Model R^{2b}
Item #25: Learned foundation in academic program			
Education (n=176)		.02	.047
BSc[c]	0.335 (0.122-0.917)		
MSc[d]	Reference		
Gender (n=177)		.046	.035
Male	2.19 (0.988-4.854)		
Female	Reference		
Item #26: Formal training in search strategies			
Education (n=177)		.004	.061
BSc	0.343 (0.157-0.747)		
MSc	Reference		
Work settings (n=180)		<.001	.137
General hospital	0.859 (0.353-2.087)		
Rehabilitation hospital	0.225 (0.096-0.530)		
Specialized hospital	Reference		
Item #27: Knowledge of Web-based database			
Education (n=178)		<.001	.098
BSc	0.190 (0.064-0.565)		
MSc	Reference		
Gender (n=179)		.01	.053
Male	2.535 (1.212-5.304)		
Female	Reference		
Work settings (n=181)		.03	.055
General hospital	0.713 (0.265-1.920)		
Rehabilitation hospital	0.334 (0.130-0863)		
Specialized hospital	Reference		
Item #28: Formal training in critical appraisal			
Education (n=178)		.02	.041
BSc	0.438 (0.215-0892)		
MSc	Reference		
Work settings (n=181)		<.001	.113
General hospital	1.250 (0.557-2.807)		
Rehabilitation hospital	0.007 (0.150-0.735)		
Specialized hospital	Reference		
Item #29: Confident in appraisal skills			
Gender (n=179)		.003	.068
Male	2.819 (1.378-5.768)		
Female	Reference		
Work settings (n=181)		.002	.092
General hospital	0.401 (0.246-1.754)		
Rehabilitation hospital	0.004 (0.096-0.631)		

Attitude or belief and factor	Odds ratio (95% CI)	Model P[a] value	Model R^{2b}
Specialized hospital	Reference		
Area of specialty (n=177)		.008	.092
Neurology	5.143 (1.680-15.740)		
Cardiopulmonary	2.815 (0.946-8.376)		
Orthopedics	0.002 (1.712-10.257)		
Pediatrics	Reference		
Item #30: Confident in search skills			
Education (n=178)		.02	.046
BSc	0.317 (0.105-0.955)		
MSc	Reference		
Gender (n=179)		.002	.085
Male	3.899 (1.522-9.984)		
Female	Reference		

[a]In logistic regression, one level of the independent variable serves as a reference against which the odds of the other levels occurring are determined.
[b]Nagelkerke R^2.
[c]BSc: Bachelor of Science degree.
[d]MSc: Master of Science degree.

Figure 3. Self-reported knowledge of specific terms.

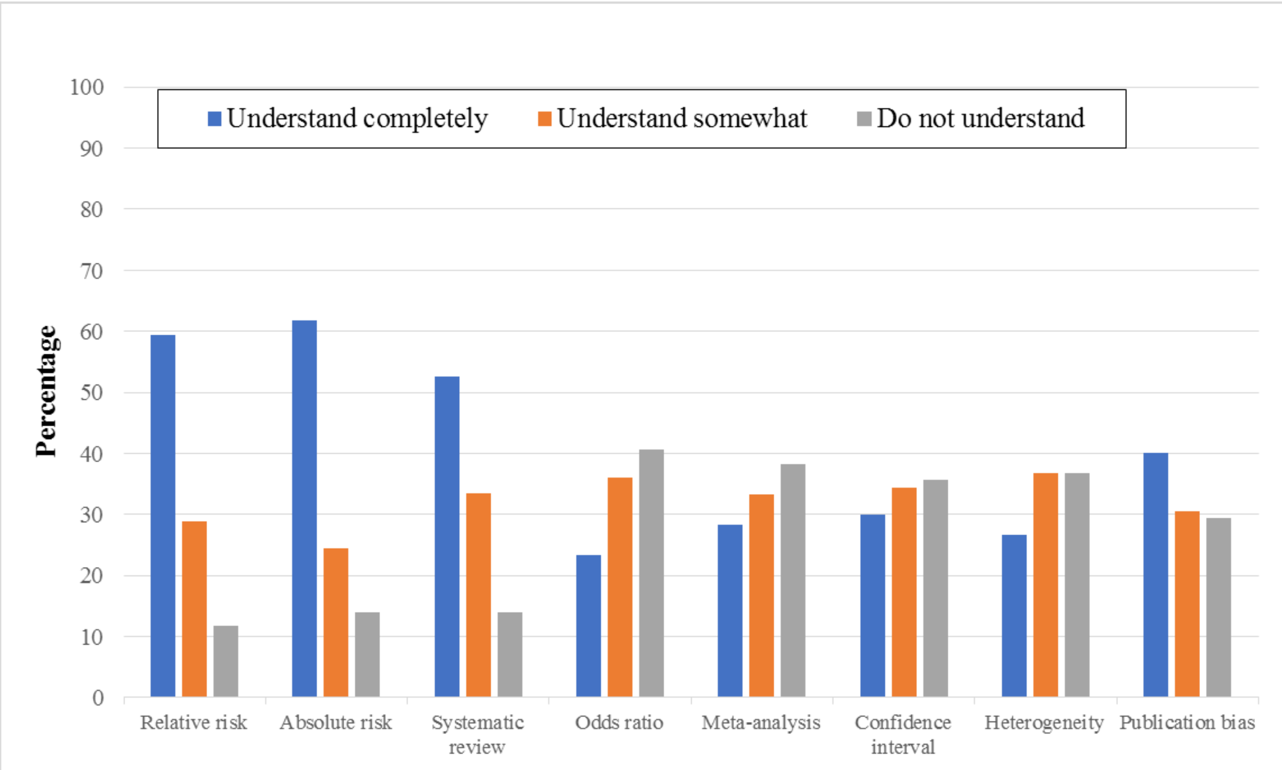


Table 4. Factors (demographics) associated with understanding of specific terms. The number of respondents varies because of missing data.

Terms and factor	Odds ratio (95% CI)	Model *P*[a] value	Model R^{2b}
Odds ratio			
Gender (n=176)		.04	.033
Male	1.948 (1.035-3.667)		
Female	Reference		
Meta-analysis			
Education (n=175)		<.001	.095
BSc[c]	0.248 (0.107-0571)		
MSc[d]	Reference		
Gender (n=176)		.014	.046
Male	2.221 (1.159-4.259)		
Female	Reference		
Confidence interval			
Education (n=175)		<.001	.099
BSc	0.232 (0.097-0.558)		
MSc	Reference		
Gender (n=175)		.05	.030
Male	1.905 (0.991-3.661)		
Female	Reference		
Work settings (n=180)		.001	.109
General hospital	0.697 (0.282-1.722)		
Rehabilitation hospital	0.235 (0.098-0.565)		
Specialized hospital	Reference		
Heterogeneity			
Education (n=175)		.003	.069
BSc	0.314 (0.140-0.704)		
MSc	Reference		
Publication bias (n=175)			
Education		<.001	.121
BSc	0.160 (0.054-0.475)		
MSc	Reference		
Gender (n=176)		.003	.071
Male	2.929 (1.404-6.111)		
Female	Reference		

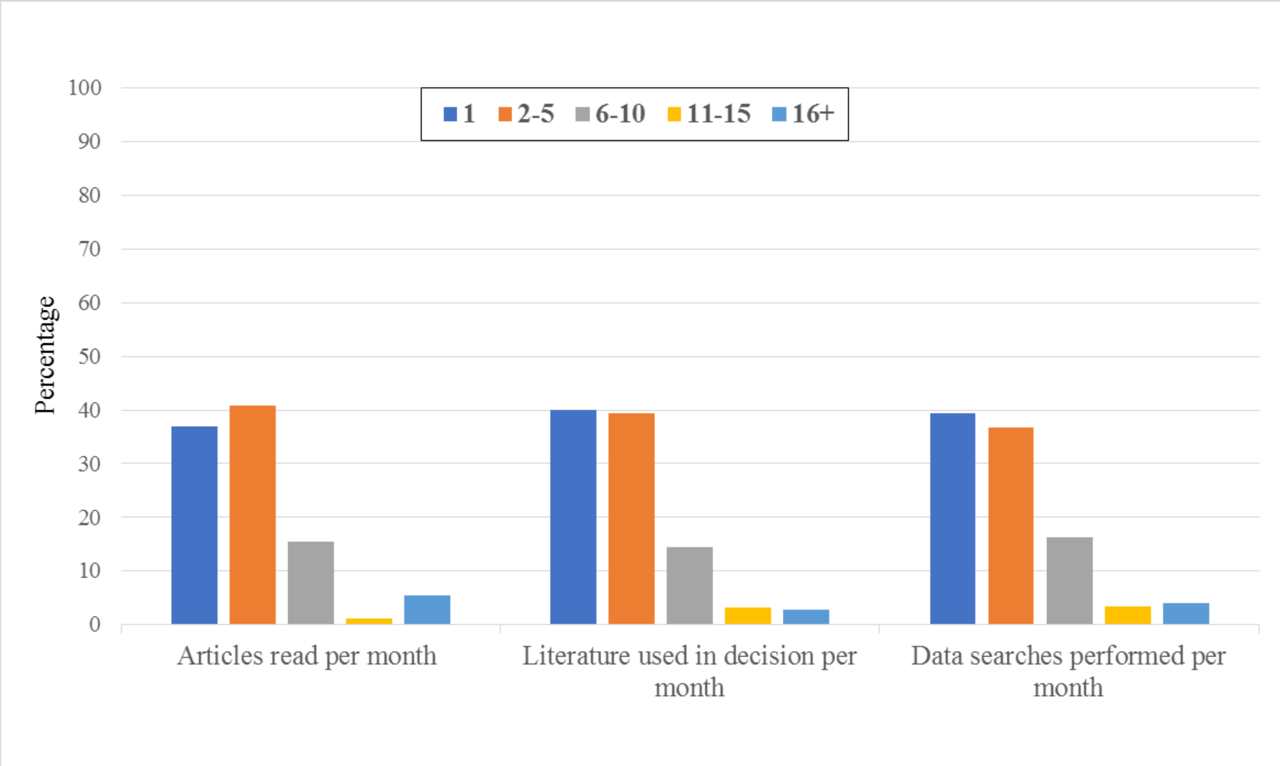
[a]In logistic regression, one level of the independent variable serves as a reference against which the odds of the other levels occurring are determined.

[b]Nagelkerke R^2.

[c]BSc: Bachelor of Science degree.

[d]MSc: Master of Science degree.

Figure 4. Self-reported attention to the literature.



Attention to the Literature

On average, per month, the majority of the PTs read 1 to 5 articles related to their clinical practice (77.9%); used 1 to 5 articles in the process of clinical decision making (79.4%); and performed 1 to 5 data searches for practice-relevant literature (76.2%; Figure 4).

Access to and Availability of Practice Guidelines and the Literature

At work, practice guidelines were available to the majority of PTs (83.5%) and were available on the Web (71.7%). However, access to current paper journals (78.1%) and/or relevant databases (56.8%) was not available to the PTs at their work. Therefore, these individuals mostly accessed the relevant databases away from their work (78.7%; Figure 5).

The work settings and hours, age, gender, and area of specialty were significantly associated with the access to and availability of practice guidelines and the literature (Table 5). For instance, access to paper journals and relevant Web-based databases at work was more possible among PTs working in general hospitals than access among those working in rehabilitation or specialized hospitals. Access to relevant databases outside of work was more likely among middle-aged PTs practicing orthopedic PT.

Barriers

Almost 59% of the PTs ranked lack of time as the greatest barrier to the use of EBP in their practice, with approximately 70% indicating that this factor was one of the top 3 barriers. Lack of information resources (49%) and inapplicability of research findings to their patient population (40.6%) were the second and third greatest barriers, respectively (Figure 6).

Results From the Semistructured Interview

Participant Description

All but 2 of the interviewees were female. The participants held BSc degrees in PT, except the head director, who held an MSc degree in PT. The age of the interviewees ranged from 40 to 50 years.

Interview Themes

Background, Knowledge, Attitudes, and Skills for Evidence-Based Practice

The interview results revealed that 80% of the PT directors had heard about EBP and 60% attended EBP workshops. All of the directors showed willingness to adopt EBP into their PT practice and emphasized the importance of offering continuous training courses or workshops on this topic. These directors believed that PT is primarily evidence based, and 1 director stated the following: “All of the physical therapy techniques that are used for patients are evidence based.”

With regard to the knowledge and skills required to practice PT based on evidence, 1 director indicated that enthusiastic PTs should have the knowledge and skills needed to search, find, and apply the best and most up-to-date treatment techniques and stated the following: “We have some specialists who are truly active in their practice and are ready to do the best job for the better care of patients—most are new graduates from BSc programs or hold MSc degrees or PhDs.”

Figure 5. Self-reported access to and availability of literature.

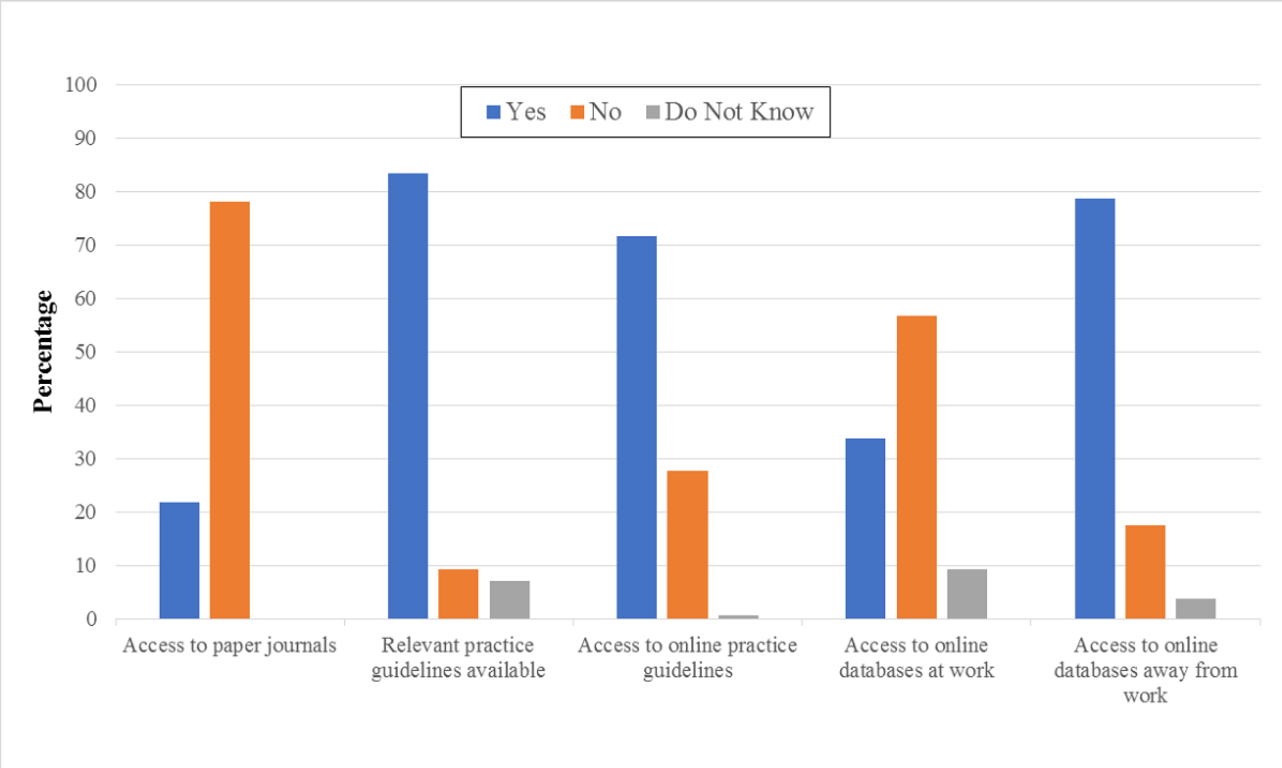
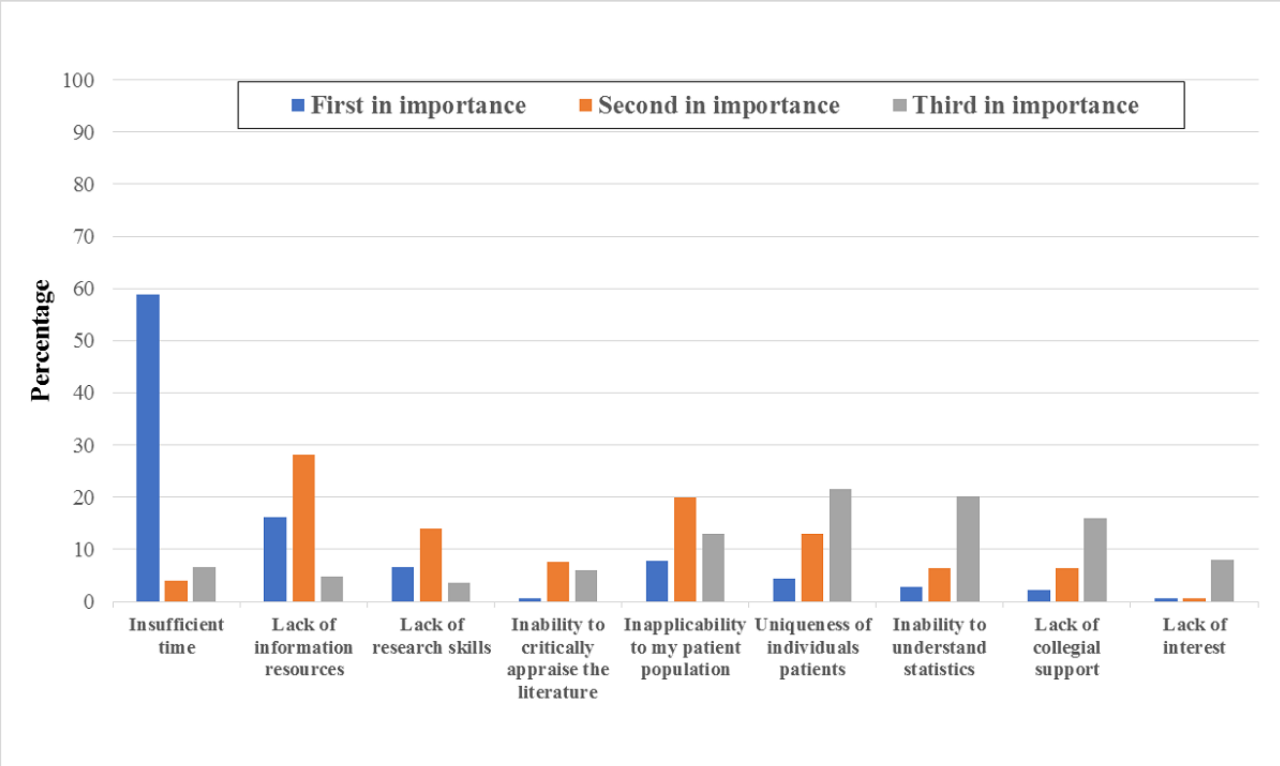


Table 5. Factors (demographics) associated with access to and availability of the literature. The number of respondents varies because of missing data.

Terms and factor	Odds ratio (95% CI)	Model P[a] value	Model R^2[b]
Access to paper journals			
Work settings (n= 181)		<.001	.188
General hospital	1.154 (0.508-2.622)		
Rehabilitation hospital	0.105 (0.028-0.396)		
Specialized hospital	Reference		
Relevant practice guidelines available (n=170)			
Working hours/week		.014	.121
<10	0.330 (0.095-1.142)		
10-19	0.231 (0.032-1.680)		
20-29	5.538 (0.636-48.262)		
30-39	0.699 (0.238-2.058)		
40+	Reference		
Access to Web-based practice guidelines			
Gender (n=176)		.02	.044
Male	2.288 (1.127-4.646)		
Female	Reference		
Access to Web-based databases at work			
Work settings (n=181)		.001	.099
General hospital	2.242 (1.003-5.009)		
Rehabilitation hospital	0.587 (0.245-1.411)		
Specialized hospital	Reference		
Access to Web-based databases away from work			
Age (years; n=182)		.02	.082
20-30	2.231 (0.604-8.243)		
31-40	6.091 (1.662-22.324)		
41-50	4.556 (1.190-17.433)		
51+	Reference		
Area of specialty (n=177)		.004	.109
Neurology	0.165 (0.042-0.653)		
Cardiopulmonary	0.244 (0.058-1.022)		
Orthopedics	0.648 (0.171-2.457)		
Pediatrics	Reference		

[a]In logistic regression, one level of the independent variable serves as a reference against which the odds of the other levels occurring are determined.
[b]Nagelkerke R^2.

Figure 6. Self-reported ranking of barriers to evidence-based practice.



Opinions on Implementing Evidence-Based Practice

All of the interviewees agreed on the importance of EBP in PT, as applying the latest and best therapy for patients is the main aim in health care. However, the interviewees believed that EBP in PT relies on staff readiness. Of them, 1 of the interviewees discussed the importance of EBP with her staff and received this response from a staff member: “It is an unimportant addition to our practice, and we do not need to go for it”.

All of the directors underlined the need for EBP in their practices and to look for the best way to incorporate EBP into routine work. Of them, 1 director stated the following: “PT is not a stressful profession, and we are not working under pressure, so it’s feasible to practice EBP to provide better care.”

Barriers and Facilitators to Adopting Evidence-Based Practice in the Physical Therapy Field

The interview results show that there were 2 main barriers to EBP in the PT departments: (1) staff resistance because of a lack of interest or unwillingness to do extra work and (2) busy staff schedules.

Most of the interviewees (80%) mentioned that some staff made individual efforts to conduct Web-based searches on the literature reviews using their personal laptops and Wi-Fi connections. Furthermore, all of the interviewees mentioned the need for workshops to provide staff with the knowledge and skills needed for EBP in PT. Of them, 1 director stated the following: “a lack of knowledge and skills is considered a barrier.”

The interviewees pointed out that the atmosphere of the work environment has a positive influence. However, they stated that the culture of the organization and attitudes of the patients do not influence adopting a new technique of therapy. Most of the interviewees (90%) confirmed that the key factor when selecting and applying the best therapy is the capability of the practitioner to communicate with the patient effectively. The importance of communication skills for PTs was stressed by most of the interviewees. Of them, 1 individual said: “We always rely on our communication skills to convince patients to take the recommended PT, and these skills are required for applying new techniques, as in the case of EBP.”

All of the interviewees agreed on the importance of the support from upper management and stakeholders to implement EBP, such as the financial support needed for providing computer labs and access fees required for medical databases. Of them, 1 of the interviewees commented: “I think we need a formal decision from the upper management to go for EBP so that all facilities required would be offered accordingly.”

Discussion

Overview

In general, the PTs in this study had positive attitudes and showed interest in learning or improving the skills necessary to incorporate EBP into their practice. Their educational background, knowledge, and skills related to accessing the literature, interpreting the research evidence, and applying this information to therapeutic intervention practices were well-founded during their undergraduate education. However, their access to and the availability of electronic resources to implement EBP, together with the support to use such resources at work, were lacking.

Positive Attitude, but Not the Beliefs

Despite the overall positive attitude of PTs and their interest in EBP, which was in agreement with several previous studies [6-13], some PTs in this study were skeptical in some of their beliefs. They believed that EBP might create unreasonable demands on them, particularly the PTs who were working more hours per week. The PTs also believed that strong evidence was not available to support most of the interventions they used with their patients. This belief was more persistent among PTs working in the general hospital than the belief in those working in the rehabilitation or specialized hospitals. A possible explanation for this difference might be the variety of cases seen in the general hospital. Another possible explanation might be the lack of resources, a reported barrier toward adopting EBP in this study, which in turn might limit the access of PTs to electronic databases that would offer necessary research evidence. These reported uncertainties were consistent with previous studies reporting that the unavailability of evidence [10,11,14], busy schedule, and lack of time inhibited EBP [6-8,10,11,15,16]. Finally, the PTs in this study believed that EBP does not consider patient preferences. This belief is probably because of their lack of understanding of the 3 principle elements of EBP: the best available and most up-to-date research evidence, the clinical experience of the health care providers, and the values and preferences of the patient at any stage of the medical care process [22]. Thus, it appears that the PTs in this study thought that EBP is concerned only with the use of the best available and most up-to-date research evidence and ignores the preferences of patients. This feeling was evident during the interviews with the directors, as 1 director criticized the demand for EBP and claimed that their daily practice was already based on evidence. This belief also points to the lack of communication with the patients. Hence, PTs should communicate effectively with and address the preferences of patients to incorporate new evidence regarding therapies [23]. The results of the interviews reinforce this notion and support the importance of communication skills in EBP during PT treatment.

Educational Background, Knowledge, and Skills

In this study, the PTs had learned the basics of EBP during their undergraduate education, including the knowledge of the statistical terms and the skills necessary to access and interpret information from the literature. This finding agrees with the findings of a previous international study [12]. In addition, findings from the interviews show that newly graduated PTs or PTs with postgraduate degrees were active and could contribute positively to EBP to provide the best PT care. Thus, it is reasonable to infer that the majority of the PTs in this study had the competency to adopt EBP. However, knowledge of some advanced statistical terms, such as *odds ratio*, *meta-analysis*, *confidence interval*, and *heterogeneity*, was deficient among the PTs. These findings reveal the need for the continuous participation of PTs in training courses or workshops to expand their knowledge. The qualitative results support this finding, wherein the PT directors asked for workshops, local or abroad, for preparing qualified evidence-based practitioners.

Administrative and Technical Support at Work

At work, the PTs in this study had insufficient administrative support to use EBP and limited access to information resources to promote EBP. In addition, lack of time, lack of information resources, and inapplicability of research findings to specific patient populations were reported. These findings were consistent with several previous findings [6-8,10,11,14-17]. Similarly, the interview findings in this study showed similar barriers against implementing EBP. Furthermore, cultural factors had no influence on adopting EBP in PT, as the health care system in the State of Kuwait focuses on patient care, and this finding was confirmed in a previous study [5]. However, because of a lack of higher management support in terms of providing the facilities required (eg, electronic libraries) and encouragement for EBP or the lack of interest or unwillingness of some PTs to adopt new tasks in their busy schedules, staff resistance might arise.

Implications of Findings

On the basis of the study findings and interviews, several solutions emerged. Multimedia Appendix 2 lists the possible barriers and solutions. The solutions are relevant to the directors, staffs, and patients, locally and to countries with a similar work culture.

Strength and Limitations

This study was the first to be conducted among PTs from all specialties in government hospitals in Kuwait. Taking the high response rate into account (92%), the results can be considered to represent the target population of PTs across government hospitals. However, this study did not include PTs working in private hospitals or clinics. Thus, the findings cannot be generalized beyond the study sample. Although the questions used in the study questionnaire were derived from previously validated and reliably tested tools, the validity and the reliability of this questionnaire were not tested in this specific population. Furthermore, this study relied on self-reported data; thus, the PTs might have over reported some information. However, the qualitative results support the overall findings in several ways.

Conclusions

The PTs in this study lacked support at work and were in need of a continuous education program to expand their knowledge after graduation. Thus, identifying methods and strategies to support PTs in adopting EBP in the State of Kuwait is necessary.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Interview questions.

[PDF File (Adobe PDF File), 135KB - mededu_v5i1e12795_app1.pdf]

Multimedia Appendix 2

Barriers and solutions.

[PDF File (Adobe PDF File), 89KB - mededu_v5i1e12795_app2.pdf]

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Abbreviations

BSc: Bachelor of Science
EBP: evidence-based practice
KMLA: Kuwait Medical Licensing Authority
MoH: Ministry of Health
MSc: Master of Science
PTs: physical therapists
PT: physical therapy

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Original Paper

Computer Programming: Should Medical Students Be Learning It?

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Abstract

Background: The ability to construct simple computer programs (coding) is being progressively recognized as a life skill. Coding is now being taught to primary-school children worldwide, but current medical students usually lack coding skills, and current measures of computer literacy for medical students focus on the use of software and internet safety. There is a need to train a cohort of doctors who can both practice medicine and engage in the development of useful, innovative technologies to increase efficiency and adapt to the modern medical world.

Objective: The aim of the study was to address the following questions: (1) is it possible to teach undergraduate medical students the basics of computer coding in a 2-day course? (2) how do students perceive the value of learning computer coding at medical school? and (3) do students see computer coding as an important skill for future doctors?

Methods: We developed a short coding course to teach self-selected cohorts of medical students basic coding. The course included a 2-day introduction on writing software, discussion of computational thinking, and how to discuss projects with mainstream computer scientists, and it was followed on by a 3-week period of self-study during which students completed a project. We explored in focus groups (FGs) whether students thought that coding has a place in the undergraduate medical curriculum.

Results: Our results demonstrate that medical students who were complete novices at coding could be taught enough to be able to create simple, usable clinical programs with 2 days of intensive teaching. In addition, 6 major themes emerged from the FGs: (1) making sense of coding, (2) developing the students' skill set, (3) the value of coding in medicine, research, and business, (4) role of teaching coding in medical schools, (5) the concept of an enjoyable challenge, and (6) comments on the course design.

Conclusions: Medical students can acquire usable coding skills in a weekend course. They valued the teaching and identified that, as well as gaining coding skills, they had acquired an understanding of its potential both for their own projects and in health care delivery and research. They considered that coding skills teaching should be offered as an optional part of the medical curriculum.

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KEYWORDS

coding; medical education; undergraduate curriculum

Introduction

In recent years, there has been an increasing recognition that the ability to understand and construct simple computer programs (coding) is now a core skill and likely to be even more so in the future. This reflects the increasingly digital world in which we live and work and the growing need for more individuals to be able to engage with this type of technology. For example, the National Health Service (NHS) has recognized that when faced with an increasingly tight budget and time constraints, technology has the potential to help improve efficiency. Doctors and other health care professionals are in a unique position to identify problems that could be resolved or helped, in part, by technology. There have been numerous examples in the past few years of technology such as computer programs or specialist websites being used in clinical care [1-3] or research [4], and this is likely to continue to be the trend going forward. However, doctors and other health care professionals usually lack the understanding of which real-life problems could be resolved using computational approaches and very few have the ability to code the necessary software. Therefore, we need to increase the number of health care professionals who have some relevant expertise. At present, primary school children are now being taught how to code, but there will be a gap of at least ten years in the United Kingdom before a large number of students arrive at medical school already possessing these skills.

With this in mind, we developed an introductory *Coding for Medics* course to teach medical students basic programming and introduce them to the concepts of computational thinking. This is the starting point to bridge the gap between these future doctors and the technology industry and potentially facilitate greater collaboration between them.

In general, there are 2 main approaches to teaching computer coding [5-7]. The *coding* approach focuses on teaching practical programming skills to solve usual real-life problems. Examples include Software Carpentry [8], which teaches coding to researchers, New York University's Code Academy [9] and Duke University's Web-based courses on coding [10]. In contrast, the *theoretical* approach concentrates on computational thinking to teach the ability to break a complex problem into small, solvable components and automate parts or perhaps all of this using an algorithm. Examples include Massachusetts Institute of Technology's recent introduction of a minor course in Computer Sciences for noncomputer science majors [11] and Carnegie Mellon University's Center for Computational Thinking [12]. All the courses mentioned here have significant overlap with each other in that they use relatively modern computer languages and teach a combination of theory and practice. However, they differ in whether they concentrate on teaching practical coding to solve problems or develop computational thinking. The *Coding for Medics* course described here was designed to primarily focus on practical coding skills with the minimal amount of theory needed to underpin these skills. This approach was chosen in the hope that students would develop practical skills to take away and that they could then apply the skills independently rather than learn from a purely theoretical approach.

There are only a couple of examples of doctors or medical students being taught programming, both in the last 2 years, which we believe indicate a growing interest in this area. A recent paper from the University of Toronto teaches Python in a weekly session that runs over 1 year [13]. A course in the Netherlands ran over 2 days and aimed at teaching app building to doctors with good success [14]. However, outside medicine, there have been a number of courses aimed at teaching coding and computational thinking to nonspecialists. For example, within our own institution of Imperial College London, the undergraduate biology students are taught bioinformatics and some of their biology and biochemistry courses involve using the computer language, Python, to manipulate protein structure files.

A precourse questionnaire to find out precourse coding experience was administered, and postcourse written anonymous feedback was collected. In addition, a qualitative study was designed to evaluate the program by documenting students' achievements and exploring their perceptions of the value of coding in medical school. The aim of this study was to address the following questions:

1. Is it possible to teach undergraduate medical students the basics of computer coding in a 2-day course?
2. How do students perceive the value of learning computer coding at medical school?
3. Do students see computer coding as an important skill for future doctors?

Methods

Design and Delivery of The Coding for Medics Course

The *Coding for Medics* course was developed as a 2-day course, which aimed to take complete coding novices and develop them to a point at which they could design and write simple computer programs. The course was taught in the Python (Version 3) computer language as it is used for teaching introductory courses in other departments at Imperial College London because of its capacity to teach the underlying concepts and as it is freely available.

The learning objectives were structured around the simple elements of programming (see Textbox 1). There was also a small component on developing computational thinking. The course was structured with an initial 2 days of intensive teaching with 1 lead academic supported by teaching assistants (TAs) with a ratio of 1 TA to 6 students. The TAs were mostly other students from the Computer Science department of the same university, adopting the example of Stanford University, which drew TAs from its student population to teach introductory classes [15].

Textbox 1. The intended learning objectives of the Coding for Medics course.

By the end of this short course students will be able to:

1. Install different programming languages
2. Describe and discuss the difference between major families of computer programming languages
3. Install and use an Integrated Development Environment (IDE)
4. Describe how to structure a problem to allow the application of computational techniques
5. Find and use online resources on programming
6. Choose appropriate data types for simple computations
7. Describe and discuss difference in different control structures
8. Implement and test different control structures
9. Control simple input and output from a program
10. Read data in from an external file
11. Simple error handling and debugging

Following the intensive 2-day introduction, participants were given 2 to 3 weeks during which they designed, wrote, and submitted a simple project in their private study time. They were supported by a private online forum and email during this period. Students wrote a half-page summary of their project, which included the background, the problem they wanted to tackle, and how they mapped this computationally. These were reviewed, and students attended a short, formative feedback session to review common theme and problems emerging from their projects. Students received their feedback and were able to revise certain concepts (such as functions) with the teaching staff. This session concluded with a talk signposting the next steps available to students. The course was deliberately kept short as we were aware that medical students particularly suffer from curriculum overload, and we wanted to identify the minimum amount of time that would provide the students with usable skills.

Course Participants

The course was free and open to medical students in any year of the undergraduate medicine program at Imperial College London. It was scheduled during holidays or weekends to avoid timetable clashes with compulsory medical school teaching.

Study Design

A precourse questionnaire was distributed to students to gather basic demographics and to assess their previous experience of coding. At the end of the course, all participants were invited to give written feedback. This comprised open-ended, white-space questions exploring their views on the positive features of the course and what changes would improve future iterations. A written feedback on the course specifics was collected from students at the end of each iteration, and this was analyzed thematically. A voluntary FG took place after each iteration, the purpose of which was to determine students' views on the potential value of coding in the undergraduate curriculum. FGs took place in Imperial College London Medical School in July 2015 and February 2016. FG participants were purposively sampled from the complete cohort of 33 course attendees from 2 courses. All course attendees were invited to participate, and 13 students took part (n=9, n=4). The FGs were conducted by a person who had not been involved in the development or teaching of the course or the original design of the research study. Qualitative data were analyzed thematically [16].

Ethics

The study received ethical approval from the local Medical Education Ethics Committee (MEEC1415-28).

Results

Student Demographics and Previous Experience

The precourse questionnaire was completed by 94% (31/33) of the participants. Their mean age was 22 years (SD 3.3), and there were slightly more males (58%, 19/33) than females. The students came from all years of the 6-year undergraduate medical program with years 1, 3, and 5 contributing the highest number of participants (8, 7, and 7, respectively). Most students reported having no programming experience before joining the course (87%, 27/31). In all, 85% of the students gave written feedback at the end of the course.

Student Outcomes

A total of 25 participants (75%, 25/33) submitted projects that ranged in complexity from simple symptoms sorters to more complicated data analysis of a Web-based dataset. Students used the main components they had learned about in the course and applied it to a practical small project. For example, 1 student developed an analysis tool of a Web-based dataset on breast cancer. Although this was not formally assessed, the project summaries showed depth in understanding and application of computational thinking (eg, demonstrated by sensible mapping from the problem to the code), in addition to practical coding skills.

Qualitative Data Analysis

A total of 6 major themes emerged from the qualitative data analysis of both FGs and written feedback:

1. Making sense of coding
2. Developing the students' skill set

3. The value of coding in medicine, research, and business
4. Role of teaching coding in medical school
5. The concept of an enjoyable challenge
6. Comments on the course design

Making Sense of Coding

Students reported that a key part of the course was to develop an understanding of what coding is; they also reported that it broke their previously-held perceptions that coding is the preserve of the computer-obsessed or mathematically gifted. They reported surprise because of the fact that coding required only a computer and a free downloadable program to get started and that it could be done by any medical student, making it much more accessible than they had previously thought:

> *Anyone can do it as long as you get taught or teach yourself.* [Student, First focus group (FG)]

> *Before…I didn't know where to start. We know [now] loosely how it fits in the world and ways to follow it and make it relevant to our own lives.* [Student A, First FG]

Developing the Student's Skill Set

In line with the objective measures of their ability to perform simple projects, students felt that they had established some basic skills in coding that would form a solid starting point for developing further research skills in the future or developing some kind of innovative project (such as a health app). They recognized that they were not expert coders themselves but valued the opportunity to learn the basics and develop the language to be able to talk to expert coders for future collaborations, having understood what is feasible with code. Students also felt that having acquired the basics, it was useful to have the next steps highlighted for them so that they could develop their own skill set specific to their interests.

Interestingly, students also felt that they had developed new ways of thinking and problem solving, breaking large problems into small solvable components. They recognized that although this is a key skill when coding, it is also applicable to other aspects of their medical studies and research. Students felt that as coding was an extension of their logic, it helped them think about things in a more logical way, and this could be applied in clinical contexts. They felt that as a large part of Medicine is problem solving, learning basic computational thinking was beneficial:

> *I found the course quite useful in just understanding how to break things down into simple concepts.* [Student A, second FG]

> *I think that was probably the best part of the project for me. Hear what problems people have tackled with their code in ways I never even thought of even with my own project. I was still thinking very linearly.* [Student B, second FG]

> *I think it would be incredibly useful for me to have this coding knowledge so I can use it in research…I think having this base knowledge means I can build on it and in future perhaps go down the career path the TAs or the course lead had.* [Student A, second FG]

> *In terms of trying to figure out which problems are computable and which ones aren't and realising that actually what you thought isn't computable might as well be.* [Student C, second FG]

The Value of Coding in Medicine, Research, and Business

Students were able to imagine many different uses for coding in developing innovation in Medicine, research, and business. Many described *limitless possibilities* for what you could do with code if you were competent enough. They could see coding as having many potential applications including developing business technologies in health care, data manipulation, and analysis in research and for making efficiency savings in the NHS:

> *The other thing is that the course gave us an appreciation of how coding can help clinical research or lab research.* [Student B, first FG]

> *The only way to make the NHS better without spending more money is to make it more efficient and I think using innovations such as those that can be instigated by computer programs, those would be very useful. They would enrich the NHS and probably you on a personal level as well.* [Student C, second FG]

> *I don't think it's only just within science because coding is used to make apps and create technology which will…solve other business problems within medicine and outside of medicine.* [Student C, first FG]

> *...if we think something is feasible [to do with coding], it probably is.* [Student D, first FG]

Role of Teaching Coding in Medical School

Students felt that learning to code has a place in medical school, particularly learning that is based within a university with a high number of technological courses such as Imperial College London. They expressed surprise at the fact that it was not already widely on offer. They were clear that this course should remain optional as they were doubtful that all medical students would be sufficiently interested and engaged to complete it. They were also clear that coding competency is different from digital literacy and although all doctors should be digitally literate, not all doctors will need to be competent coders:

> *I think it's odd that…where every other degree course does have coding involved throughout… medicine has never had it involved at all.* [Student A, second FG]

> *I wouldn't force it on everyone because not everyone is going to want to do it… I know that it's a really digital world out there and you are going to come across code but you might never need to code.* [Student D, first FG]

> *I'd quite like it to be a BSc on Bioinformatics or Computer Science.* [Student F, first FG]

> *If [the medical school] wants to teach us research skills, I think then this kind of coding should very much be part of it.* [Student C, second FG]

The Concept of an Enjoyable Challenge

Students reported that although difficult at times, with a lot to learn in a short period of time, it was fun to learn coding. In general, they reported that they enjoyed the course and enjoyed learning a new skill. They felt that it challenged them in a different way when compared with how they normally learn in medical school. The written feedback was largely positive, with students feeling that they had achieved something by the end of the course and had enjoyed themselves. The key negatives were the pace of the course and a steep learning curve:

> *I think a lot of medics would enjoy this because it's problem solving and that's kind of what we do in medicine, problem solving.* [Student D, second FG]

Course Specifics

Much of the written feedback received was about specific parts of the course such as individual sessions or topics. In general, students liked the task-orientated focus of the course and appreciated that they were able to try to write code as they went along and not only at the end of the session. They also reported that it was better when these tasks were relevant to clinical topics. They liked the informal nature of the course and indicated an enthusiastic teacher and a high TA-to-student ratio (1:6) were the keys to success as they would have struggled with the steep learning curve without that level of support:

> *I liked the fact that it moved very quickly on to a sort of hands-on approach and the fact we covered a large amount.* [Written anonymous feedback, first course]

> *The TAs were extremely useful – I wouldn't have been able to do it without them.* [Written anonymous feedback, first course]

Discussion

Principal Achievements

We have demonstrated that medical students who were complete novices at coding could be taught enough to be able to create simple usable clinical programs with 2 days of intensive teaching. Therefore, it would be feasible to introduce teaching of basic computing skills without overloading the medical curriculum, particularly if it were to be introduced as an option. This is one of the first courses specifically designed to teach undergraduate medical students to code and is in contrast to the other published example [14], teaching students over an intense period of time rather than over 1 year. This demonstrates that there can be a variety of ways to get content into the curriculum. Interestingly, the other published course also uses Python and covers similar material [14].

The students identified that the course needed to be practical, with low student-to-TA ratio, and made relevant to clinical problems. Of note, out of original 33 students who completed this course, 2 have now gone on to work with the course lead on extended projects of their own. Moreover, 1 student is writing a program to transform and analyze routine publishable data on cancer outcomes and the other is helping to develop a software for a prognostic tool for oncology patients.

A wider consideration about teaching coding to medical students is about its value to future doctors. Technology is increasingly being used in the day-to-day work of a doctor and/or clinical researcher, for example, electronic health records, electronic prescribing, wearable technologies (such as heart rate and exercise monitors), medical devices, and telemedicine as well as a plethora of interactive health apps and websites. By completing this course, students are acquiring skills that allow them to interact and manipulate the digital tools needed to develop their own apps, websites, research tools, and innovative technologies; this goes far beyond the requirements for digital literacy stipulated by the General Medical Council [16]. It may be that the definition of computer literacy will change as more pupils leave school with coding skills and thus the average person becomes more and more skilled in using computers. This course provided a simple starting point for students to start developing skills in this area and potentially go on to develop their own projects.

Interestingly, and unexpectedly, students recognized that their own skill set had increased after the course by developing not only practical coding skills but also the ability to think computationally. They not only identified that breaking a large problem down into smaller solvable steps was key for coding but also identified that it had uses in other parts of their lives. This was also seen in the paper detailing the University of Toronto course, which found a similarly in the students' thinking about the course improving their approach to solving problems [14]. This has direct application in research where a big research question is often addressed by breaking it down into a series of smaller studies. The fact that students felt that this way of thinking might help them with solving clinical problems was an unexpected gain from attending this course. Although this is a limited observation, it supports the idea that computational thinking teaches key abstract, transferrable thinking patterns; it would be worth exploring this concept in further studies designed for this purpose.

Limitations

A limitation of this study is that this project was relatively small and therefore provides no information about the scalability of teaching coding en masse to medical students. If medical schools do want to teach coding to their students on a large scale, further studies would be needed. In addition, the students were a self-selected group who we might expect to be more enthusiastic about learning about coding than the average student. Another limitation is that we also do not have information about how much time students spent on self-study between the main course and submitting a project for formative feedback.

Future Development

The feedback we have had from those on the course has led to us continuing to offer it and to additionally extend it to a new 10-week module in Computational Medicine, which is now offered as an option to all students in their BSc year. This has allowed us to ease the pace of the course and add new coding work to include R and databases. Using R to develop statistical programming skills is a key part of the BSc option and it complements the core coding skills teaching. The extended option also increases the amount of computational thinking and theory and introduces a new element to encourage students to develop their experience in presenting and discussing technical topics to their peers. The BSc option culminates in an extended project. We have also continued to offer the 2-day Coding for Medics, and applications continue to grow. It is offered 2 to 3 times per year, and we now have at least eighty places per iteration. Despite this, it is oversubscribed, which we feel demonstrates a real appetite for this among students. Now, we also aim to include about 25% postgraduate health care professionals or researchers per iteration of the course. In addition, former students of the Coding for Medics course have gone on to found a medical student coding society, which currently has 200 members.

Conclusions

It is possible to teach medical students the basics of computer coding in only 2 days. Students considered that coding skills teaching should be offered as an optional part of the medical curriculum. Students are open to and value coding opportunities in medical school. They reported that it teaches computational thinking, which is a transferable skill (ie, breaking a larger problem into small solvable components), in addition to the practical skill of coding. They consider it to be an important skill for the future.

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Authors' Contributions

CEM and MW designed the study. MW designed the *Coding for Medics* course and taught on this with MG. CEM and TL analyzed the data. CEM and SFS wrote the original manuscript.

Conflicts of Interest

None declared.

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Abbreviations

FG: focus group
NHS: National Health Service
TA: teaching assistant

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Original Paper

Development and Evaluation of a Hybrid Course in Clinical Virology at a Faculty of Pharmacy in Lille, France

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Abstract

Background: During their studies, pharmacy students must acquire the specific skills in clinical virology required for their subsequent professional practice. Recent experiments on teaching and learning in higher education have shown that hybrid courses strengthen the students' commitment to learning and enable high-quality knowledge acquisition.

Objective: This study concerned the design and deployment of a hybrid course that combines face-to-face and Web-based instruction in clinical virology for fourth-year pharmacy students. The study's objectives were to (1) measure the students' level of involvement in the course, (2) gauge their interest in this type of learning, and (3) highlight any associated difficulties.

Methods: The study included 194 fourth-year pharmacy students from the Lille Faculty of Pharmacy (University of Lille, Lille, France) between January and June 2017. The students followed a hybrid course comprising an online learning module and 5 tutorial sessions in which professional situations were simulated. The learning module and 3 online evaluation sessions were delivered via the Moodle learning management system. Each tutorial session ended with an evaluation. The number of Moodle log-ins, the number of views of learning resources, and the evaluation marks were recorded. The coefficient for the correlation between the marks in the online evaluation and those in the tutorials was calculated. The students' opinions and level of satisfaction were evaluated via a course questionnaire.

Results: The course's learning resources and Web pages were viewed 21,446 and 3413 times, respectively. Of the 194 students, 188 (96.9%) passed the course (ie, marks of at least 10 out of 20). There was a satisfactory correlation between the marks obtained in the online evaluations and those obtained after the tutorials. The course met the students' expectations in 53.2% of cases, and 57.4% of the students stated that they were able to work at their own pace. Finally, 26.6% of the students stated that they had difficulty organizing their work around this hybrid course.

Conclusions: Our results showed that pharmacy students were strongly in favor of a hybrid course. The levels of attendance and participation were high. However, teachers must be aware that some students will encounter organizational difficulties.

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KEYWORDS
virology; pharmacy; education, distance; e-learning

Introduction

Background

A degree in pharmacy can lead on to various professions such as community pharmacists, hospital pharmacists, medical biologists, pharmacists in industry (production, quality control, marketing, etc), and regulatory pharmacists. Pharmacy students choose their career track progressively, as they complete internships and are exposed to learning experiences in the course of their studies. In France, these vocational studies are organized around an initial 3-year diploma in pharmaceutical science and then a 2-year specialist diploma [1]. Pharmacy students then choose between 2 options for the third and final part of their initial training: a short cycle for future community pharmacists and those working in industry or a long cycle for future hospital pharmacists and medical biologists. In our faculty of pharmacy, third-year students receive lectures and tutorials in general virology. During the fourth year, the clinical virology teaching is delivered in the hybrid format described in this study. At the end of the fourth year, students commit to a career track for 1 to 5 years. Pharmacy studies are, therefore, lengthy; during this time, the teaching staff monitor the acquisition of specific professional skills while encouraging the students to get involved in the learning process throughout the course.

Information and Communication Technology in Education and Electronic Learning

Recent developments in the field of information and communication technologies (ICT) for education and the now widespread availability of ICT tools have opened up new possibilities for initializing and continuing education in the health care professions. Historically, education in this field was based on a teacher lecturing to relatively passive students in a lecture room. Over the last few years, student-focused teaching has been developed by using interactive systems (eg, voting buttons in the lecture room), serious gaming, professional simulations, and hybrid courses that combine online and in-class learning [2]. A large number of studies performed in various health care sectors have shown that hybrid courses (1) facilitate the acquisition of in-depth knowledge via online lectures and evaluations and (2) enable the development of professional skills during face-to-face teaching (the latter can be organized around debates, group presentations, practicals, simulated professional exercises, and commented readings of texts) [3-6]. Hybrid courses appear to reinforce the students' commitment to learning and enable the high-quality acquisition of knowledge [7]. A recent meta-analysis compared blended learning with more conventional courses; blended learning was found to be associated with greater acquisition of skills, particularly in health care professionals—a group whose commitment to gaining new skills is rarely doubted [8]. Among undergraduates, the level of motivation for acquiring new skills and experiences has a key role in academic success [9]. Although hybrid courses appear to increase the levels of satisfaction and motivation among nursing and medical students, we are not aware of studies conducted among undergraduate pharmacy students [10,11].

Hybrid Courses in Virology

Medical virology lends itself well to hybrid courses in which complex theoretical knowledge can be acquired online and know-how can be developed during face-to-face teaching sessions. Innovative teaching and learning techniques in virology are now emerging; they range from picture-card and memory-card methods [12] to the reverse classroom [13] and the creation of virtual viruses [14].

Study Objectives

This study focused on a hybrid course in clinical virology for fourth-year pharmacy students at the Lille Faculty of Pharmacy (University of Lille, Lille, France). The study's objectives were to (1) quantify the students' involvement in a hybrid course, (2) assess the students' level of interest in this type of learning, and (3) highlight any difficulties encountered during this new type of course. A convergent study design (as defined by Creswell and Plano Clark) was used to assess relationships between quantitative variables (such as connection time, course marks, etc) and qualitative variables [15].

Methods

Study Population

The hybrid virology course was developed for fourth-year pharmacy students. The study took place during the year's second semester, that is, between January and May (Figure 1). A total of 210 fourth-year students were registered for 2017.

Description of the Hybrid Course

Fourth-year pharmacy studies are organized as coordinated courses (CCs) in several disciplines. The CCs take place between January and May; a 2-week CC in hepatogastroenterology is followed by a 4-week CC in infectious diseases and then a 3-week CC on the bronchopulmonary tract. For the sake of consistency, the course's independent (online) working and in-class tutorials were organized in the same manner (Figure 1).

The course module was made available on the Moodle learning management system (LMS), which was hosted on the Lille Faculty of Pharmacy's server. It began with a conventional lecture during which the lecturer presented the teaching and earning objectives, the course's timeline (notably the dates of the in-class teaching), the evaluation procedures (based on the continuous appraisal of coursework), the Moodle LMS (through which the students could access the learning resources), the examination sessions, and a discussion forum. All the registered fourth-year pharmacy students were entered by default for the course module on the Moodle LMS, which they could access by using their university username and password. At the same time, the students could order paper copies of all the learning resources via the system at the end of the presentation lecture and could then collect the paper copies 4 days later.

Online Learning Resources

The learning resources were made available to all the registered students via the dedicated zone on Moodle. The course was based on textbooks in clinical virology [16-18] by using the Opale (scenari.org) multimedia management tool and a template document to simultaneously generate a paper copy, a website that could be uploaded to the Moodle platform, and sets of multiple-choice questions (MCQs) [19]. The course covered all the knowledge to be acquired via short videos, downloadable summary documents produced by the lecturer, and links toward free accessible articles on the internet (ie, enriched content). The course's structure mirrored that of the CCs (Textbox 1). For each CC, the learning objectives were clearly specified. For each virus in the course, the knowledge was distributed into sections covering some general background on virology, the basics of epidemiology, the clinical presentations, the diagnostic tools, and the principles of patient management (prevention and treatment). For each viral syndrome, the virus responsible, the specific clinical and diagnostic features, and the principles of treatment and prevention were detailed. The learning resource was presented to the students as a photocopy on which tags for enriched content on Moodle and on the internet were indicated. Along with the learning resource prepared by the lecturer, additional documents were available for consultation (vaccination schedules, articles from specialist journals, summary sheets, etc).

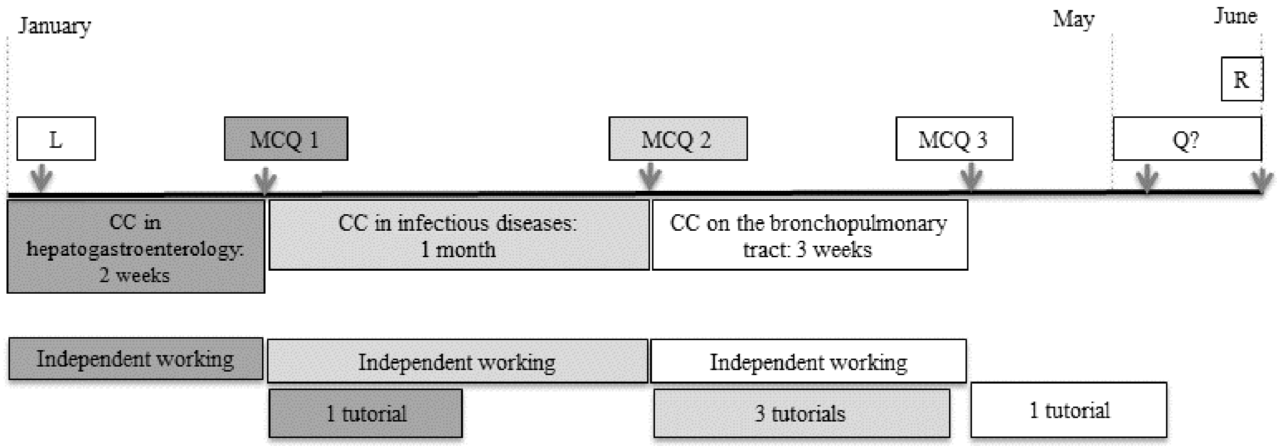
Online Evaluations

At the end of an independent learning period (corresponding to a CC), knowledge acquisition was assessed via an online set of 20 MCQs that had to be completed in under 20 min. A total of 3 MCQs were administered between January and May (Figure 1). After connecting to Moodle, the student had up to 20 min to complete the MCQs; after that time, the results were recorded and the session closed automatically, regardless of whether or not the student had answered all the questions. For each student, 20 MCQs were randomly drawn from a database containing 40 to 70 questions, depending on the course. The MCQ session could be accessed over a 5-day period.

In-Class Tutorials

At the end of an independent learning period, students were invited to attend a total of 5 in-class tutorials (these sessions lasted 1.5 hours and consisted of 25 to 30 students at a time). During the first part of the session, the lecturer answered the students' questions. In the second part, the students were invited to participate in role-playing games that simulated practical situations encountered by community pharmacists. The learning objective was for the students to be able to apply their knowledge to simulated professional practice and to best assist patients during drug dispensing and/or the provision of advice on preventing viral infections (treatment goals, procedures for administering antiviral drugs, advice on vaccination, etc). For each practical situation, the students formed groups of 3 and took turns playing the roles of the pharmacist, the patient, and the observer. The student playing the role of the patient was given a written description of the practical situation and the associated expectations. The student playing the role of the observer was given an evaluation grid for noting specific aspects, such as the pharmacist's general attitude, the answers to the patient's questions, and the specific information on drug dispensing and/or prevention that the patient should receive in the scenario. At the end of the scenario, the observer reported his/her observations to the other players. A total of 2 different scenarios were simulated in each session, and the students changed roles for each situation. After the 2 scenarios had been completed, the students debriefed with the lecturer. At the end of each tutorial session, each student had to fill out a written evaluation (lasting about 10 min) in the form of 2 questions on the topic with short, open answers.

Figure 1. Schematic diagram of the hybrid course. Coordinated courses (CCs) in hepatogastroenterology are indicated by dark gray boxes; CCs in infectious disease indicated by light gray boxes; and CCs on the bronchopulmonary tract are indicated by white boxes. L: opening lecture; MCQ: online multiple choice questionnaire; Q?: period during which the students could evaluate the course via a questionnaire; R: retake exam.



Textbox 1. Learning resources within the hybrid module (section, subsection, and chapters).

Coordinated course on gastroenterohepatology

- Viruses
  - Hepatitis A virus
  - Hepatitis B virus
  - Hepatitis C virus
  - Hepatitis E virus
  - Gastroenteritis virus
- Syndromes
  - Viral gastroenteritis

Coordinated course on infectious diseases

- Viruses
  - Herpes virus
  - Enterovirus
  - Human immunodeficiency virus
  - Papillomavirus
  - Rubella
  - Measles
  - Mumps
- Syndromes
  - Viral meningoencephalitis

Coordinated course on the bronchopulmonary tract

- Viruses
  - Influenza
  - Syncytial respiratory virus
- Syndromes
  - Bronchiolitis in the newborn
  - Upper respiratory tract infections
  - Lower respiratory tract infections

Evaluation of Coursework

The learning module was evaluated by averaging the 3 scores from the online MCQ marks and the 5 evaluations completed at the end of the tutorials (the tutorial marks). An average score of 10 or more out of 20 constituted a pass. Students who failed the continuous appraisal were asked to attend a retake examination in June; this took the form of an online 20-min, 20-MCQ session in an examination hall and then a 1-hour written examination with 2 questions.

Data Collection and Analysis

The study took place between January and June 2017. Several types of data were collected:

1. To assess the students' participation in the online learning module, we recorded the time connected to the course's Web page in each session, the number of forum messages, the total number of learning resource views per month, and the number of students having consulted each teaching resource between January 13, 2017, (the date on which the module was opened), and June 30, 2017, (the date on which the module was closed).
2. To assess the students' level of success in the course module, the marks obtained in the MCQ sessions and in the evaluations performed at the end of each tutorial session were recorded, and the mean value was calculated for each student.
3. To quantify the students' opinion of the hybrid course, we analyzed the answers to a modified version of the lecture

evaluation questionnaire that has been used at the University of Lille for the last few years. The study questionnaire comprised all the usual questions plus an additional question on any difficulties that the students had encountered. There were 18 closed questions and 2 open questions. The students completed the questionnaire online (on the Moodle platform) between April 4, 2017, and May 30, 2017.

Statistical Analyses

The coefficient *r* for the linear correlation between the MCQ marks and the tutorial marks was calculated, and the residuals were analyzed using IBM SPSS Statistics for Windows software (version 19.0, IBM Corp, Armonk, NY) [20]. After a linear model (Y=aX+b) had been built, the residuals were calculated as the difference between the marks obtained and those predicted by the model. Residual values above 3 or below −3 were considered to be aberrant. This analysis enabled us to detect and then exclude 8 aberrant values.

The time spent connected to the course's Web page was analyzed by calculating Pearson coefficient *r* for the linear correlation with the overall mark on one hand and the in-class *mark* on the other hand. The coefficient *r* ranges between −1 and 1: the further away the value is from 0, the more significant the correlation. Depending on the value of *r*, a correlation *t* test was also performed.

Ethical Approval

The students were informed that their Moodle data and questionnaire answers would be collected and analyzed for research purposes. The collection of all data on the University of Lille's LMS has been registered with the French National Data Protection Commission (Commission Nationale Informatique et Libertés, Paris, France).

Results

Characteristics of the Study Population

A total of 210 (114 females and 96 males) fourth-year pharmacy students were registered for 2017. Furthermore, 16 of the 210 registered students were repeating their fourth year and had already completed a virology course a year earlier. Hence, the study population comprised 194 students.

Consultation of the Learning Resources

The Moodle log-ins and forum messages were tracked. A total of 8 messages were posted on the forum by the lecturer and 5 were posted by the ICT technician. None of the students posted a message on the forum.

Between January 13, 2017, and June 30, 2017, 194 students viewed the course's Web page for a median (range) of 9.213 (0-98.847) seconds. The learning resources were viewed 21,446 times by the 194 students, that is, an average of 110.5 log-ins per student. The highest number of views per month (n=8849) was observed in January. This number decreased progressively until April (the month when the in-class tutorial sessions finished), with 1991 views. The views in May (n=287) and June (n=134) concerned the students convened for the retake examination.

The course's Web page was viewed 3413 times by the students during the course period. Furthermore, 174 of the 194 students viewed the additional learning resources at least once. The most frequently viewed documents concerned viral hepatitis (the French national guidelines on the management of hepatitis C infections, a treatment summary, and a vaccination schedule). The least frequently viewed documents concerned the measles-mumps-rubella. All the students ordered a set of photocopies online and collected it.

Course Pass Rates

The mean mark obtained for the 3 online MCQ sessions was 13.9 out of 20. The mean mark obtained for the evaluations performed at the end of the tutorial sessions was 14.4 out of 20 (range 1.2-19). Moreover, 11 of the 194 students participated in less than 4 of the 5 tutorial sessions. Overall, the mean mark for the continuous appraisal (MCQs and post-tutorial evaluations) was 14.0 out of 20 (range 0.6-18.6). The online MCQ sessions enabled us to assess the knowledge acquired by the students during the independent work periods, and the post-tutorial evaluations provided a guide to the professional skills acquired during the simulation exercises. The linear correlation coefficient *r* for the 2 types of marks was 0.466 (n=193; $P<.001$). In view of the large sample size and the external factors that could influence these marks (the level of attendance, the marks obtained in the subject in the previous year, the commitment to personal work and to revision, etc), we considered that the correlation between the 2 types of marks was satisfactory. After eliminating the aberrant values via a residual analysis, the correlation coefficient *r* was .483, emphasizing the satisfactory correlation between the 2 means. Our results revealed a correlation between the level of the theoretical knowledge and the quality of the professional skills acquired.

Furthermore, 15 students scored below 10 out of 20, and so were asked to attend the retake examination. Moreover, 5 students did not attend, and 1 of the 10 attendees failed the examination. Hence, 188 of the 194 students (96.9%) passed the course module. Finally, 188 of the 194 students completed the questionnaire on the hybrid course, corresponding to a response rate of 96.9%.

With a view to evidencing a correlation between the time spent consulting the online version of the course and the final examination mark, we extracted the time spent connected to the course's Web page; the correlation was not statistically significant. In fact, the linear correlation coefficient was $r=0.15$ ($P=.07$) when the full set of observations was taken into account. However, the number of the connection times were clearly too long (more than 3 hours) or too short (a few minutes) and therefore could not be considered as objective measures of the amount of work. We, therefore, limited our correlation analysis to *reasonable* connection times of between 30 min and 90 min, but the correlation was again not statistically significant ($r=-0.173$; $P=.40$). The same result was obtained when considering the *in class mark* with the whole dataset ($r=0.123$; $P=.15$) and with *reasonable* page connection times alone ($r=-0.070$; $P=.66$).

The Students' Opinion of the Course

A total of 4 questions addressed the module's structure (Figure 2). Furthermore, 60% of the students considered that they had been well informed about the course's learning objectives and that the proportion of independent learning required had been accurately specified. The students generally considered that the relative proportions of online work and in-class tutorials had been explained and that the evaluation procedures had been well described. A total of 21% of the students stated that they had not consulted any of the learning resources on Moodle, and 26% of the students stated that they had consulted all the resources.

In addition to the online teaching, 5 in-class tutorial sessions had been based around simulations of professional situations, so that the students could apply the theoretical knowledge acquired online to practical situations in a context managed by the lecturer. Moreover, 2 questions dealt with the hybrid course's impact on the students' level of interest in their studies in general and the discipline covered (clinical virology) in particular (Figure 2). The students considered that this type of course was a valuable part of their education and had increased their level of interest in clinical virology. The great majority considered that the course had met their expectations in terms of learning.

Finally, a smaller majority (64%) considered that the hybrid course had helped them to solve practical problems. The hybrid course obliged the students to work more independently. Furthermore, 1 of the questionnaire items focused on any difficulties that the students may have had in this respect (Figure 3). A student could tick more than 1 answer, if he/she so wished. Only 53% considered that the course had met their educational expectations. On the whole, the students considered that the course had enabled them to work at their own pace and that it had boosted their motivation to learn. However, difficulties in getting organized and getting down to work were mentioned.

Figure 2. The students' opinions of organizational aspects of the hybrid course, and the hybrid course's impact on the value of the teaching in general and the virology teaching in particular.

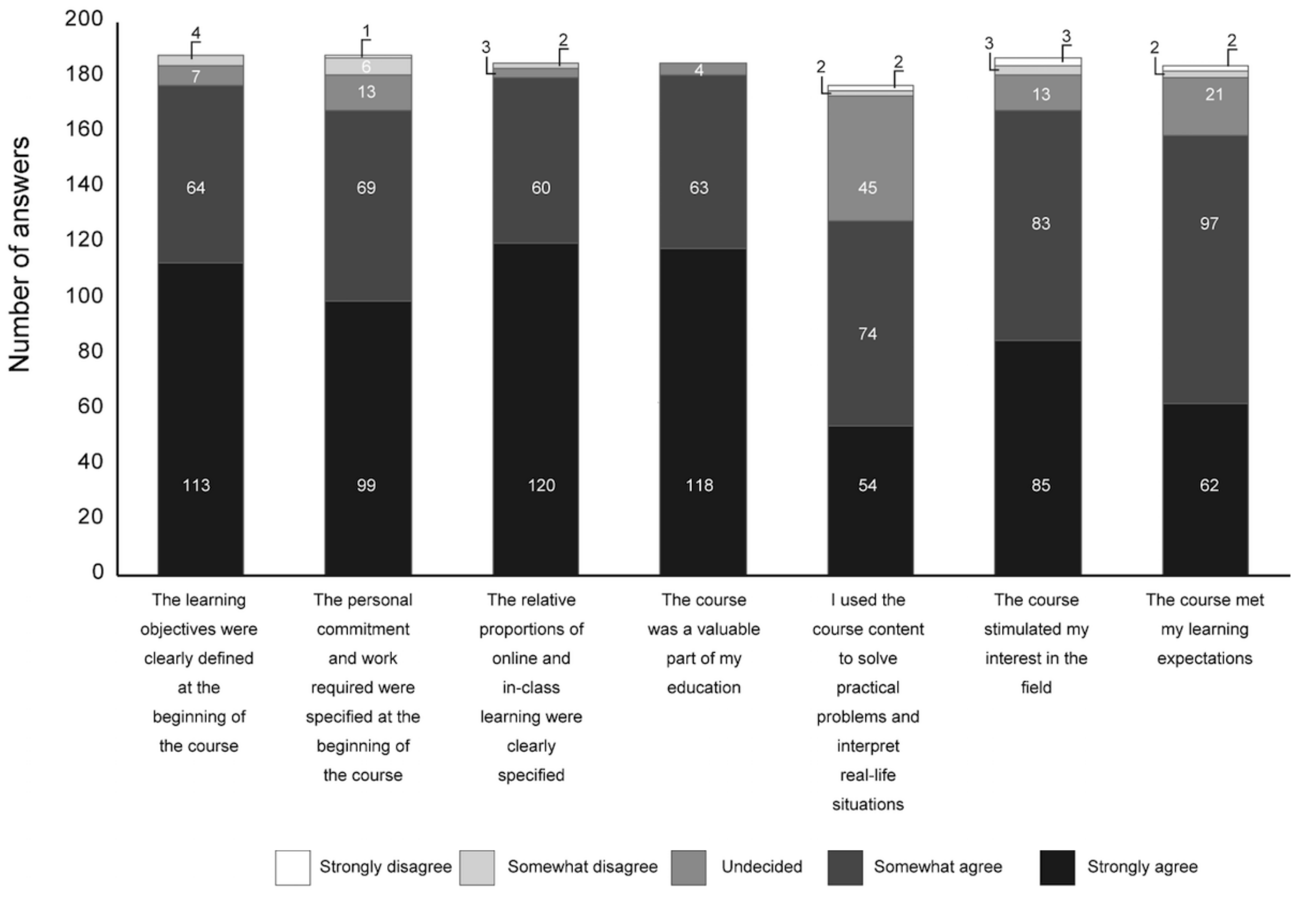
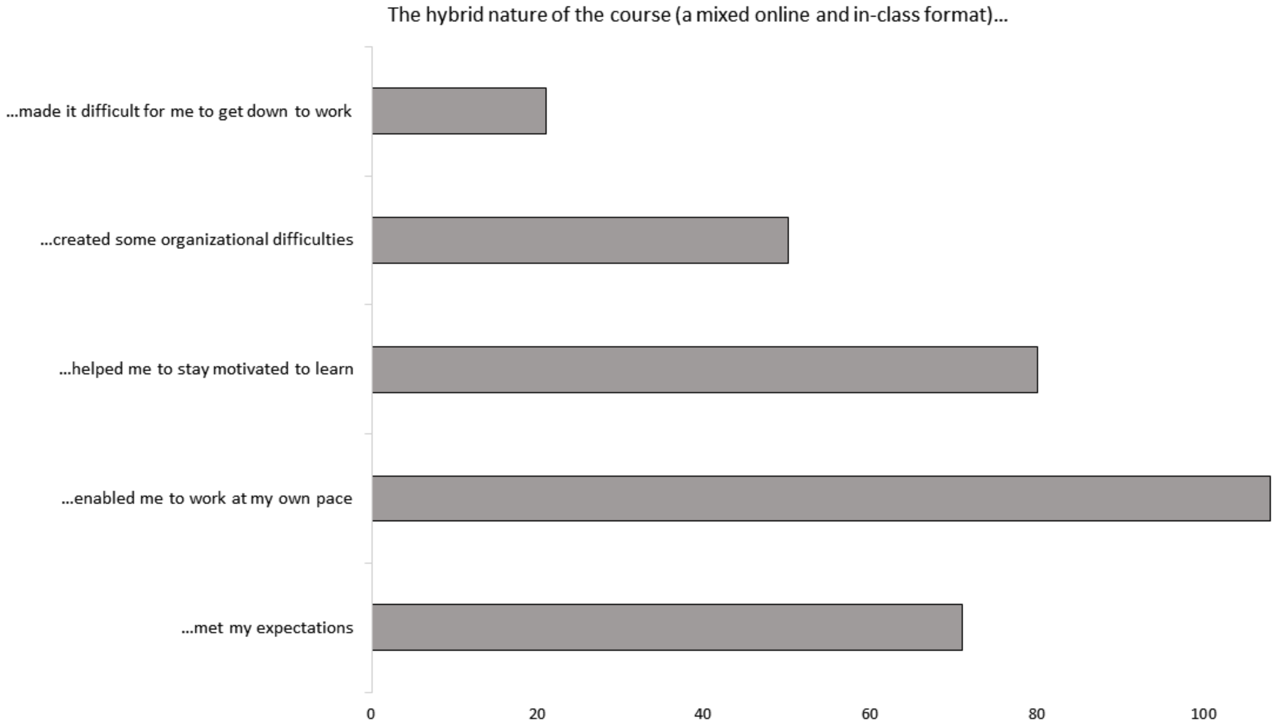


Figure 3. The students' evaluation of the hybrid course, with regard to the level of motivation and work structure. The students could tick several items in the list.



Discussion

Main Conclusions

Faced with low levels of attendance at lectures and with a view to offering new learning methods, we developed and deployed a hybrid course in virology for the first time in our faculty. We noted a high level of commitment from the students, with over 21,000 log-ins on the learning platform and high levels of attendance at the tutorial sessions. In fact, only 11 students attended less than 4 of the 5 tutorial sessions, although they passed the online MCQ sessions. At the end of the course, 15 students failed the module by failing to obtain a mark of 10 or more out of 20. These 15 included the 11 students who had not attended the majority of the tutorial sessions. However, after the retake examination, only 6 of the students failed the course overall. There was no correlation between the time spent viewing the online course and the final examination result. However, 98% of the students registered for the course received a paper copy. Hence, the page connection time did not necessarily reflect the time spent studying the course material. These results suggest that the paper copy alone enabled the students to acquire the knowledge evaluated in the examination.

In the feedback questionnaire, the students considered that this type of teaching met their expectations. Even though the hybrid course constituted the first experience of hybrid teaching for the majority of participants, the level of participation was high and enabled the students to pass the course evaluations.

During the course, the students were confronted with simulated professional scenarios for the first time. Our results showed a satisfactory correlation between the theoretical knowledge acquired during independent working and the students' ability to acquire professional skills. These data are in line with the many studies showing that professional simulations improve the level of preparation for working life [21,22]. The degree of correlation between the theoretical knowledge and the acquisition of the professional skills might be further improved by building a predictive model of success in the course evaluations, which would notably take into account the students' level of attendance at lectures, their average mark in virology in the previous year, and their average mark for the previous year as a whole. This type of predictive model might help to improve the students' learning experience. In fact, certain students reported difficulties in work organization and independent working. To stimulate the students' commitment and interest, these exercises should simulate a more diverse range of professional scenarios, reflecting the panel of skills required of pharmacists. During the pharmacy degree, more emphasis should be placed on professional simulations so that students understand the value of this exercise for their future profession.

The students consulted the learning resources (notably the short videos) very frequently (over 3000 views). This type of learning resource adds value for the students who view them. Our finding should encourage university teachers to produce this type of resource—even though this may require significant effort, along with assistance from the ICT staff. As also observed in the literature, we found that none of the students used the forum to interact with other students or with the lecturer [7]. The additional course materials were not extensively consulted, and their educational value should probably have been better explained. Finally, we confirmed Ladage et al's [23] report that students like to receive a photocopy of the learning resources. The students then readily consulted the online learning resources to find more information on a tricky point or to gain an overview of the topic. This observation prompts us to think that when designing a hybrid course, the lecturer must offer different types of educational media [6].

Although hybrid courses are widely used in continuing professional education, they are not yet widely applied in undergraduate courses [24-26]. Students faced with novel learning methods must adapt and organize their working habits to meet the constraints of hybrid courses [7]. Even though our students considered that this type of course met their educational expectations and participated willingly, some reported (via the course questionnaire) difficulties in work organization and/or getting down to work. Given that the development of this type of course is strongly encouraged by universities, students should be provided with support (eg, through tutorials or courses on work methods,) throughout their degree course. The students liked the teacher-led tutorials, which appeared to help them plan their learning and to increase their level of enthusiasm for independent working [27,28]. A learning performance dashboard (indicating a student's educational progression and the marks achieved in assessments, etc) might constitute a useful aid [29] as long as the teachers help the students to interpret the dashboard data [30]. In-class tutorial sessions enable discussion between students and the lecturers and among the students themselves, and also serve as an opportunity to acquire feedback on the acquisition of theoretical knowledge and the online exercises [16,17]. These in-class tutorials must be designed to promote interaction between the students and the lecturer and among the students themselves [18]. Finally, the in-class tutorials serve to reassure the students with regard to their learning strategies and to encourage them to pursue their efforts.

Lecturers developing hybrid courses could also benefit from support from electronic learning experts for both technical aspects (digital engineering) and educational aspects (learning engineering).

Limitations

The implementation of the hybrid course was accompanied by the complete reorganization of our clinical virology courses for fourth-year pharmacy students: the replacement of lectures by online learning, an increase in the number of tutorial sessions (from 3 to 5), and the introduction of continuous appraisal. Hence, it was not possible to measure the learning impact of a hybrid course on the students' academic success by comparing the results obtained by the students who attended the hybrid course with those of students who attended a conventional course the year before.

The hybrid module was used during a single academic year with a single-year group of students. The collection of data over several years would enable one to compare the level of performance from the 1-year group with the next and, potentially, to evaluate any changes in learning strategies in response to the above-mentioned organizational difficulties.

Our assessment of the correlation between the theoretical knowledge acquired during the independent working sessions and the professional skills acquired during the simulations highlighted a number of factors that might influence the students' learning. Further analyses of these factors and the data collected in the hybrid module might enable us to build a predictive model of academic success and the acquisition of professional skills by the students in our faculty.

Furthermore, we did not find a significant correlation between the page connection time and the marks in the evaluations. In future research, we intend to transform the linear Web page into a nonlinear medium by adding tests that modulate the students' progression through the course module. These tests (located at learning milestones) will enable students to evaluate their knowledge and will personalize each student's progression through the module [31-33].

With regard to the online evaluations performed, the marks may have been biased by the students' consultation of documents or by information swapping between students. However, the application of course assessments after the tutorial sessions may have countered this bias.

Our results showed that fourth-year pharmacy students were strongly in favor of a hybrid course and that the course met their educational expectations. This type of course enabled students to work at their rhythm, although teachers must be aware that some students will encounter difficulties organizing their work.

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Conflicts of Interest

None declared.

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Abbreviations

CC: coordinated course
ICT: information and communication technologies
LMS: learning management system
MCQ: multiple-choice question

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Original Paper

Development and Evaluation of the Online Addiction Medicine Certificate: Free Novel Program in a Canadian Setting

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Abstract

Background: Despite the enormous burden of disease attributable to drug and alcohol addiction, there remain major challenges in implementing evidence-based addiction care and treatment modalities. This is partly because of a persistent lack of accessible, specialized training in addiction medicine. In response, a new online certificate in addiction medicine has been established in Vancouver, Canada, free of charge to participants globally.

Objective: The objective of this study was to evaluate and examine changes in knowledge acquisition among health care professionals before and after the completion of an online certificate in addiction medicine.

Methods: Learners enrolled in a 17-module certificate program and completed pre- and postknowledge tests using online multiple-choice questionnaires. Knowledge acquisition was then evaluated using a repeated measures *t* test of mean test scores before and after the online course. Following the certificate completion, a subset of learners completed the online course evaluation form.

Results: Of the total 6985 participants who registered for the online course between May 15, 2017 and February 22, 2018, 3466 (49.62%) completed the online pretest questionnaire. A total of 1010 participants completed the full course, achieving the required 70% scores. TThe participants self-reported working in a broad range of health-related fields, including nursing (n=371), medicine (n=92), counseling or social work (n=69), community health (n=44), and pharmacy (n=34). The median graduation year was 2010 (n=363, interquartile range 2002-2015). Knowledge of the addiction medicine increased significantly postcertificate (mean difference 28.21; 95% CI 27.32 to 29.10; $P<.001$). Physicians scored significantly higher on the pretest than any other health discipline, whereas the greatest improvement in scores was seen in the counseling professions and community outreach.

Conclusions: This free, online, open-access certificate in addiction medicine appeared to improve knowledge of learners from a variety of disciplines and backgrounds. Scaling up *low threshold* learning opportunities may further advance addiction medicine training, thereby helping to narrow the evidence-to-practice gap.

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KEYWORDS

medical education; substance-related disorders; education, distance

Introduction

Background

Approximately 29 million people are affected by substance use disorders (SUDs) annually [1], with an estimated 21 billion dollars of associated productivity losses in the United States alone [2]. In recent years, a sharp rise in opioid-related deaths has led to numerous public health emergency declarations, and the number of alcohol use disorders is increasing globally [3-5]. Still, uptake of evidence-based SUD treatment is low and people with SUDs often receive inadequate care [6]. This is despite recent progress in addiction science, which has highlighted the important role of skilled health care providers and the efficacy of established psychosocial and pharmacological therapies in improving treatment outcomes [1,6-8]. Moreover, most health care providers frequently report feeling unprepared to effectively identify and treat SUDs, and the stigma toward persons with SUDs persists among the health professions [9-11].

To address these gaps in practice, health professionals need better education and training in addiction medicine. However, such specialized training programs can be inaccessible because of limited space, inability to compensate participants for their time, and the location of training (often big, urban centers) [12-15]. In addition, many of these programs accept only a particular subset of health care professionals—for instance, only physicians or social workers—and have limited resources for expansion. At the same time, effectively training a variety of health care providers in evidence-based treatment of SUDs is critical for providing quality care, as well as curbing the current opioid epidemic. One solution to overcome these challenges is the expansion of online training programs, which can reach a large number of participants, train professionals from a wide range of health disciplines, be delivered at a relatively low cost, and can be accessed from a wide variety of settings [16,17]. Although the literature suggests that online continuing professional development courses in health care can be equally effective as traditional classroom-based courses [17-19], this has not been demonstrated for addiction medicine.

Objectives

We sought to evaluate changes in knowledge acquisition before and after the completion of a new, comprehensive, and accredited online certificate in addiction medicine, accessible and free of charge to learners worldwide.

Methods

Course Description

The Addiction Care and Treatment Online Certificate is a free course and certificate program open for anyone wishing to improve their knowledge of substance use, although it is targeted at health professionals. The course involves 17 modules related to the identification, management, and treatment of SUDs. Textbox 1 lists the course learning objectives and topics covered. Each module is comprised a 20- to 75-min video lecture (including a slideshow with spoken voice-over) by an expert in the relevant topic. Each module (with the exception of modules 1 and 17) is then followed by a brief multiple-choice test of the module material. All multiple-choice questions are in single best answer format with 4 answer options. Those looking to obtain a formal certificate and Continuing Medical Education certificate must complete all the modules, achieving a minimum passing score of 70% on all postmodule tests. Overall, the online course takes approximately 16 hours to complete; however, it is self-paced, so learners can complete each module in their own time. Modules do not have to be completed in chronological order, allowing learners to select the topics that most interest or benefit them. Once learners complete the course, they must pass through an online evaluation form (with one mandatory question on potential bias in course content) to receive a digital certificate.

Before release, this course was accredited via review and approval by the University of British Columbia Division of Continuing Professional Development. This required a formal committee with representation of the target audience, a high degree of evidence, and no industry bias or involvement. The course also met the certification criteria of the College of Family Physicians of Canada, as well as Maintenance of Certification Program of The Royal College of Physicians and Surgeons of Canada.

Course Development and Background

On the basis of the informal and formal consultations with a range of stakeholders by the course's planning committee, it was clear that there was a general lack of awareness of the range of evidence-based treatments for SUDs. Specifically, there was an unmet need for specific education and training for health care professionals on SUDs that was accessible and provided at no cost. In response to this need, the British Columbia Centre on Substance Use (BCCSU) developed this structured course in partnership with content experts throughout British Columbia. This included physicians in the areas of psychiatry, public health, internal medicine, and family medicine. Although the target audience of the program is primarily prescribers, modules were created to be accessible to all allied health disciplines, including nurses, social workers, psychologists, and were also accessible for a general audience.

The course design utilizes a case-based learning structure, with theoretical and academic context nested in the introductions to the module. The topics, content, and speakers were selected through recommendations and advice from the planning committee. Each module is taught by a faculty member who has extensive experience with the particular topic and would be considered an expert in the province. Physician members of the planning committee were instrumental in ensuring that all materials were evidence-based and relevant to physicians practicing in the primary care environments. Before beginning their presentations, the course's lead author (EW) and the planning committee required faculty members to submit detailed module outlines. These were thoroughly reviewed, and feedback was returned to presenters for incorporation into their lecture and presentation slides. The finalized presentations were then reviewed to ensure validity and objectivity of content. The lectures were recorded between August 2015 to May 2016. The course was hosted on the host center's website using a WordPress content management system.

Textbox 1. Learning objectives and topics covered in The Addiction Care and Treatment Online Certificate.

Learning objectives

1. Incorporating screening diagnosis and brief intervention and referral to treatment for substance use disorders in clinical practice.
2. Selecting the appropriate pharmacological and psychosocial treatment interventions based on the best evidence, as well as individual patient needs, circumstances, and preferences.
3. Providing safe and effective treatment to patients and their families throughout the induction, maintenance, and/or discontinuation process across the continuum of care for substance use disorders.
4. Setting treatment goal monitoring and evaluating progress and providing patient-centered support across the continuum of care for substance use disorders.
5. Appreciating the complexity of substance use disorders, diversity of care, and providing informed referrals to evidence-based support services.
6. Promoting recovery, safety, wellness, and harm reduction to improve patient care and support for those with substance use disorders.
7. Implementing strategies for safer prescribing practices for medications with abuse/diversion potent (ie, opioids for analgesia, benzodiazepines, etc).

Topics or modules (time in module)

1. Introduction to addiction medicine (20 min)
2. Screening, diagnosis, and brief intervention for substance use disorders (45 min)
3. Opioid use disorder (50 min)
4. Tobacco use disorder (45 min)
5. Alcohol use disorder (35 min)
6. Withdrawal syndromes (60 min)
7. Stimulant use disorder (20 min)
8. Polysubstance use (65 min)
9. Comorbid mental illness and substance use disorders (35 min)
10. Pain and substance use disorders (65 min)
11. Common medical complications (45 min)
12. Safe prescribing (75 min)
13. Overdose prevention and harm reduction (45 min)
14. Psychosocial interventions (50 min)
15. Addiction in the workplace (75 min)
16. Recovery oriented systems of care (30 min)
17. Cases consolidating knowledge (35 min)

The course leads and advisory committee guide the ongoing, year-round recruitment activities. Participant recruitment strategies include disseminating advertisements through electronic mailing lists, posters, brochures, descriptions and links on the bccsu.ca website, lay media advertisements, conference participation, newsletters, social media, and word of mouth. In addition, the course was promoted through in-person seminars focused on substance use across Canada.

Procedures

To take the online course, participants first had to register using the online registration form. Here, learners were given space to fill in their full name and email address and were asked to select their home province from a drop-down menu (all Canadian provinces and *Other* were listed). Providing province information became mandatory after the first month of the course. In the registration form, learners were also asked to select their professional discipline from a given list. Following registration, learners completed a multiple-choice knowledge test (the *pretest*) to evaluate baseline knowledge of course content. In addition, following each module, learners completed multiple-choice knowledge tests (the *posttests*) to evaluate the understanding of the material just taught.

As 2 of the modules (1 and 17, the introduction and conclusion) lacked posttests, to pass the online course, learners had to complete a total of 15 posttests. When all posttests were completed with a minimum 70% score, learners were then given the option to complete an online evaluation form, gauging their satisfaction with the program and the applicability of course material to their clinical practice. The evaluation form also asked for further demographic information, such as professional discipline, the year that learners completed their professional degrees, and the health care settings in which they provide services.

Textbox 2. Sample question and format.

Question: Evidence-based first-line anticraving and relapse prevention therapies for the treatment of alcohol use disorder include: (1) Naltrexone 50 mg once daily; (2) Acamprosate 666 mg once daily; (3) Gabapentin 300 mg once daily; (4) Celexa 40 mg once daily.

Correct answer: 1

Explanation: Naltrexone is typically provided 50 mg once daily and has a number needed to treat to prevent a return to any drinking of 20. Acamprosate has a number needed to treat to prevent a return to any drinking of 12 and is an alternative first-line agent, but it is dosed 666 mg 3 times per day rather than once daily. Though less studied, Gabapentin appears to be an effective anticraving agent but the optimal studied dose was 600 mg 3 times per day. Celexa is not a pharmacotherapy for alcohol use disorder.

Citations:

1. Jonas DE et al. Pharmacotherapy for adults with alcohol use disorders in outpatient settings: a systematic review and meta-analysis. *JAMA*. 2014 May 14;311(18):1889-900.
2. Mason BJ et al. Gabapentin treatment for alcohol dependence: a randomized clinical trial. *JAMA Intern Med*. 2014 Jan;174(1):70-7.

Survey Development

Questions on pre- and posttests were collaboratively developed by the course's lead author (EW) and the lecturers. Questions were updated by the course coordinator (AG), BCCSU staff, and experienced clinicians in addiction medicine. All pre- and posttests used a multiple-choice format and were designed to measure changes in learners' knowledge of addiction medicine and SUDs. The pretest contains 30 knowledge questions of material from all course modules. Each posttest contains 3 to 10 multiple-choice questions, covering only material from the relevant module. Textbox 2 represents the question format adhered to in this course. Although all pretest questions were asked postcourse, it was impossible for these questions to be matched item-to-item with the pretest results, because of the online platform setup. Although a minimum score of 70% was required to pass each posttest, there was no such requirement for the 30-item pretest. Learners can also attempt posttests multiple times, resulting in the number of learners passing each module being unequal to the number of all recorded attempts at each posttest. As a result of learner feedback, some posttest questions were altered over the course of the study period. For example, changes were made to the phrasing of questions in the module *Alcohol Use Disorder*.

This study was approved by the Research Ethics Board at Providence Health Care Research Institute, University of British Columbia. All participants were informed of the study purpose, as well as the voluntary and anonymous nature of participation before signing the informed electronic consent.

Data Analysis

Data from the course registration and pre- and posttests were linked using participants' full names and email addresses. Using registration data, participants were divided into 7 broad health-related fields: (1) *medicine*, (2) *nursing*, (3) *pharmacy*, (4) *counseling/social work*, (5) *community outreach/support work*, (6) *residents/students*, and (7) *other*.

We measured the effectiveness of the course using (1) completion rate (percentage of participants who attempted all 15 posttests out of the total number of participants registered), (2) success rate (percentage of participants who successfully passed all 15 posttests out of the total number of participants who attempted *all* 15 posttests), (3) commitment rate (percentage of participants who passed all 15 posttests out of the total number of participants who attempted at least *one* posttest), and (4) mean difference between the assessments at the start (pretest) and at the end (posttests) of the online course. The pretest score was used as a proxy for precourse knowledge and the mean of all posttest scores was used as an indicator of the overall postcourse knowledge. A repeated measures design with *t* tests of mean scores on pre- and posttests therefore evaluated positive knowledge acquisition in participants who completed all 15 posttests. Scores on all tests were measured in percentage terms. When a participant attempted a posttest more than once, the mean score from all *attempts* by that participant was taken (not only those which surpassed 70%), so as to keep one posttest value per participant and module.

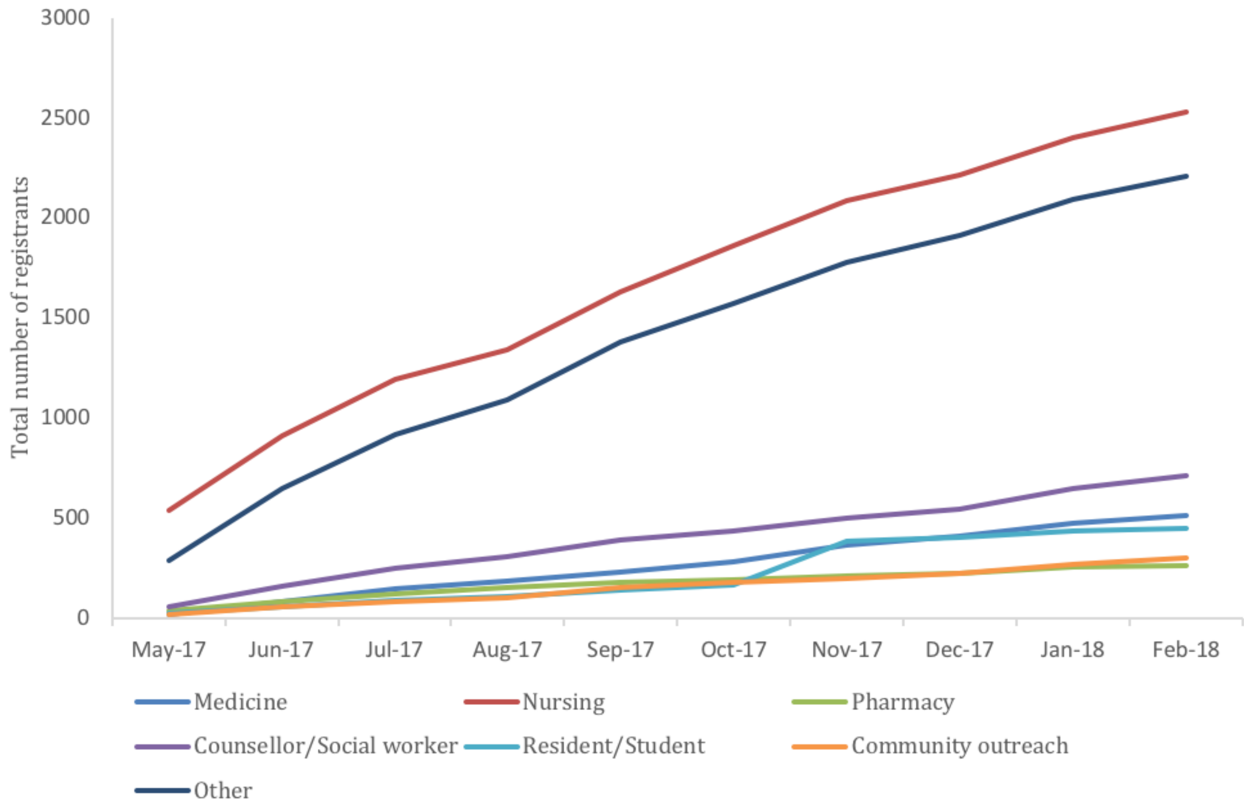
We also examined differences in test scores between participants in different health-related fields (eg, nursing, pharmacy). Health professionals with significantly greater pretest scores were taken to have greater baseline knowledge than other health professionals taking the course. In addition, health professionals with a significantly greater difference in scores were taken to have had greater knowledge benefits than other health professionals taking the course. Linear regression and paired *t* tests were used to test statistical significance of these differences with SAS 9.4 (SAS Institute). All *P* values were 2-sided.

Results

Registration and Participant Characteristics

Between May 15, 2017 and February 22, 2018, a total of 6985 persons registered for the course. During this period, there was a steady linear increase in the total number of course registrations, with a particularly sharp rise in the number of nurses (Figure 1). Of those who registered, 3466 completed the pretest and attempted at least one module's posttest. A total of 1010 then attempted every posttest at least once, all of whom achieved the minimum passing score of 70% on one attempt of each test. Therefore, the course had a completion rate of 14.45%, a success rate of 100%, and a commitment rate of 29.14%.

Figure 1. Total number of registrations in the online addiction medicine certificate from May 2017 to February 2018, stratified by professional discipline (N=6985). Jan: January; Feb: February; Jun: June; Jul: July; Aug: August; Sep: September; Oct: October; Nov: November; Dec: December.



Among the 1010 course completers, participants self-reported working in a broad range of health-related fields, mostly nursing (371/1010, 36.73%) and medicine (92/1010, 9.11%; Table 1). There was an overall difference in the province of origin between those who did and did not complete the course (*P*=.013), with a higher proportion of Ontarians and Prairie residents among completers versus noncompleters (Table 1).

Knowledge of Addiction Medicine

Attempting (regardless of pass/fail status) all 15 modules with posttests was a study inclusion criterion. However, as all learners who attempted every module also passed the course, a total of 1010 *attempters* were included in the analyses.

Postcertificate, the knowledge of addiction medicine increased significantly (mean difference 28.2; 95% CI 27.3 to 29.1; *P*<.001; Table 2). Physicians scored between 6.9 and 10.6 percentage points higher on the pretest than other health disciplines. The greatest improvement in scores was seen in the counseling and community outreach professions (Table 3).

Table 1. Sociodemographic characteristics of the sample, with *P* values, stratified by certificate completion status.

Characteristic	Total (N=3466), n (%)	Completion status, n (%)		*P* value
		Completers (n=1010)	Ongoing learners[a] (n=2456)	
Province				.013
British Columbia	1371 (39.56)	362 (35.84)	1009 (41.08)	
Prairie provinces (SK, MB, AB)[b]	716 (20.66)	237 (23.47)	479 (19.50)	
Ontario	237 (6.84)	71 (7.03)	166 (6.76)	
Quebec/Atlantic regions (NB, NL, NS, PEI)[c]	101 (2.91)	24 (2.38)	77 (3.14)	
Missing/other[d]	1041 (30.03)	316 (31.29)	725 (29.52)	
Self-identified discipline				<.001
Medicine	274 (7.91)	92 (9.11)	182 (7.41)	
Nursing	1265 (36.50)	371 (36.73)	894 (36.40)	
Counseling or social work	346 (9.98)	69 (6.83)	277 (11.28)	
Pharmacy	124 (3.58)	34 (3.37)	90 (3.66)	
Student or resident	239 (6.90)	61 (6.04)	178 (7.25)	
Community outreach	167 (4.82)	44 (4.36)	123 (5.01)	
Other	1051 (30.32)	339 (33.56)	712 (28.99)	
Practice setting[e] (n=475)				—[f]
Community-based organization	—	99 (17.3)	—	
Physician office–based practice	—	64 (11.2)	—	
Private drug treatment clinic	—	18 (3.1)	—	
Provincial health authority	—	152 (26.6)	—	
Community health center	—	101 (17.7)	—	
Other[g]	—	138 (24.1)	—	

[a]This includes participants who may have registered but have not yet started the course, participants who had not yet completed the course at the time of data collection, and participants who completed the course but did not pass.

[b]SK: Saskatchewan; MB: Manitoba; AB: Alberta.

[c]NB: New Brunswick; NL: Newfoundland; NS: Nova Scotia; PEI: Prince Edward Island.

[d]This includes participants from international settings, as well as those with missing location data.

[e]Only participants who passed the course filled in this information in the satisfaction form; totals do not add up to 475 as participants could select more than one service setting.

[f]Not applicable.

[g]Other settings included hospitals, mental health facilities, pharmacies, group homes, and more.

Table 2. Knowledge in addiction medicine among learners completing the free online certificate (n=1010).

Module	Statistics
Pretest total, mean percentage score (SD)	52.6 (14.5)
Posttest scores per module, mean percentage score (SD)	
Screening, diagnosis, and brief interventions	84.9 (14.3)
Opioid use disorder	78.1 (21.7)
Tobacco use disorder	88.3 (15.4)
Alcohol use disorder	75.1 (23.2)
Withdrawal syndromes	79.6 (21.9)
Stimulant use disorder	76.5 (19.1)
Polysubstance use	75.1 (26.5)
Comorbid mental illness and substance use disorder	77.1 (24.8)
Pain and substance use disorders	77.8 (22.6)
Common medical complications	78.1 (21.9)
Safe prescribing	74.1 (24.3)
Overdose prevention and harm reduction	83.5 (22.0)
Psychosocial interventions	81.9 (18.0)
Addiction in the workplace	85.5 (17.5)
Recovery-oriented systems of care	81.4 (18.0)
Posttest total, mean percentage score (SD)	80.8 (8.7)
Mean difference between total pre- and posttest scores (95% CI)	28.2[a] (27.3-29.1)

[a]*P*<.001.

Table 3. Pairwise comparisons between medicine and other disciplines on pretest scores and change in score from pre- to posttest (n=1010).

Discipline	Pretest scores, mean difference (95% CI)[a]	Change in pre- and posttest scores, mean difference (95% CI)[a]
Medicine	Reference group	Reference group
Nursing	−8.4[b] (−14.1 to −2.8)	2.6 (−0.7 to 5.8)
Pharmacy	−8.2[c] (−12.8 to −3.6)	5.0 (−0.7 to 10.6)
Resident/student	−7.9[b] (−11.1 to −4.6)	3.3 (−1.4 to 7.9)
Counseling/social work	−9.9[b] (−14.3 to −5.4)	5.6[d] (1.1 to 10.0)
Community outreach/support worker	−10.6[b] (−15.8 to −5.5)	7.9[e] (2.7 to 13.0)
Other	−6.9[d] (−10.2 to −3.6)	2.3 (−1.0 to 5.6)

[a] Negative mean difference signifies a score/change in scores lower than that of the reference group. Positive mean difference signifies a score/change in scores higher than that of the reference group.

[b]*P*<.001.

[c]*P*=.003.

[d]*P*=.015.

[e]*P*=.003.

A subset of 475 participants (47.0%) completed the course satisfaction form. The most commonly reported service settings were provincial health authorities, community health centers, and community-based organizations (Figure 1). The median graduation year was 2010 (n=363, interquartile range 2002-2015). Most (89%) of the participants who completed the course evaluation either agreed or strongly agreed that the course successfully met their learning needs. In addition, the majority of the participants rated the course's relevance to their practice (83%) and incorporation of evidence-based research (93%) as *above average* or *excellent* (Table 4).

Table 4. Participant responses to select evaluation criteria for the Addiction Care and Treatment Online Certificate.

Statement	Rating (%)					
	Strongly disagree / Poor	Disagree / Below average	Neutral / Average	Agree / Above average	Strongly agree / Excellent	Not applicable
This course was effective in meeting my learning needs	2.5	1.7	5.3	33.3	54.5	2.7
Relevance to my practice	0.2	1.9	12.6	38.9	43.3	3
Incorporation of evidence-based research	0.2	0.2	4.8	33.2	57.9	3.6

Discussion

Principal Findings

We sought to evaluate the changes in knowledge acquisition before and after completion of a comprehensive online certificate in addiction medicine. Following the course, the knowledge of addiction medicine increased significantly, with a completion rate of 14.5% (percentage of participants who attempted all 15 posttests out of the total number of participants registered), success rate of 100% (percentage of participants who successfully passed all 15 posttests out of the total number of participants who attempted *all* 15 postests), and commitment rate of 29.1% (percentage of participants who passed all 15 posttests out of the total number of participants who attempted at least *one* posttest). Physicians scored significantly higher on the pretest than any other health discipline, whereas the greatest improvement in scores was seen in the counseling professions and community outreach. A majority of participants reported that the course was effective in meeting their learning needs, was relevant to their practice, and well-incorporated evidence-based research.

This course is a novel online training program in addiction medicine—a field in urgent need of expanded educational opportunities for health care providers [9,10,20]. As of February 2018, the course had nearly 7000 registrants, confirming the strength of low threshold, online models for facilitating rapid scale-up of evidence-informed training in addiction medicine, and a high demand [21-23]. This demand was particularly notable among nurses who composed the largest proportion of health providers in our sample and saw the sharpest increase in registrations. As reported in previous papers [24], the completion rates of open online courses are often lower than those of traditional in-person training, and this may be more a product of participants' individual preferences or needs, rather than the course material or structure. As such, the observed completion rate of this course is in line with previous studies of open online courses, which report completion rates from 0.9% to 36.1% (median 6.5%) [24,25]. It is also important to note that the online certificate in addiction medicine was intentionally structured for participants to select the modules most relevant to them.

Similar to previous studies of online courses on SUDs, we found a significant increase in knowledge of addiction medicine postcertificate [22,23,26,27]. In addition, this study highlighted which health professions may derive the most benefit from such a course. Aligned with prior literature, which has shown that education in SUD care is often lacking in social work and counseling curricula [22,28], participants in counseling/social work and community outreach demonstrated the greatest improvement in scores. For example, in one study of university-level counseling and social work programs, it was found that just 69% of masters-level counseling programs, 3% of bachelors-level social work programs, and 2% of masters-level social work programs required a course in SUD care [29]. Still, the online format can present unique barriers—including time- and schedule-constraints—as noted by previous studies of online training in SUDs [30].

Limitations

Several limitations may reduce the generalizability of our findings. First, because of the inconsistencies in the data, for some participants, it was impossible to link their course registration data and test scores. Second, the large number of participants from western Canada may have introduced bias into the results, as health care professionals' knowledge and training in addiction medicine may vary by setting. Promoting the course to a more international audience could improve training and highlight the needs of health care professionals in a wider range of contexts. Third, the self-selection of registrants for the course may mean that the study participants were more likely to have a higher level of interest or experience in addiction medicine—it is likely that practitioners who seek specialized training are more prone to positive attitudes toward, and learning experiences with people who have SUDs [31]. Fourth, as participants were able to attempt each postmodule test as many times as they liked, and a minimum score of 70% was required to pass each test, our overall posttest value may have been positively skewed. This limitation was carefully considered before analyses, balancing perspectives that a participant's final passing attempt at each posttest (1) represented new retained knowledge and (2) was the product of selecting the correct answer by chance. Therefore, we averaged the scores from all attempts by a single participant at each posttest. This mean score was then used to calculate a total group mean score for the course. Finally, we did not capture a corresponding change in provider behavior following the course. Future research examining the impact of this course in addiction care settings would be valuable.

Conclusions

In this study, over 6000 participants began and over 1000 participants completed online training in addiction medicine. Overall, our analyses suggest that the course can feasibly increase knowledge in addiction medicine to a wide range of health care providers. Scaling up *low threshold* learning opportunities may further advance addiction medicine training, thereby helping to narrow the evidence-to-practice gap.

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Conflicts of Interest

None declared.

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Abbreviations

BCCSU: British Columbia Centre on Substance Use
SUD: substance use disorder

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Original Paper

Faculty and Student Interaction in an Online Master's Course: Survey and Content Analysis

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Abstract

Background: The provision of online educational courses has soared since the creation of the World Wide Web, with most universities offering some degree of distance-based programs. The social constructivist pedagogy is widely accepted as the framework to provide education, but it largely relies on the face-to-face presence of students and faculty to foster a learning environment. The concern with online courses is that this physical interaction is removed, and therefore learning may be diminished.

Objective: The Community of Inquiry (CoI) is a framework designed to support the educational experience of such courses. This study aims to examine the characteristics of the CoI across the whole of an entirely online master's course.

Methods: This research used a case study method, using a convergent parallel design to study the interactions described by the CoI model in an online master's program. The MSc program studied is a postgraduate medical degree for doctors or allied health professionals. Different data sources were used to corroborate this dataset including content analysis of both asynchronous and synchronous discussion forums.

Results: This study found that a CoI can be created within the different learning activities of the course. The discussion forums integral to online courses are a rich source of interaction, with the ability to promote social interaction, teaching presence, and cognitive learning.

Conclusions: The results show that meaningful interaction between faculty and student can be achieved in online courses, which is important to ensure deep learning and reflection.

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KEYWORDS

online learning; faculty & student interaction; Community of Inquiry; medicine

Introduction

Background

Since the creation of the World Wide Web in the early 1990s, the provision of Web-based educational programs has soared. The emergence of digital technology has allowed universities to veer away from traditional teaching methods and offer Web-based courses to both on-campus and off-campus students. In the United States, participation in at least one Web-based course has risen from 9.6% of students in 2002, to 31.6% in 2016, equating to over 6 million students. Of these, 3 million students are taking exclusively Web-based distance courses [1,2].

The rapid expansion and demand of these courses, however, present challenges to educators, both technologically and pedagogically. The emergence of the Web-based course has removed the co-location of student and faculty and with it any interaction engendered by face-to-face physical meetings. A conceptual framework, known as the Community of Inquiry (CoI) was developed by Garrison et al [3] to help support the educational experience of Web-based courses. The CoI assumes that deep learning requires the development of a community and identifies three elements that are essential to form such a community within these courses: social presence, cognitive presence, and teaching presence.

Community of Inquiry Framework

The CoI framework [3] is a process model of Web-based learning developed to help guide faculty and student interaction and communication to encourage critical thinking, inquiry, and discourse. The CoI framework suggests that deep learning in a computer-mediated distance learning course occurs through the interaction of three core elements: (1) social presence, (2) cognitive presence, and (3) teacher presence. Dewey's legacy [4] of a collaborative constructivist learning experience argues that a student will develop meaningful and long-lasting understanding of a topic if supported socially, intellectually, and with the guidance of an appropriately knowledgeable instructor.

Social Presence

Defined by Garrison et al [3] as "the ability of participants...to project their personal characteristics into the community, thereby presenting themselves to the other participants as real people," it has been argued that a social presence should be among the first components to be established in a Web-based course to initiate learning [5]. The CoI model identifies three areas within the presence that can help examine ways that students develop social presence: affective expression, open communication, and group cohesion.

Cognitive Presence

Garrison et al define cognitive presence as "the extent to which the participants in any particular configuration of a CoI are able to construct meaning through sustained communication" [3]. It is this element that the authors view as the most important to engender success and is heavily influenced by Dewey [6], Kolb [7], and the science of reflective thinking.

The Practical Inquiry model [8] was developed to define the cognitive presence in the CoI and involves a 4-step process that begins with a *triggering event* when the student encounters a problem that requires a resolution. The *exploration* phase involves the search for information, and the *integration* phase links concepts and creates hypotheses. Finally, the *resolution* phase is where the student has tested these and is able to defend or revise them.

Teaching Presence

Teaching presence is defined as "the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" [9]. Teaching presence is seen as unifying the social and cognitive processes [3] through direction and leadership of the educational experience. There is a considerable body of evidence suggesting that teaching presence is crucial to student learning [10-14] and that it is a significant determinant to student satisfaction and sense of community.

In the CoI framework, there are three categories of teaching presence that have been identified [9]: design and organization, facilitating discourse, and direct instruction.

Development of the Community of Inquiry Tool

The CoI framework provides a useful theoretical base to research Web-based learning, but most of the literature has focused on single components of the CoI. To address this, a team of collaborators from a range of institutions developed an instrument to measure the three categories of presence [15]. This quantitative tool comprises a 34-item, 5-point Likert scale and aims to measure students' perceptions of the social, cognitive, and teaching presence in a Web-based course.

Much of the literature on the CoI has focused on examining single aspects of Web-based courses. Studies of the CoI instrument have been undertaken at a higher education level within business courses, and there have been few studies involving CoI within health care. This study examines the faculty and student interaction of the whole taught-component of an entirely Web-based Master of Science (MSc) medical course. It aims to explore the experience of the CoI facilitated in the program by exploring student-faculty interaction.

Methods

Setting

This study was carried out at an inner London university with a student enrollment of just under 17,000. The MSc program studied is a postgraduate medical degree for doctors or allied health professionals. Lasting 2 years, the first year comprises the entire taught component, and the second year is set aside solely for the preparation and completion of a dissertation project.

The first year of the program was the focus of this study. In this year, there were 8 taught modules worth 15 credits, each lasting 4 weeks. The program was entirely Web-based, with up to 48 audio-recorded PowerPoint presentations per module, asynchronous case-based discussions, and 8 synchronous discussion sessions per module. Asynchronous discussions allow groups that are separated in time and place to share knowledge by posting and replying to "threads" that are initiated either by students or faculty [16]. Synchronous discussions were Web-hosted conferences led by one member of faculty to which all students were invited to join.

Participants

The year of study had 22 participants, of whom 3 were from medical professions other than medicine. Each was a graduate from the field of medicine and its allied professions. All were employed full-time, and their experience varied from first-year post-graduate doctors through to established independent practitioners.

Design

This research used a case study method, with a convergent parallel design to study the interactions described by the CoI model in a Web-based master's program. A survey designed to measure the aspects of the CoI within a course using only a single data source was thought to be unlikely to complete the aim in sufficient depth. Therefore, different data sources were used to corroborate this dataset including content analysis of both asynchronous and synchronous discussion forums.

Survey

The survey collected basic demographic data from each student as well as their perceptions of the course based on the CoI framework. The survey was distributed via email and completed approximately 6 months after completion of the first year of the program.

The study used the CoI instrument designed by Arbaugh et al [15]. This consists of a 34-item survey, each consisting of a 5-item Likert scale. It measures perceived cognitive presence, social presence, and teaching presence. Results were analyzed by calculating a composite score for each question based on the mean responses of all respondents. A further subscale score was calculated based on the mean responses to the relevant questions for social, cognitive, and teaching presences.

Transcript of Discussion Forums

Asynchronous discussion forums were archived from the academic year studied and transcribed anonymously. A sample of 10 discussion transcripts was chosen for analysis. The first and the last discussion were included, and a further 8 transcripts throughout the year were chosen based on the number of postings as well as the subject heading.

One synchronous discussion forum was chosen and fully transcribed and anonymized. The forum consisted of a session lasting 1 hour and 9 minutes, with one member of faculty, and 8 students. The forum was chosen because it occurred in the middle part of the course when it was anticipated that students and faculty had grown more accustomed to the technology and each other, potentially giving a true reflection of the CoI of the course.

Ethical Approval and Consent

Ethical approval was sought and approved from the researcher's own institution, and the ethics department of the university hosting the course. Individual "opt-in" consent was sought from each participant for content analysis of anonymized transcribed synchronous and asynchronous discussion forums. In cases where consent was refused, the content of the individual's posts was removed from analysis.

Content Analysis

The transcripts of the asynchronous and synchronous discussion forums were analyzed using a coding protocol based on the description of the CoI framework coding protocol template (Table 1), published within the original CoI paper by Garrison et al [3]. The template has been the subject of further research and validated by a number of studies [11,17,18].

Table 1. Community of Inquiry (CoI) framework coding protocol template.

CoI presence	Category	Indicators (examples)
Social	Emotional Expression	Emotions, narratives
	Open Communication	Risk-free expression
	Group Cohesion	Encouraging collaboration
Cognitive	Triggering Event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting new ideas
	Resolution	Applying new ideas
Teaching	Instructional Management	Defining and initiating discussion topics
	Building Understanding	Sharing personal meaning
	Direct Instruction	Focussing discussion

Results

Basic Demographics

There were 22 students enrolled for the first year of this master's course. Two students withdrew their participation early during the academic year. Of the 20 remaining students, their basic demographic details are shown in Table 2.

Survey Responses

The survey presented the participants with some demographic questions, followed by the 34 items of the CoI instrument [15]. Eighteen of the 20 students who completed the first year of the MSc course completed the survey.

Table 3 shows the responses for the survey grouped by presence, with the mean score and standard deviation. The Likert scale consisted of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree).

A mean score of 4.0 in any item equated to an agreement with the statement, and a standard deviation of less than 1.0 suggests stronger agreement [19].

Table 4 shows the calculation of the mean responses per presence, as well as the overall composite mean score. With small standard deviations, this suggests that course participants strongly agreed that the course delivered a social and cognitive presence and agreed that teaching presence was also observed. Overall, the mean composite score from the CoI survey indicates that a CoI was perceived by the participants of the master's course.

Table 2. Student demographics (N=20).

Characteristics	n (%)
Gender	
Male	8 (40)
Female	12 (60)
Occupation	
Physician	17 (85)
Nurse	2 (10)
Other	1 (95)
Nationality	
United Kingdom & Ireland	9 (45)
Europe	3 (15)
United States	4 (20)
Asia	3 (15)
Africa	1 (5)

Asynchronous Discussion Analysis

Ten discussion forums were chosen for analysis. Seventeen of the 22 initially enrolled students contributed to the message boards with 165 individual message posts and a total of 18,233 words available for analysis.

The CoI framework provided a coding template [3] that was used to conduct a content analysis of the asynchronous discussion forums. The frequency of each type of coded presence as depicted in Table 1 was counted, giving an overall aggregate description of the 10 discussions, and the group itself.

In total, there were 269 separate codings of presences across the 10 discussion threads. The majority (n=135) were indicators of social presence, followed by 82 instances coded indicating cognitive presence and 52 indicating teaching presence.

Instances of social presence were the most prevalent in discussion threads (Figure 1). This is particularly evident when there were no postings from an instructor, as indicated by discussion numbers 1, 5, and 5. When the instructor did post, however, the percentage of teaching presence increased, but the percentage of cognitive presence also appeared to increase.

Figure 2 shows how the individual presence count per message post changed over the course of the 10 threads. Figure 3 is a representation of the proportion of each element of cognitive presence within the coded asynchronous discussions. The majority of instances of cognitive presence are at the lower level of thinking, triggering event and exploration.

Table 3. Community of Inquiry survey responses.

Item	Question	Mean (SD)
Teaching presence		
1	Faculty clearly communicated important course topics.	4.2 (0.71)
2	Faculty clearly communicated important course goals.	3.8 (1.04)
3	Faculty provided clear instructions on how to participate in course learning activities.	3.8 (0.71)
4	Faculty clearly communicated important due dates/time frames for learning activities.	3.1 (1.18)
5	Faculty members were helpful in identifying areas of agreement and disagreement on course topics that helped me learn.	4.1 (0.68)
6	Faculty members were helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	4.4 (0.51)
7	The instructor helped keep course participants engaged and participating in productive dialogue.	4.3 (0.59)
8	Faculty members helped keep the course participants on task in a way that helped me learn.	4.2 (0.55)
9	Faculty members encouraged course participants to explore new concepts in this course.	4.2 (0.65)
10	Faculty actions reinforced the development of a sense of community among course participants.	4.3 (0.49)
11	Faculty members helped focus discussion on relevant issues in a way that helped me learn.	4.3 (0.49)
12	Faculty members provided feedback that helped me understand my strengths and weaknesses.	3.1 (1.16)
13	Faculty members provided feedback in a timely fashion.	2.3 (0.71)
Social presence		
14	Getting to know other course participants gave me a sense of belonging in the course.	4.4 (0.85)
15	I was able to form distinct impressions of some course participants.	4.2 (0.86)
16	Online or Web-based communication is an excellent medium for social interaction.	3.8 (0.94)
17	I felt comfortable conversing through the online medium.	3.9 (0.87)
18	I felt comfortable participating in the course discussions.	4.1 (0.76)
19	I felt comfortable interacting with other course participants.	4.1 (0.68)
20	I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	4.0 (0.59)
21	I felt that my point of view was acknowledged by other course participants.	4.1 (0.54)
22	Online discussions help me develop a sense of collaboration.	4.3 (0.57)
Cognitive presence		
23	Problems posed increased my interest in course issues.	4.4 (0.61)
24	Course activities piqued my curiosity about the subject matter.	4.3 (0.67)
25	I felt motivated to explore content-related questions.	4.5 (0.51)
26	I utilized a variety of information sources to explore problems posed in this course.	4.4 (0.51)
27	Brainstorming and finding relevant information helped me resolve content-related questions.	4.3 (0.57)
28	Online discussions were valuable in helping me appreciate different perspectives.	4.5 (0.51)
29	Combining new information helped me answer questions raised in course activities.	4.3 (0.69)
30	Learning activities helped me construct explanations/solutions.	4.1 (0.68)
31	Reflection on course content and discussions helped me understand fundamental concepts in this class.	4.7 (0.49)
32	I can describe ways to test and apply the knowledge created in this course.	4.2 (0.86)
33	I have developed solutions to course problems that can be applied in practice.	4.4 (0.71)
34	I can apply the knowledge created in this course to my work or other non–class-related activities.	4.3 (0.57)

Table 4. Mean responses for Community of Inquiry (CoI) survey.

CoI presence	Mean (SD)
Teaching presence	3.9 (0.64)
Social presence	4.1 (0.18)
Cognitive presence	4.4 (0.15)
Overall CoI	4.1 (0.46)

Figure 1. Presences by percent and number of instructor posts.

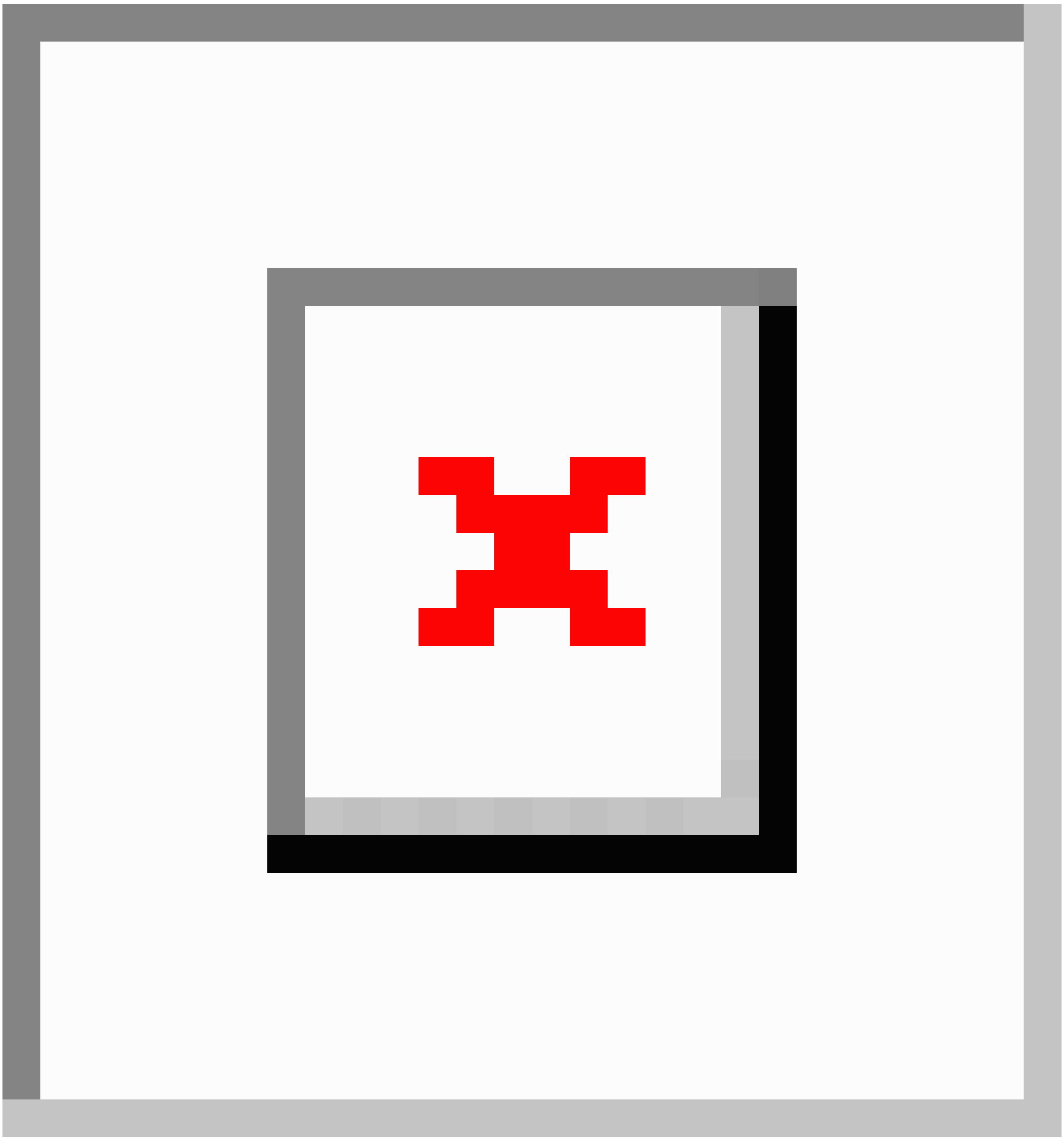


Figure 2. Presences per message post.

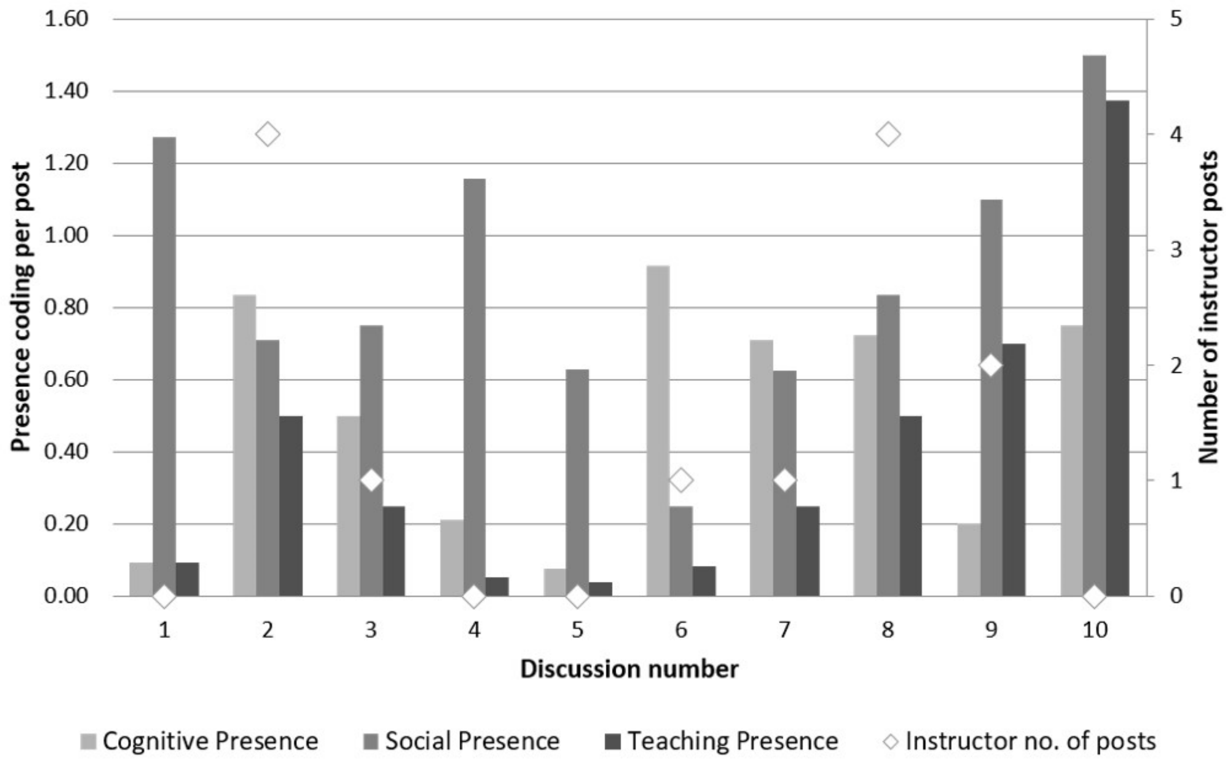
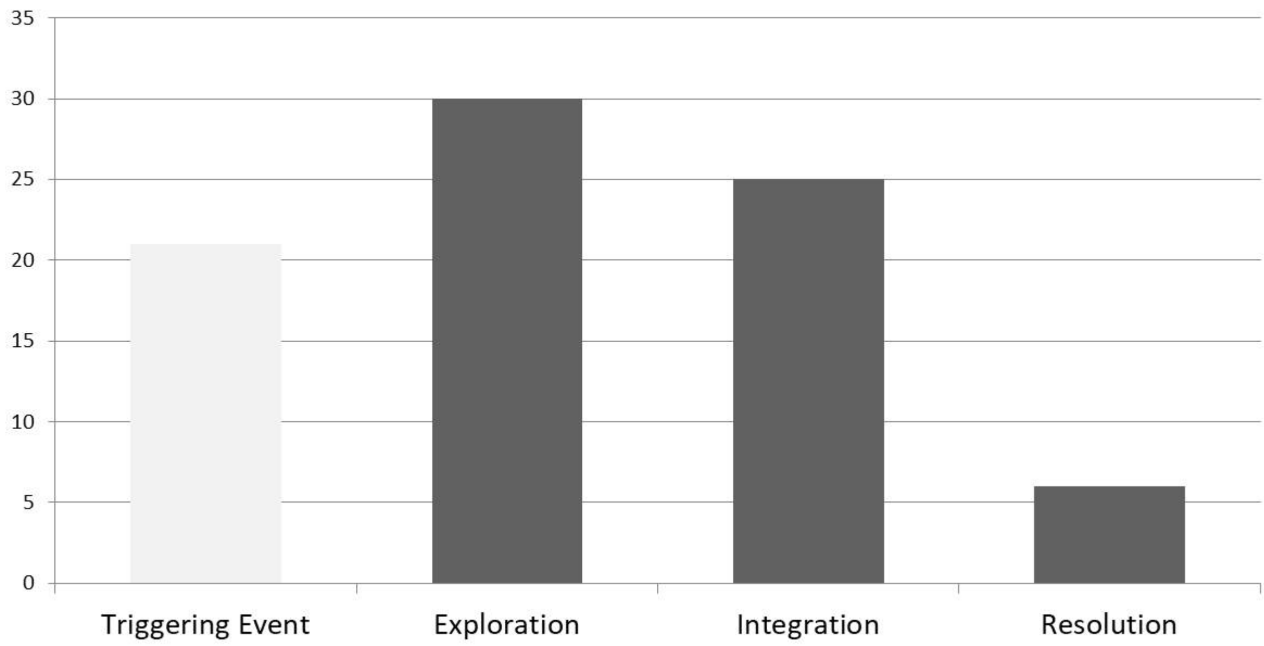


Figure 3. Cognitive presence breakdown for asynchronous discussion.



Synchronous Discussion Analysis

One interactive session was chosen. This session was led by one member of faculty, and 8 students logged on for the forum, interacting through video, audio, and text. The transcribed document consisted of 324 individual posts, with 117 posts from the instructor. After removal of the content of the 2 students who did not provide consent, there were 7389 words for analysis.

The same coding protocol was used as for the asynchronous discussions, using the coding template from Garrison et al [3]. The analysis showed a total of 135 presences coded, made up of cognitive presence 47 times, social presence 37 times, and teaching presence 51 times.

Within the synchronous discussion, there were more instances of teaching presence than any other presence. The indicator that was coded most was for direct instruction, followed by explanation of issues (coded by “building understanding”).

There were numerous instances of cognitive presence, with similar numbers of each category within the discussion. Within the social presence, there was markedly less group cohesion indicated.

Figures 4-6 show a breakdown of the instances of the CoI categories within the transcript. The x-axis shows each incidence of coding, against the position (y-axis) within the document (0=start of document, 4000=end). Figure 4 shows the breakdown for cognitive presence. While triggering event, exploration, and integration all appear evenly within the discussion, the resolution category (indicated by application of new ideas, creating solutions, etc) occurred relatively late in the discussion.

Figure 4. Cognitive presence in synchronous discussion.

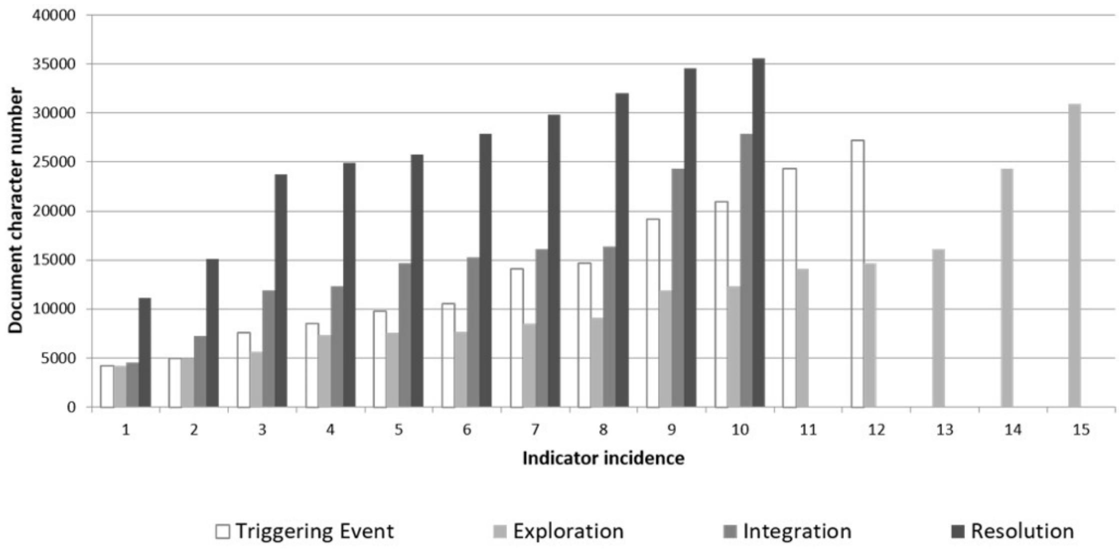


Figure 5. Social presence in synchronous discussion.

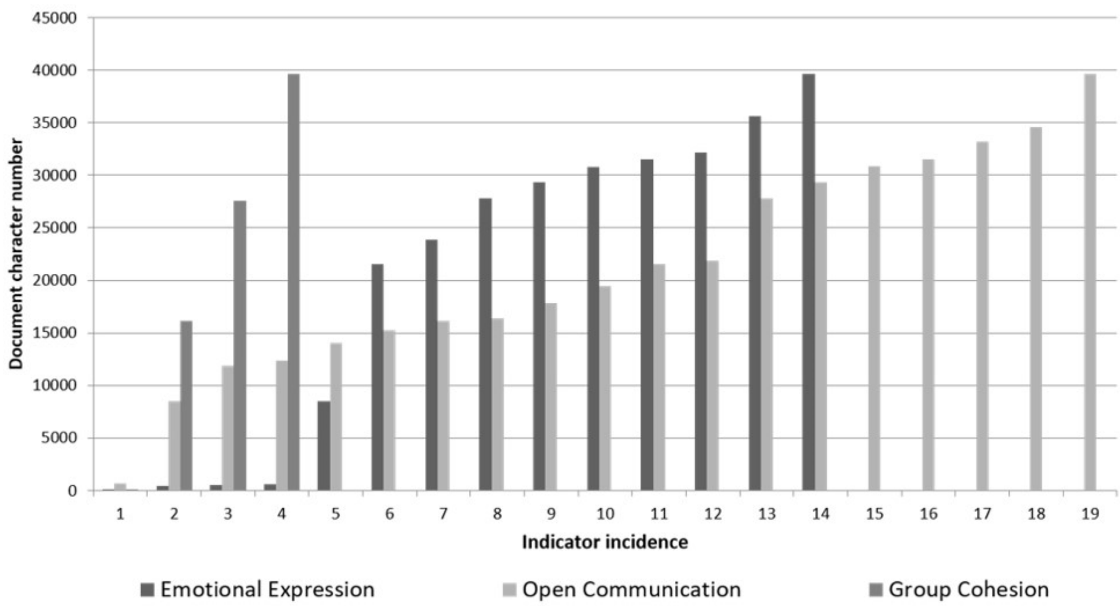


Figure 6. Teaching presence in synchronous discussion.

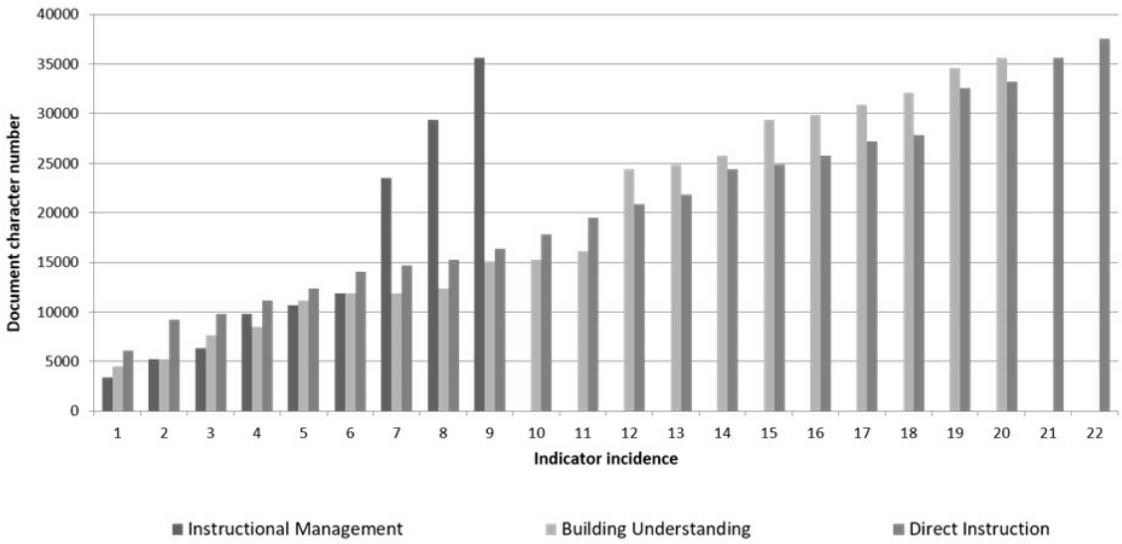


Figure 5 shows the breakdown for social presence. Group cohesion occurs early as faculty and students get acquainted, with emotional expression (eg, emotion, autobiographical narrative, humor) occurring toward the middle and end of the hour's discussion, as they become more relaxed and confident in each other's presence. The open communication (eg, acknowledgement, risk-free expression) appears to be evenly spread throughout.

Figure 6 displays the breakdown of teaching presence. Instructional management is when the instructor introduces topics. The chart shows a fairly uniform pattern of building understanding and direct instruction throughout the forum.

Discussion

Principal Findings

This study appears to be the first such research to use multiple sources of data to describe the characteristics of Community of Inquiry of a whole Web-based course. As such, it is difficult to place the findings in comparison to other literature. Kumar et al [20] are one of the few to have studied a course as a whole, researching asynchronous and synchronous forums. However, they use only a quantitative data source and conclude that social presence was more difficult to foster than cognitive and teaching presences. The university course studied for this paper showed similar levels of presences using the survey tool, although teaching presence was less than "agreed" on the composite score (ie, score <4.0). However, the value of comparing scores of courses as a whole is not clear.

This study does indicate that a CoI is possible across a wide range of learning activities of a Web-based course. It has identified areas of strength and weakness, and as such can aid course developers and others to improve areas of weakness. Specific findings are as follows.

Survey

The survey showed that students perceived that a strong CoI was created in the master's course. The overall composite score of all the items from all respondents was 4.1 (SD 0.46). Cognitive presence was the most strongly perceived, with every item in agreement. The survey asked 12 questions on cognitive presence, three each for triggering event, exploration, integration, and resolution. The results from this study indicate that each of the phases of cognitive presence was well met. However, five of the teaching presence items did not give agreement. It is interesting to see that those consist of three of the first four questions, designed to assess "design & organization," and also two of the last three questions, designed to assess "direct instruction." The last two both featured "feedback" in the item, which had been acknowledged within the faculty to have been substandard in the early phases of the course. The design and organization were suboptimal with early teething problems with the administrative aspects of the course. These did improve over the academic year, but the students perceived them to be weaker aspects of the course. High teaching presence has been correlated with high cognitive presence by Akyol and Garrison [17], and Shea and Bidjerano [10] concluded that higher levels of instructor facilitation led to higher cognitive presences. In this study, the survey items that measured "facilitation" all met the criteria for strong agreement, and coupled with the strong cognitive presence, would also support those findings, even though such correlations were not part of the research design.

Social presence has been described in the literature as being crucial to the development of critical discourse in Web-based environments. While social presence alone will not result in deep learning, such learning is extremely unlikely to occur in its absence [10]. The findings from this research show that the students generally felt able to develop group cohesion and were comfortable interacting within the course and among their peers. Garrison in his review of the CoI [11] emphasizes the importance of developing group cohesion as a means of fostering a strong environment that may encourage deep learning, putting less importance on personal relationships and socioemotional presence. The findings of this study reveal strong results for such less important aspects, but Garrison also points out that to develop group cohesion, getting to know each other is an important part early in the process.

Asynchronous Discussion Forums

Asynchronous discussion forums are the most dominant form of computer-mediated communication and among the most studied in the literature. This study analyzed the contents of 10 separate discussions, comprising 165 comments and over 18,000 words. The aggregate CoI coding showed that social presence was the most dominant within these discussions, followed by cognitive then teaching presences.

The major criticism of these types of communication has been the lack of social presence and community [21]. The lack of immediacy and dynamic interaction compared to face-to-face communication, as well as the frustrations of posting and reading long messages have all been reported to reduce the engagement and participation of students [22]. This study showed that social interaction is inherently possible in asynchronous forums, as supported by other authors [16,23], and that the creation of a CoI can occur.

The cognitive presence within the discussions was generally higher in this study when instructors participated in the forum (Figure 2), although the last discussion (number 10) had no instructor presence. However, studying only the broad cognitive presence without the breakdown of which element of the presence occurs can either overestimate or underestimate its importance. Evidence of higher levels of thinking (integration and resolution) suggest that more deep and meaningful learning may have occurred [8,24,25]. These studies, however, have stressed how content analysis has generally found that asynchronous discussions develop more instances of lower level thinking. This study would support that finding (Figure 3). The data from analysis of the 10 discussions show that the majority of instances of cognitive presences were coded at the lower cognitive level of triggering event and exploration, with 30% being integration of ideas, but only 7% of instances being at the highest level of resolution.

However, as Garrison has pointed out [8], the CoI occurs only when all three presences occur and that teaching and social presence promote cognitive presence. Figure 1 shows which discussions had the most presences, compared to number of instructor posts. The discussions with most codes (discussion numbers 2, 7, and 8) had more equal proportions of each presence within them, with discussions 2 and 8 having the greatest number of instructor posts. This would suggest that a CoI was created in these posts, but that in these cases the instructor presence appeared to be important in creating that. Discussion number 10 scored most highly for teaching presence; however, there were no posts from an instructor. This was the last thread of the year and suggests the students may have gained more experience and confidence in directing the discussion and sharing their knowledge in the form of direct instruction. Similar findings have been reported by Akyol and Garrison in a study of the CoI [17], who noted increases in teaching presence over time in a course.

Synchronous Discussion Forums

These sessions were designed to be the primary source of interaction within the course, allowing students and faculty to get to know each other. Students were encouraged to use webcams for these sessions or audio feeds to increase the interactivity. The forums were places where grievances could be aired and problems discussed with faculty members. They typically consisted of casual opening exchanges, as well as the learning experiences from what was hoped to be a CoI.

The findings of this study suggest that these sessions did provide such a community. The content analysis of the transcript of one such forum shows 51 instances of teaching presence, 47 instances of cognitive presence, and 37 instances of social presence in a 1-hour session. Despite the ability of the forum to develop social interaction, the social presence was lower than the other two presences of the CoI framework. It is possible that this lower presence was because the forum that was chosen for analysis was in the middle of the course and that students and faculty were already acquainted. However, one might expect more “banter” as characters become better known.

The breakdown of CoI categories in the transcribed forum showed that the elements of practical inquiry (ie, triggering, exploration, integration, and resolution) were similarly expressed within the cognitive domain, whereas the emotional expression and open communication were dominant in the social presence domain. Direct instruction from the faculty member and his ability to build understanding were also high on the teaching presence front.

These findings correlate with results from the literature. Groen et al [26] comment on the ability of casual chat to build a sense of community, and that is reflected by emotional expression being the dominant coding category in this study’s content analysis (Figure 5). The steady presence of the open communication category throughout the discussion also represents development of the community within the session, while the strong cognitive presence indicates meaningful learning could have occurred.

The potential of deeper learning is supported by the cognitive breakdown (Figure 4). The exploration of themes tended to occur earlier in the discussion than integration and resolution, suggesting that as the forum progressed the students were more capable of higher levels of thinking as their understanding of the topics increased.

Teaching presence was strong in the synchronous discussion (Figure 6). This raises a possible concern. The presence of a dominant teacher runs the risk of the session developing into a teacher-centered activity, reducing the learning potential from a constructivist perspective [27]. The content analysis of the transcribed forum had a heavy direct instruction component, and 117 of the 324 posts were from the faculty member. However, there is no evidence from this study that information overload or distraction was a problem in this course, as Hiltz and Turoff [28] have warned against.

Strengths and Limitations

There are several limitations to this study. The setting of a single graduate-level course meant that the number of participants available were small. Only 22 students were initially enrolled in the course, and two withdrew early in the academic year resulting in 20 students eligible for the study. The course was also in its first year of existence and thus experienced difficulties at the start. This was quickly recognized by the faculty and administrative staff but resulted in suboptimal administrative tasks and communication, delays in feedback processes, and early technology difficulties. This may have influenced some of the study results. Toward the middle and end of the year, these processes were tightened and strategies to ensure timely feedback and clarity in organization were instigated.

The master's program in this research was in a health care discipline, and the area of study a highly niche topic with no such comparable course available worldwide either in topic or delivery. Therefore, it is hard to know how transferrable these findings may be to other disciplines or courses.

The CoI survey was sent to students only once approximately 6 months after the end of the year in question. An earlier mid-course survey combined with the end of year survey would have enabled comparison of how a CoI changed over time and whether the problems listed above may have altered the findings.

Time and resource restraints meant that only a selection of discussion forums was analyzed. Therefore, it is unclear whether the results are generalizable. This was mitigated in part by choosing a synchronous forum in the middle of the year, with no prior knowledge of content or participants. A range of asynchronous forums across the year were also chosen to try to obtain a representative sample of the course.

However, the research also has strengths. The relatively small number of participants enabled an in-depth examination of the study question. Larger sample sizes may have resulted in an amount of data that would not be possible for a single researcher to analyze. Although the course was a health care discipline, the participants were inter-professional graduates. This resulted in differing perspectives and backgrounds giving the researcher more enriched data than may have been available if only physicians or nurses had been enrolled.

Areas for future research include repeating the study in future years to compare how CoI may change as the course becomes more mature and as faculty and administration are more familiar with Web-based learning and reacting to feedback. A larger study would allow more content analysis of discussion forums. How CoI changes over time could be studied by analyzing both synchronous and asynchronous forums in a more structured manner at set times of the year.

Conclusion

The results of this study show that a Community of Inquiry is possible in a Web-based master's program. The significance of this study is in its methodology. It has set out to explore the CoI not only of a course in its entirety, but also within some of its constituent parts. Analysis of the CoI survey has shown global trends over the year. The content analysis provided rich information that would not have been evident from just the survey and highlighted areas of pedagogical strengths and weaknesses, which can improve the CoI presence of the course if addressed. These results would suggest that strong learning opportunities are entirely possible in Web-based courses.

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Conflicts of Interest

None declared.

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Abbreviations

CoI: Community of Inquiry
MSc: Master of Science

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Review

Telemedicine Training in Undergraduate Medical Education: Mixed-Methods Review

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Abstract

Background: Telemedicine has grown exponentially in the United States over the past few decades, and contemporary trends in the health care environment are serving to fuel this growth into the future. Therefore, medical schools are learning to incorporate telemedicine competencies into the undergraduate medical education of future physicians so that they can more effectively leverage telemedicine technologies for improving the quality of care, increasing patient access, and reducing health care expense. This review articulates the efforts of allopathic-degree-granting medical schools in the United States to characterize and systematize the learnings that have been generated thus far in the domain of telemedicine training in undergraduate medical education.

Objective: The aim of this review was to collect and outline the current experiences and learnings that have been generated as medical schools have sought to implement telemedicine capacity-building into undergraduate medical education.

Methods: We performed a mixed-methods review, starting with a literature review via Scopus, tracking with Excel, and an email outreach effort utilizing telemedicine curriculum data gathered by the Liaison Committee on Medical Education. This outreach included 70 institutions and yielded 7 interviews, 4 peer-reviewed research papers, 6 online documents, and 3 completed survey responses.

Results: There is an emerging, rich international body of learning being generated in the field of telemedicine training in undergraduate medical education. The integration of telemedicine-based lessons, ethics case-studies, clinical rotations, and even teleassessments are being found to offer great value for medical schools and their students. Most medical students find such training to be a valuable component of their preclinical and clinical education for a variety of reasons, which include fostering greater familiarity with telemedicine and increased comfort with applying telemedical approaches in their future careers.

Conclusions: These competencies are increasingly important in tackling the challenges facing health care in the 21st century, and further implementation of telemedicine curricula into undergraduate medical education is highly merited.

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KEYWORDS

telemedicine; education, medical, undergraduate; schools

Introduction

The Context of Telemedicine in the United States

Telemedicine has grown exponentially over the past few decades in the United States. It is currently utilized by a majority of health care institutions and its market is expected to reach over US $40 billion in 2018 [1,2]. The current health care landscape in the United States likewise presents ideal conditions to accelerate this growth. A national physician workforce shortage, geographic maldistributions of primary care, and specialist physicians as well as an untenably high national health care expenditure, all serve to incentivize the telemedicine enterprise.

Telemedicine is an expansive field, distinct from but overlapping with telehealth, electronic health, and mobile health. One of the foundational questions preceding the development of any curricula is where to draw the lines in defining telemedicine. Sood et al found that telemedicine was the most fundamentally defined as the provision of health care services over a spatial distance through the use of telecommunication technology with the aim of providing benefit to a patient or population [3]. These benefits include the key aspects of the Triple Aim, such as the improvement of access to health care services, the reduction of health care costs for patients and for society, and the provision of more convenient and higher quality health care [4].

These benefits are rapidly becoming realized as more hospital systems, large employers and health insurance companies, individual states, and the federal government itself are increasingly turning toward telemedicine for health care solutions [1,5,6]. Implementation of a telemedicine visit program at a single rural Veterans Affairs hospital found reductions of over 820,000 miles of travel time for 1859 patients over the course of 9 years [7]. Ample evidence has also been generated supporting the influence that telemedicine exerts in improving health care outcomes in an array of different settings and conditions [8].

Underlying the unfoldment of telemedicine in the United States has been the concomitant emergence of enabling societal and cultural trends. With 84% of US adults reporting that they use the internet and 92% of US adults reporting that they own a cellphone, American society is more technologically equipped than ever before [9]. A willingness to rely on the utilization of such technology in answering health questions is increasingly apparent, with 70% of US adults reporting that their first source of medical information is searching the internet. These trends signify a ripening opportunity for telemedicine to fulfill the health care needs of an increasingly digitally enabled society that is willing and able to utilize modern technology.

Despite this reality, several barriers still remain in the widespread uptake of telemedicine as a health care delivery paradigm as common as traditional medical care. A Market Innovation Center Consumer Choice Survey characterized a number of consumer concerns regarding telemedicine utilization. Primary among these was the doubt regarding the quality of care delivered through telemedicine; other major concerns included the security of health information in the digital space, as well as the potential lack of personal connection with health care providers over telemedicine visits [10].

The Role of Undergraduate Medical Education in Telemedicine

Training physicians to deliver high-quality, secure, and personable health care through telemedicine can serve to alleviate these concerns and promote the population-wide adoption of telemedicine. In fact, medical students who interact with telemedicine during their undergraduate medical training find that it contributes to the development of core competencies in patient care, medical knowledge, and practice-based learning; interestingly, these benefits tended to be stronger when telemedicine exposure occurs during undergraduate medical education as compared with during graduate medical education [11].

Finally, a number of concerns that hinder the adoption of telemedicine at the provider level, as well as system-wide level, have become increasingly apparent. These include concerns regarding legal and liability uncertainties, licensure requirements, and nascent reimbursement mechanisms [12]. Although these issues are becoming incrementally resolved at a governmental- and structural-level, undergraduate medical education can serve to equip future physicians with a more comprehensive understanding of the telemedicine space in their locality. Although the many uncertainties within the telemedicine field will take time to be delineated, effective and evolving telemedicine curricula can go a long way in encouraging future physicians to interact with telemedicine.

As telemedicine becomes more ubiquitous in our nation's health care delivery system, it is imperative that modern physicians are trained to leverage such technology effectively. In this regard, undergraduate medical education represents an invaluable window of opportunity for building these capacities in future physicians. The American Medical Association (AMA) has similarly articulated the need for telemedicine training for medical students and residents and has subsequently encouraged its adoption by medical schools and other institutions [13].

The Liaison Committee on Medical Education's (LCME) Annual Medical School Questionnaire from 2015 to 2016 shows that over a quarter of the nation's allopathic degree-granting medical schools have implemented telemedicine training components into the preclinical phase of their curriculum and nearly half have implemented it into the clerkship phase [14,15]. The learning being generated by these institutions is encouraging and warrants deeper investment in preparing future physicians to be empowered utilizers of telemedicine technology.

The aim of this review was to characterize, both qualitatively and quantitatively, the diverse approaches being undertaken by medical schools and other health care institutions to implement telemedicine training into undergraduate medical education, and to allow for a better understanding of the current state of telemedicine capacity-building in undergraduate medical education in the United States. This will allow medical schools and other stakeholders to further develop their telemedicine capacity-building curricula in the most effective, systematic, and evidence-based way possible.

Methods

Literature Review

A literature review was carried out on Scopus using the terms and Boolean operators *telemedicine* AND *medical student* OR *undergraduate medical education* OR *medical school* to yield a total of 274 journal articles. There were 2 additional peer-reviewed journal articles in the Jefferson Digital Commons, which covered telemedicine education programs that were included. Of these 276 articles, 107 were excluded as they were either older than 10 years or did not cover the inclusion criteria of examining the implementation or evaluation of a telemedicine-related curriculum or program into undergraduate medical education, either in the preclinical or the clinical years of medical schooling. The texts of the remaining 169 journal articles were read to determine if they met the inclusion criteria; of these, 9 met the inclusion criteria and were included in the literature review. A similar search was carried out on Google Scholar but did not yield any additional journal articles relevant to the study.

The principal purpose for the literature review was to extract the components of the telemedicine training curriculum at each institution rather than to evaluate study design. Therefore, no formal quality evaluation of journal articles was carried out. Rather, each journal article was dissected to determine the features of the telemedicine training component being described, when in the curriculum it was included, and how it was implemented.

Online Search and Survey

In addition, the LCME data from the AMA, which included statistics regarding telemedicine curricula implementation by US allopathic-degree-granting medical schools, were obtained. Using this information, all such schools marked as having some form of telemedicine curriculum were researched using a Web search for *telemedicine*, *telehealth*, *medical school*, *medical student*, and *medical education* to look for publicly available information regarding the telemedicine training within their curriculum. Any publicly available documents were downloaded and analyzed to determine the features of the telemedicine training component being described, when in the curriculum it was included, and how it was implemented.

In addition, for each medical school reporting to the AMA to have a telemedicine component within their curriculum, an appropriate contact was identified and contacted via an email explaining the research project, requesting a conversation to learn more about the institution's telemedicine curriculum, and including a survey link for those that were unable to communicate via phone. This contact was the administrative or faculty member listed as being in charge of telemedicine within a medical school or associated health care system. When there was no such person, the Associate Dean or Deans of Curriculum were identified and contacted. The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) for the distributed survey is included as Multimedia Appendix 1.

Synthesis of Findings

Overall, through the online search for publicly available documents and the cross-sectional survey of faculty members responsible for telemedicine and/or medical school curriculum, 70 institutions were contacted and researched, yielding 7 interviews, 4 peer-reviewed research papers, 6 online documents, and 3 completed survey responses. These sources of information were primarily analyzed for the features of the telemedicine training component at each medical school, when in the curriculum such training was included, and how it was implemented. During the 7 interviews, additional questions were asked, which allowed stakeholders to share what they considered accelerators and barriers to the implementation of telemedicine in undergraduate medical education.

The information collected from the initial literature review, qualitative research, and quantitative information gathering were then synthesized into a congruent and comprehensive review of the current trends in telemedicine competency development in the domain of undergraduate medical education.

Results

Telemedicine in the Preclinical Phase

The preclinical years of undergraduate medical education represent an important window of opportunity for telemedicine training and exposure. At present, an array of medical schools across the country are generating learning regarding the implementation of telemedicine training into the preclinical years of undergraduate medical education.

Twelve out of seventeen sampled medical schools with telemedicine curricula (71%) have implemented some form of didactic learning (Figure 1). In addition, 9 out of 17 (53%) and 10 out of 17 (59%) sampled medical schools utilize patient encounters or standardized patient encounters, respectively, to develop telemedicine competencies in medical students.

In addition, 5 out of 17 of sampled medical schools (29%) have incorporated telemedicine exposure into scholarly projects that medical students choose to pursue within a structured, but independent, framework.

The nature of telemedicine curricula has also been shown to lend itself to multipurpose implementation. Seven out of seventeen of sampled medical schools with telemedicine curricula (40%) combined telemedicine competencies with some form of interprofessional training and exposure (Figure 1).

In addition, a wide array of medical schools is finding that telemedicine training is a natural vehicle for exposing students to the considerations and concepts behind providing health care in rural settings. This is especially true of medical schools that have a vested interest in rural care, particularly those serving medical students in rural communities. In this regard, over half of sampled medical schools combined telemedicine competencies with rural medicine in some form.

Figure 1. The format and auxiliary objectives of telemedicine curricula in US MD medical schools.

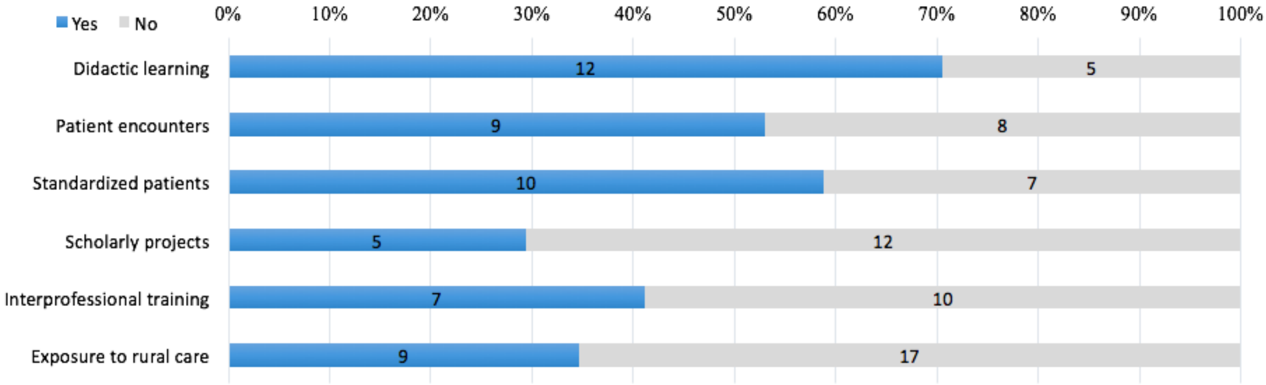
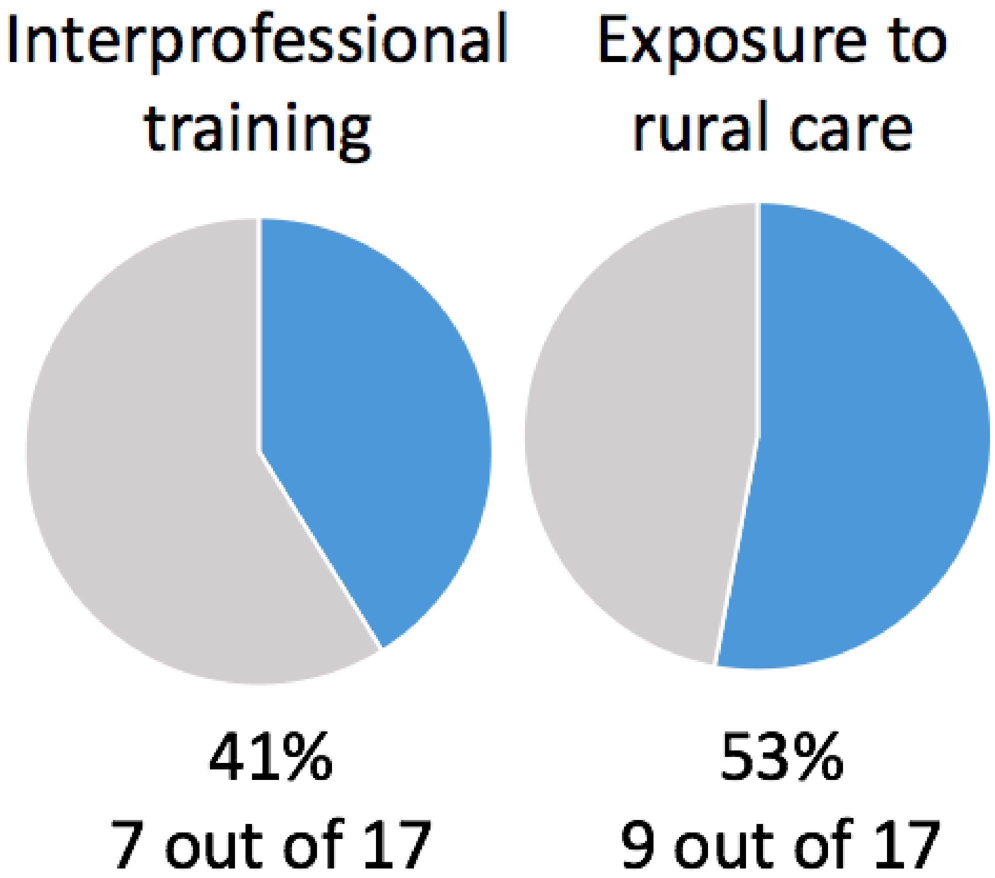


Figure 2. Proportion of US MD Medical Schools with a preclinical telemedicine curriculum by state. LCME: Liaison Committee on Medical Education; MD: Doctor of Medicine.



Telemedicine in the Clerkship Phase

The clerkship phase of undergraduate medical education is where medical schools have, for the most part, invested the greatest amount of energy into telemedicine training for medical students. This is a result of the increasing presence that telemedicine has in the practice of clinical medicine itself; formalizing the telemedicine exposure experienced during clinical rotations is a natural process, particularly in fields where telemedicine is more commonly used such as psychiatry, neurology, dermatology, and radiology and in geographic areas where telemedicine is increasingly relied upon, such as the Midwest. It is no wonder then that over 60 allopathic medical schools in the United States provide some form of telemedicine experience in their clerkship offerings.

These clerkships range from rotations that simply afford exposure to the use of telemedicine in the course of everyday practice to distinct telemedicine electives that present a more focused opportunity for medical students to develop telemedicine competencies.

As telemedicine becomes increasingly implemented into the modern health care delivery paradigm, its presence in the wards during the clerkships of medical students will grow. Thereby, most medical students will gain at least basic exposure to telemedicine as a tool for providing health care. In addition, the emergence of telemedicine-focused electives provides an opportunity for motivated students to pursue further exposure to telemedicine and develop a stronger relevant skillset. In this way, quality telemedicine training is available to those that are interested but not mandated on others.

Trends in Geographic Distribution

There is currently a large disparity between the implementation rates of telemedicine curricula among different states in the United States, particularly in regard to preclinical undergraduate medical education. There are a number of states that host a majority of schools that have implemented some form of telemedicine curriculum (Figure 2). Notable among these states are California, Pennsylvania, and Michigan, which together are home to over 1 out of every 7 medical schools in the country. There are however a number of large states where schools that have implemented telemedicine curricula in preclinical education are in the minority, including New York and Texas. Even more striking are the large swathes of the country where no medical schools include telemedicine training in any form as part of their preclinical undergraduate medical education curriculum. This is particularly concerning as these regions are often those that stand the most to benefit from telemedicine because of the large number of rural communities, such as in states like North Dakota, Kansas, and Oklahoma.

There is a marked increase in the number and distribution of medical schools in the United States when considering schools that have implemented some form of telemedicine exposure or clerkship during the clinical years of their undergraduate medical education curriculum (Figure 3). This is often because of the natural exposure that students get to telemedicine when operating in settings where it is more commonly found, either with telemetry, remote specialist consults, and rural care. Most of the West Coast demonstrates high levels of telemedicine experience implementation in the clinical curriculum, as well as the rest of the country. There are however a number of states where these schools are the minority, including Florida and Pennsylvania, and there are still states that lack any schools with telemedicine exposure implemented into their curriculum, such as Minnesota, Wisconsin, and Oklahoma.

Overall, these findings characterize and illuminate the need that still exists within undergraduate medical education throughout the nation to incorporate telemedicine competencies and exposure into established medical school curricula. In fact, such efforts would be complimentary to the current work that medical schools, professional organizations, and local, state, and federal governments are already carrying out to improve the delivery of health care to rural and otherwise underserved populations.

Contextual Forces in the Telemedicine Education Space

The importance of telemedicine training in the domain of undergraduate medical education has been clearly articulated by the AMA with the announcement of policy encouraging the adoption of telemedicine curricula by medical schools throughout the United States. However, as these telemedicine competencies are incorporated by more medical schools, attention should be given to the systematic implementation of programs and the scientific evaluation and dissemination of generated learning.

Transparency in the efforts of medical schools to incorporate telemedicine training into their curricula and discourse involving best practices needs to be fostered. At present, only 12 allopathic medical schools with telemedicine components in their preclinical or clerkship curriculum offer publicly available information regarding the format and content of such components (Figure 4).

In addition, an even smaller proportion of these medical schools have studied and published the impact of such training on medical students. This paucity of literature is a hindrance to the identification and dissemination of best practice approaches to telemedicine training in undergraduate medical education. A renewed commitment to the systematization and dissemination of knowledge is particularly justified by the nascent nature of telemedicine education in most parts of the United States; all medical schools will need to evolve their telemedicine competency components as the telemedicine landscape rapidly advances in coming years, and so all medical schools can benefit from open and knowledge-rich channels of communication.

Another trend influencing the telemedicine exposure that medical students receive during their undergraduate medical education is the emergence of strong telemedicine institutions and regional telemedicine networks. These organizations, often named telemedicine or telehealth centers, telemedicine programs, or telemedicine projects, confer upon medical students at associated institutions the ability to witness the vibrancy and scope of the telemedicine enterprise.

Project ECHO, for example, which was launched in New Mexico to allow specialists to assist primary care physicians through telemedicine, affords medical students a valuable opportunity to glimpse the capabilities of telemedicine to contribute to patient care at a population-wide level. Likewise, the Arizona Telemedicine Program serves as a strong regional resource for supporting telemedicine development and education. As more telemedicine programs at health care institutions develop, these centers for learning opportunities can be expected to play an even greater role in telemedicine training in undergraduate medical education.

Figure 3. Proportion of US MD Medical Schools with a clinical telemedicine curriculum by state. LCME: Liaison Committee on Medical Education; MD: Doctor of Medicine.

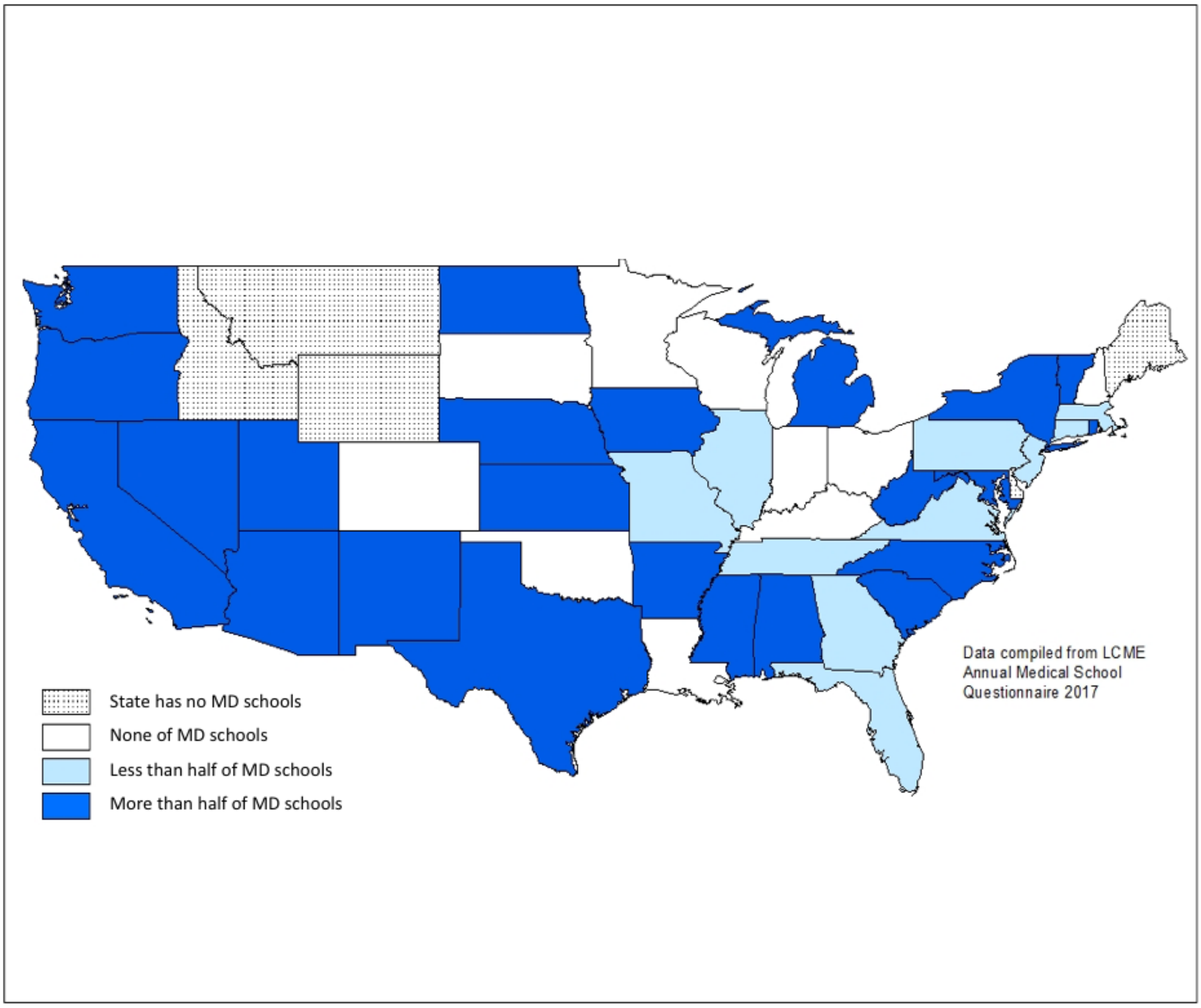
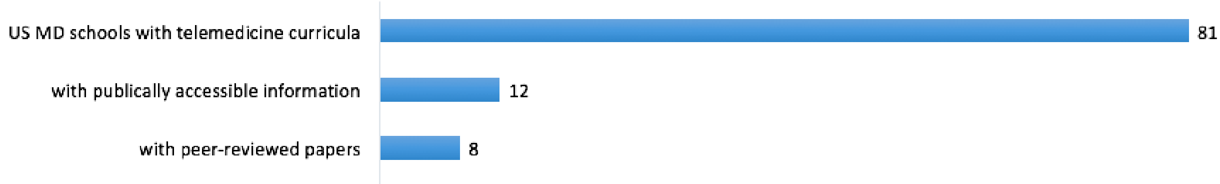


Figure 4. Availability of information regarding telemedicine curricula in undergraduate medical education in the United States. MD: Doctor of Medicine.



Discussion

The Current Landscape of Telemedicine Training

The current state of telemedicine training in undergraduate education is that of budding growth and promising development; that more than a quarter of medical schools have preclinical telemedicine training in one or more diverse ways, and that almost half of medical schools have found organic ways to incorporate telemedicine exposure into students' clerkship curriculum is promising. The geographic disparities that exist in the implementation of telemedicine training and the relationship between telemedicine exposure and the development of regional telemedicine institutes will be an important area of focus in the coming years.

Medical students have been shown to graduate feeling unprepared to utilize telemedicine effectively and feeling uninformed about the laws governing telemedicine use [16]. At the same time, there is a growing appreciation among medical students that such training would be both relevant and important for their future work [17]. Therefore, the acceleration of the implementation of telemedicine training into the undergraduate medical education curriculum in the United States is of vital importance. This is being accomplished through a diversity of institution-dependent avenues, including didactic learning, real patient and standardized patient encounters that develop telemedicine competencies, and scholarly projects that allow deeper insights into telemedicine technology.

The University of Maryland, for example, covers basic telemedicine concepts during lecture time, whereas the University of Nebraska has incorporated telemedicine into its doctoring thread. The Oregon Health and Sciences University has woven telemedicine into objective structured clinical examinations, allowing students to practice clinical skills using telemedicine technology while receiving formative feedback in a way that is financially feasible for the medical school and well-liked by students [18].

These all signify diverse approaches to fulfill the need for greater telemedicine exposure in undergraduate medical education. At the same time however, it is increasingly important that medical schools with telemedicine competencies are including them in their curriculum in a meaningful way. One of the greatest concerns among surveyed stakeholders was the meaningful use of telemedicine training and ensuring that telemedicine's inclusion in the undergraduate medical education curriculum is more than cursory.

The Future of Telemedicine Education

To accomplish this, telemedicine training in undergraduate medical education should move beyond the simple exposure of medical students to telemedicine technology and seek to augment such exposure with at least basic understanding of the complex governmental, socioeconomic, and cultural principles involved. This is especially important in light of the rapid pace of technological innovation in the telemedicine space; future physicians must not only be trained to use telemedicine but also to do so professionally, safely, and in an evidence-based manner [19].

The likely answer to this concern is already being explored by a multitude of medical schools that are finding ways to combine and consolidate different curricular aims into multifaceted educational components. By combining telemedicine training with existing competencies such as rural care exposure and interprofessional training, medical schools are able to expose future physicians to telemedicine without significant additional burden. Rather than struggling to fit telemedicine into an already overflowing curriculum, medical schools are most successfully able to include telemedicine competencies when they build them into existing components of the curriculum.

The Cleveland Clinic, for example, has incorporated telemedicine into an ethics curriculum, allowing a panel of second-year medical students to interview dialysis patients over a live video stream to learn about professionalism, patient experiences, and health care ethics [20]. At the University of Arizona (Tucson) and the University of North Dakota, telemedicine is being used to foster interprofessional training and collaboration among students from different health professions [21].

Telemedicine in the clerkship phase of the undergraduate medical education curriculum is another immensely important area of focus and is where the deepest level of development has occurred in regard to inclusion of telemedicine training in meaningful ways. Medical students that participate in telemedicine electives view telemedicine as an important educational tool and highly rate the ability of telemedicine to contribute to their medical knowledge, patient care skills, and system-based practice [11,22].

At the University of New Mexico, medical students are exposed to telemedicine as they rotate through a variety of clerkships, and students who show an interest are able to develop research projects and community interventions that utilize telemedicine. The scope of these projects has even included telemedicine in a global health context with students working abroad. As such, telemedicine training during the clerkship phase of medical education also represents a valuable opportunity for student learning to intertwine with genuine contributions to worldwide health [23].

Medical schools such as Thomas Jefferson University, the University of Texas Medical Branch (Galveston), the University of Texas (Houston), and Southern Illinois University have all implemented distinct telemedicine clerkships. At Thomas Jefferson University, third- and fourth-year medical students can participate in an elective where they aid patients and the medical team in carrying out virtual rounds, which allow patient families to participate during rounds through telemedicine [24].

At the University of Texas Medical Branch (Galveston), medical students learn about the field of telemedicine through study and exposure in multiple different practice settings. All participating students found that the experience proved helpful in focusing their future career goals and shared that they would recommend such an elective to fellow students [25].

The Barriers to Overcome for Widespread Adoption of Telemedicine Training

Although there is an immense amount of knowledge to be gained from exploring the current state of telemedicine in undergraduate medical education in the United States, there are important barriers and limitations to consider. At many institutions, telemedicine exposure exists within the curriculum only implicitly, which prevents quantitative analysis, whereas at other institutions, telemedicine competencies may be formally included in the curriculum but not actually implemented in practice. In addition, as the number of medical schools in the United States is large, the low sample size of 17 is enough to give a general snapshot of the state of telemedicine education but not an exhaustive understanding. Indeed, there is a plethora of knowledge to be gained from further research and analysis regarding telemedicine in undergraduate medical education.

Future areas of research will undoubtedly involve comparing the efficacy of existing telemedicine training components and studying the most effective way to implement telemedicine into institutions with no telemedicine training and to evolve the current telemedicine trainings that medical schools are carrying out. Importantly, the state and regional geographic disparities in the rate of inclusion of telemedicine training into the undergraduate preclinical and clerkship curriculum are an important phenomenon that surely influence the education of the future generation of physicians and must be better understood.

At the same time, it is important to understand the global context within which the telemedicine training in the United States exists. Compared with countries such as Australia, which have relied heavily on telemedicine because of geographic limitations, the United States has much development to accomplish. However, compared with other countries such as France, the spread and reach of telemedicine training in undergraduate medical education is advance [26]. There therefore seems to be an important correlation between the state of telemedicine itself within a country, and the development of the educational system necessarily to effectively utilize telemedicine.

As telemedicine has become an increasingly important presence in the health care system of the United States, its inclusion into the training of future physicians has likewise become increasingly necessary and important. The diverse approaches being undertaken by medical schools in developing telemedicine competencies in medical students is a promising sign of accelerating growth in this domain, but future effort is needed on the part of institutions to make such training meaningful and comprehensive. Further research into telemedicine training in undergraduate medical education will be an important part of the process and will be an area of need in coming years.

Conflicts of Interest

None declared.

Multimedia Appendix 1

The Checklist for Reporting Results of Internet E-Surveys (CHERRIES).

[PDF File (Adobe PDF File), 196KB - mededu_v5i1e12515_app1.pdf]

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Abbreviations

AMA: American Medical Association
LCME: Liaison Committee on Medical Education

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Review

Applications and Challenges of Implementing Artificial Intelligence in Medical Education: Integrative Review

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Abstract

Background: Since the advent of artificial intelligence (AI) in 1955, the applications of AI have increased over the years within a rapidly changing digital landscape where public expectations are on the rise, fed by social media, industry leaders, and medical practitioners. However, there has been little interest in AI in medical education until the last two decades, with only a recent increase in the number of publications and citations in the field. To our knowledge, thus far, a limited number of articles have discussed or reviewed the current use of AI in medical education.

Objective: This study aims to review the current applications of AI in medical education as well as the challenges of implementing AI in medical education.

Methods: Medline (Ovid), EBSCOhost Education Resources Information Center (ERIC) and Education Source, and Web of Science were searched with explicit inclusion and exclusion criteria. Full text of the selected articles was analyzed using the Extension of Technology Acceptance Model and the Diffusions of Innovations theory. Data were subsequently pooled together and analyzed quantitatively.

Results: A total of 37 articles were identified. Three primary uses of AI in medical education were identified: learning support (n=32), assessment of students' learning (n=4), and curriculum review (n=1). The main reasons for use of AI are its ability to provide feedback and a guided learning pathway and to decrease costs. Subgroup analysis revealed that medical undergraduates are the primary target audience for AI use. In addition, 34 articles described the challenges of AI implementation in medical education; two main reasons were identified: difficulty in assessing the effectiveness of AI in medical education and technical challenges while developing AI applications.

Conclusions: The primary use of AI in medical education was for learning support mainly due to its ability to provide individualized feedback. Little emphasis was placed on curriculum review and assessment of students' learning due to the lack of digitalization and sensitive nature of examinations, respectively. Big data manipulation also warrants the need to ensure data integrity. Methodological improvements are required to increase AI adoption by addressing the technical difficulties of creating an AI application and using novel methods to assess the effectiveness of AI. To better integrate AI into the medical profession, measures should be taken to introduce AI into the medical school curriculum for medical professionals to better understand AI algorithms and maximize its use.

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KEYWORDS

medical education; evaluation of AIED systems; real world applications of AIED systems; artificial intelligence

Introduction

Artificial intelligence (AI) has evolved sporadically through the years and most recently gained traction with the advent of deep learning and artificial neural networks. The term AI, created by John McCarthy in 1955 [1], is defined as a machine with intelligent behavior such as perception, reasoning, learning, or communication and the ability to perform human tasks [2]. AI is composed of three main paradigms: symbolic (logic based and knowledge based), statistical (probabilistic methods and machine learning), and subsymbolic (embodied intelligence and search). These paradigms address several problem domains (perception, reasoning, knowledge, planning, and communication). The current applications of AI include its use in automotives, finance and economics, medicine and education [3] including medical education, and Google's search engine.

The application of AI in medicine remains a hot topic of keen interest for researchers and is under constant development and refinement. One such advancement has machines capable of making a radiological diagnosis at an equal or even higher success rate than highly qualified consultants in that particular specialty. Another well-known example is IBM Watson, which has successfully morphed from its triumph in the game of "Jeopardy!" to the field of medical oncology. Apart from the highly publicized role of AI in radiological diagnosis, other applications include use as an adjunct to the ideal management of cancer or chronic illnesses such as chronic mental disorders [4], particularly regarding the choice of medication with the best response and side effect profiles.

Over the past 25 years, there have been significant developments of AI in education [5], with advances such as "teacher bots," a teaching assistant tasked to deliver content, provide feedback, and supervise progress [6,7]. This increasingly broader use in the field of education has proven to have the potential to help students receive specialized help and identify knowledge gaps, thereby freeing teachers from menial tasks and allowing them to respond to students more effectively and improve the personalized and adaptive teaching process.

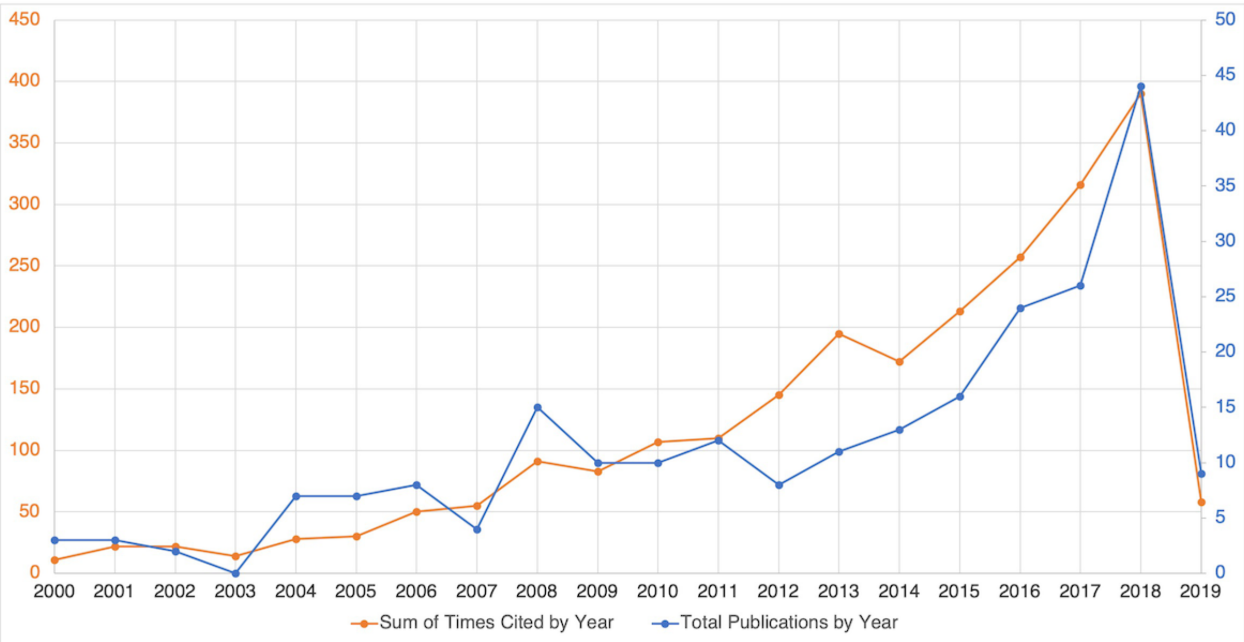
Medical education encompasses a lifelong learning continuum ranging from undergraduate to postgraduate and specialization training and beyond, also known as "continuing medical education" [8]. It is also applicable to various health care professionals, ranging from doctors to nurses and other allied health care workers. Unlike the field of medicine, there was little interest or advances in AI in medical education during the 1980s, apart from the established projects ATTENDING and GUIDON [9]. Interestingly, a preliminary search in Web of Science for the use of AI in medical education (dated August 14, 2018) demonstrated a growing enthusiasm in this field, with an increase in the number of total publications and times the articles were cited over the last two decades (Figure 1). This reflects an increase in research and development of AI in medical education in recent years.

In this age of rapidly advancing technology, the need to ground novel work on reported research is vital in order to advance the field of AI in medical education. Currently, there are limited articles [9,10] discussing or reviewing the current applications of AI in medical education.

The aim of this study was therefore to review the current reported scholarly work on AI in medical education. Two research questions guided this study:

- How is AI currently used in medical education?
- What are the challenges in implementing AI in medical education?

Figure 1. Total publications and sum of times cited by year in the last two decades. Retrieved from Web of Science for artificial intelligence in medical education, dated April 1, 2019.



Methods

We conducted an integrative review of peer-reviewed literature on AI used in medical education. Integrative reviews are the broadest type of research review method and allow for inclusion of various research designs to more fully understand a phenomenon of interest.

Data Sources and Search Strategy

We searched Medline (Ovid; 1954 to March 2019), EBSCOhost Education Resources Information Center and Education Source (1983 to March 2019), and Web of Science (1986 to March 2019) to identify articles addressing AI in medical education. We developed the search strategy in collaboration with an academic health sciences librarian. The key search terms were ("artificial intelligence" OR ai OR "machine learning" OR "deep learning") AND ("medical education" OR "medical student*" OR "medical curriculum" OR "medical school*" OR "medical training").

Inclusion and Exclusion Criteria

AI was defined as any technique that enables machines to imitate intelligent human behavior. This includes symbolic (logic based or knowledge based), statistical (probabilistic methods and machine learning), and subsymbolic (embodied intelligence, search, and optimization) AI paradigms covering different problem domains (perception, reasoning, knowledge, planning, and communication). In this study, the chosen medical education focus was on doctors' professional development across the whole education continuum, from undergraduate, postgraduate, and specialty training to continuing medical education.

Any feature of AI, such as machine learning and deep learning, was included in the search. The exclusion criteria were as follows:

- Articles on other aspects of education apart from medical education
- Articles on use of technology (such as online lectures and computer-based education) without incorporation of AI, or articles with only a brief mention of AI usage
- Article types: reviews, letters, and commentaries
- Full texts of articles available in languages other than English
- Articles published before 1954 due to lack of availability of online archiving of journals

Selection of Articles for Review

The titles and abstracts of identified articles were screened for the previously identified search criteria, and exclusion criteria were applied. All articles screened to be relevant or inconclusive were assessed in full text. Data such as current application in clinical practice, advantages of such use, and challenges of implementation of AI were extracted from all relevant articles.

Data Extraction

Data were carefully evaluated and extracted from all the eligible publications. Data retrieved from the studies included the name of the AI application, the study group, the use of AI, and the challenges of implementation as shown in Table 1.

Analysis of the Articles

Studies relevant to the use of AI in medical education were assessed using the Extension of Technology Acceptance Model and the Diffusion of Innovations theory [48] to explain the adoption of AI in medical education; data were subsequently pooled together and analyzed quantitatively using a statistical software (IBM SPSS Statistics for Windows, version 24.0; Chicago, IL), where relevant.

Table 1. Integrative review of the included studies.

Author and year	AI[a] application	Study group	Use of AI	Challenges of implementation
Clancey and Stanford Univ, 1983 [11]	GUIDON	UG[b]	Guides students to solve problems on infectious diseases using a diagnostic problem-solving approach	The need for a structured set of production rules
Papa et al, 1992 [12]	KBIT[c]	UG	Assess medical students' diagnostic capabilities	Need to create algorithms for different symptom approach
Eliot and Woolf, 1995 [13]	The Cardiac Tutor	UG	Teaches cardiac resuscitation techniques using a simulation-based tutoring system	Inability to correlate mastery of simulation with the level of ability to perform advanced cardiac life support
Billinghurst et al, 1996 [14]	Prototype sinus surgery	N/A[d]	Provides an intelligent simulation tool or surgical assistant	Requires improved script activation for immediate recognition of surgeon's actions with an appropriate response
Bourlas et al, 1996 [15]	CARDIO-LOGOS	UG, PG[e], CME[f]	Assists learners in the recognition and diagnosis of ECG[g] patterns	Variability in diagnostic criteria of ECG amongst different groups of specialists
Frize and Frasson, 2000 [16]	N/A	N/A	Provides improved learning by detecting the stage of understanding of learners and act as an aid for clinical decision making	N/A
Voss et al, 2000 [17]	LAHYSTOTRAIN	UG, PG, CME	Simulation for training in laparoscopy and hysteroscopy with the provision of feedback	N/A
Stasiu et al, 2001 [18]	CARDIOLOG	UG	Approach to the interpretation of ECG	Narrow knowledge domain restricted to basic cardiac conditions
Kintsch, 2002 [19]	Usage of Latent Semantic Analysis	UG	Assessment of clinical case summaries for medical students	Monetary investments required to develop the algorithm and evaluate the effectiveness of a program
Caudell et al, 2003 [20]	Project TOUCH	N/A	Real-time AI simulation engine in a 3D environment with VR[h] in a virtual patient	Need to validate the effectiveness of the AI system, network congestions may disrupt group interactions
Crowley and Medvedeva, 2003 [21]	SlideTutor	UG	Teaches diagnostic classification problem solving in dermatopathology	Not suitable for domains where there are no clear prototypical instances or schemas
Michael et al, 2003 [22]	CIRCSIM-Tutor	UG	Develops problem-solving skills on the baroreceptor reflex	Lack of quality explanations for wrong answers
Weidenbach et al, 2004 [23]	EchoComJ	UG, PG, CME	Teaching echocardiography in a simulated environment with feedback provision	Large data input required from real ultrasound images, extremely time-consuming process to develop the algorithm
Kabanza et al, 2006 [24]	TeachMed	UG	Teaches medical students clinical reasoning learning with appropriate feedback/prompts at an individualized pace	Technical difficulties: Having an efficient graph model with minimal loops to improve performance
Suebnukarn and Haddawy, 2006 [25]	COMET	UG	Provides aid in problem-based learning by an appropriate generation of tutorial hints	Inability to assess the effectiveness of COMET unless compared with learning with human tutors, lack of ability to interpret students' interactions in the chat tool due to lack of natural language processing capabilities
Woo et al, 2006 [26]	CIRCSIM-Tutor	UG	Allows students to practice qualitative causal reasoning in physiology when solving a problem	Inability to interpret and handle expressions of frustration and answers to open questions
Kabassi et al, 2008 [27]	N/A	UG, PG, CME	Develops an adaptive electronic learning system on atheromatosis	The need for capture and analysis of requirements and multidisciplinary input from medical tutors and software engineers
Vicari et al, 2008 [28]	AMPLIA	UG, PG, CME	Supports medical diagnostic reasoning	Students' lack of confidence in the system's ability to help them to arrive at the correct diagnoses

Author and year	AI[a] application	Study group	Use of AI	Challenges of implementation
Kazi et al, 2009 [29]	Extension of COMET	UG	Tutoring system for medical problem-based learning on diabetes, myocardial infarction, and pneumonia	Inferred concepts were mostly overgeneralized or nonrepresentative of the original concepts
Chen and Association for Institutional Research, 2010 [30]	N/A	UG	Construction of a curriculum assessment model using artificial neural network and support vector machine	Trial and error is required to determine training tolerance and configurations for the neural networks
Chieu et al, 2010 [31]	TELEOS project	PG	Teaching the concept of sacroiliac screw fixation in orthopedic surgery	N/A
Lemmon et al, 2011 [32]	N/A	PG	Simulation for junior doctors in the hospital ward setting	The use of an AI chat system based on predefined medical decision-making process, the virtual patient response has limited scalability
Flores et al, 2013 [33]	SimDeCS	UG, PG	Improves diagnostic reasoning in clinical problems in the context of a serious game	Variable reliability due to failure of the AI system
Islam, 2013 [34]	N/A	UG, PG, CME	Analysis of surgical skills in medical students or surgical residents with the provision of feedback	Technical difficulties may limit the effectiveness of the system, eg, the need for high-speed internet connection to upload the video quickly for immediate feedback
Chen et al, 2014 [35]	N/A	UG	Assess students' notes, identifies their competencies, and aligns them with learning objectives	A large sample size of gold standard annotation by geriatric educators is required
Cao et al, 2015 [36]	CVREA[i]	PG	Provides an effective training platform for anesthetists using a VR environment	The need for a multidisciplinary team: Anesthetists are unable to process data in an engineering way, and engineers are unable to produce clinically interpretable data
Kutafina et al, 2015 [37]	N/A	N/A	Training and evaluation of hand-washing techniques	Randomized controlled trial required to evaluate the effectiveness of the system in comparison with traditional methods of learning
Walkowski et al, 2015 [38]	N/A	UG	Correlation of students' viewing behaviors of whole-slide images with their test performances	Technical difficulties in development of the machine learning model due to the usage of a different decision trees for each question
Latifi et al, 2016 [39]	N/A	PG	Provide a framework for automated essay scoring using clinical decision-making questions	Need for detailed scoring rubrics and large sample size required for machine learning
McFadden and Crim, 2016 [40]	KBIT	CME	Evaluating the effectiveness of an AI-driven tutor in comparison with didactic lectures	Challenges in assessing the effectiveness of AI due to confounding factors, eg, complete case vignettes provided in the study, which is unlike a real clinical setting
Hamdy et al, 2017 [41]	Virtual Patient Learning	N/A	Provides real patient encounter using an online simulation system to evaluate students' communication and decision-making abilities	Inability to explore the extent of positive effects on clinical reasoning and communication skills
Khumrin et al, 2017 [42]	N/A	UG	Provides guided learning pathway and personalized feedback for students' approach to patients presenting with abdominal pain	Difficulty in the provision of effective and individualized feedback for each student
Alonso-Silverio et al, 2018 [43]	N/A	UG, PG	Evaluation of basic laparoscopic skills	Lack of sensitivity to identify trainees who outperform those who are less experienced
Oquendo et al, 2018 [44]	N/A	UG, PG, CME	Performance evaluation of a pediatric laparoscopic suturing task	Difficulty in rating certain scores due to the lack of participation of individuals at the same level of performance

Author and year	AI[a] application	Study group	Use of AI	Challenges of implementation
Chen et al, 2018 [45]	Trove radiology resident dashboard	PG	Automates ICD[j]/CPT[k] classification to provide a more up-to-date dashboard for radiology residents	The rule-based approach had a lack of scalability
Hayasaka et al, 2018 [46]	N/A	N/A	Use of AI-equipped robots as simulated patients	Worry that usage of robots may result in the training of standardized doctors
Kolachalama and Garg, 2018 [47]	N/A	UG	Uses machine learning content in the curriculum to focus on population health and improve patient care	Lack of content specialist in AI to teach students the application of AI knowledge in clinical settings

[a]AI: artificial intelligence.

[b]UG: undergraduate.

[c]KBIT: knowledge-based inference tool.

[d]N/A: not applicable.

[e]PG: postgraduate.

[f]CME: continuing medical education.

[g]ECG: electrocardiogram.

[h]VR: virtual reality.

[i]CVREA: computational VR environment for anesthesia.

[j]ICD: International Statistical Classification of Diseases and Related Health Problems.

[k]CPT: Current Procedural Terminology.

Results

Overview

Our search in the different databases revealed a total of 679 articles (Figure 2). After removal of the duplicates (n=185), the remaining 494 unique articles were screened based on the title and abstract; of those, 416 articles were excluded, as they were not about AI or medical education. Of the remaining 78 articles that were assessed for eligibility, 37 articles were found to be relevant to the use of AI in medical education. Three primary uses of AI in medical education were identified: use of AI as learning support (n=32), assessment of learning (n=4), curriculum review (n=1). Of the 37 articles, 34 articles were found to be relevant to the challenges of implementation of AI in medical education.

Current Use of Artificial Intelligence in Medical Education

Data gathered from the articles such as advantages of the current uses as well as the challenges of implementation of AI in medical education mentioned in the articles were pooled together and analyzed quantitatively.

One article discussed the use of AI, artificial neural networks (ANN), and support vector machine (SVM) specifically, for assessing the curriculum of medical students. Chen et al [30] described the advantage of ANN and SVM over logistic regression in data analysis: They are more adept models for solving nonlinear problems and establishing relationships between variables. The use of AI in assessing the curriculum of medical education can provide an overview of the effectiveness and students' satisfaction with the program, which is paramount in training future doctors in medical diagnosis and treatment.

A total of 32 articles discussed the use of AI platforms or systems explicitly designed to improve students' learning (Multimedia Appendix 1), and 7 articles discussed the use of AI as an adjunct to a virtual environment or simulation for trainees, a majority of which are most relevant to the surgical specialty. The TOUCH project, LAHYSTOTRAIN, and EchoComJ are examples of systems developed using an intelligent tutoring system alongside a virtual reality simulation program. These systems provide added benefits of a virtual environment alongside the benefits of an intelligent tutoring system, including immersive, interactive, and safe environments in a VR simulation, as described by Caudell et al [20].

Four articles examined the use of machine learning models in the assessment of students' learning (Multimedia Appendix 1). Three articles assessed the use of AI in automated scoring of assignments, and one article [38] assessed the use of machine learning algorithms in predicting the correctness of students' answers based on their viewing behaviors. Common advantages include an objective assessment of students' work, more cost-effectiveness and time efficiency, and the ability to provide immediate feedback on their assignment, allowing students to reflect on their work.

In addition, there were three main target groups identified in the 37 reviewed articles (Figure 3): medical undergraduates (n=25), postgraduates (n=14), and those continuing medical education (CME; n=8). No specific target group was identified in 6 of the articles; all participants were referred to as "students."

Figure 2. Search strategy for literature on the use of artificial intelligence in medical education in undergraduate, postgraduate, and specialty training in medicine and beyond (continuing medical education). ERIC: Education Resources Information Center.

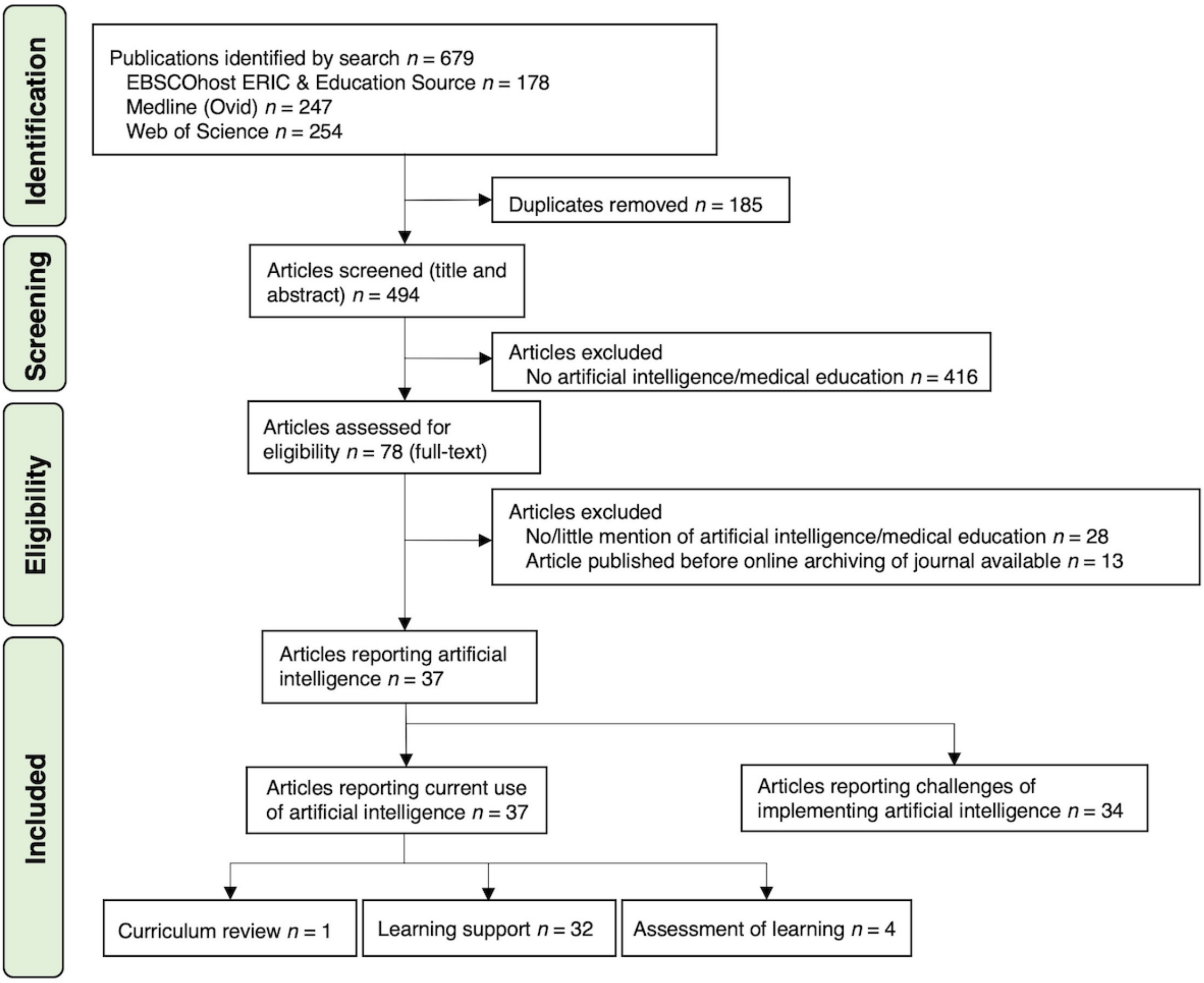
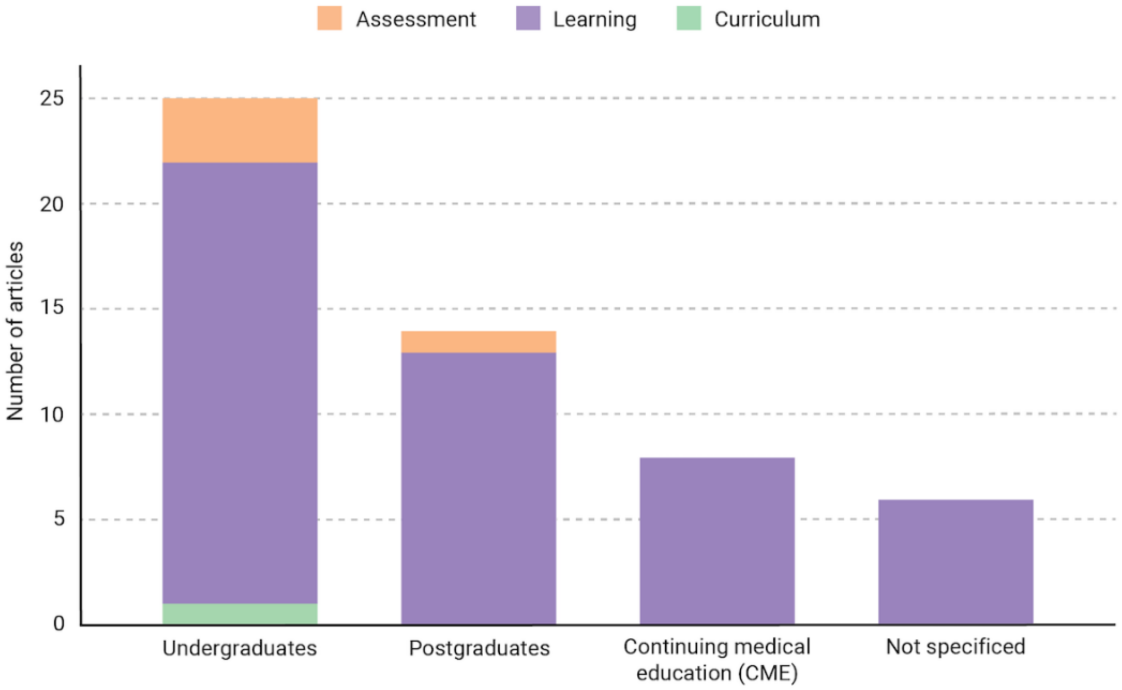


Figure 3. Subgroup analysis showing the number of articles in each focus group for the target audiences.



Challenges in Implementing Artificial Intelligence in Medical Education

One of the elements of Extension of Technology Acceptance Model is perceived usefulness, which includes factors such as difficulty in assessing effectiveness (n=14) and limited scalability (n=6) of the AI system (Figure 4). As discussed by Suebnukarn et al [25], the ideal method of assessing the effectiveness of the system is to conduct a study comparing the use of the AI system with traditional methods of teaching. McFadden et al [40] demonstrated the effectiveness of an AI-driven simulator with a statistically significant improvement in diagnostic accuracy of 22% posttraining as compared to a multimedia-based, expert-led training with a nonstatistical improvement of 8%. Limited scalability of the AI system refers to the narrow range of application of any developed AI system, as the expert models are usually constructed and applicable to a particular specialty of medicine or medical condition.

The critical elements of the Diffusion of Innovations model used to assess the challenges include innovation, communications channel, time, and the social system. The challenges described in the articles mainly centered around the innovation itself (Figure 4). This includes the technological difficulties in acquiring a large sample size needed for the development of the model (n=16), the requirement for a qualified and experienced content specialist to design the curriculum for machine learning (n=10), and the communication challenges relative to the knowledge gap between physicians and engineers (n=4).

In addition, two articles [16,34] discussed the issue of privacy and confidentiality and raised the concern of patient confidentiality when providing data used for an expert system, whereas another study [34] described the measures taken to secure user data.

Figure 4. Hierarchical presentation of the challenges of implementation of artificial intelligence (AI) in medical education. The upper blue rectangle shows the proportion of articles in each challenge category in the technical aspects of AI. The lower red rectangle shows the proportion of articles for challenges relating to perceived usefulness (in red) and perceived ease of use (in light red).

Discussion

In this study, we reported the roles and advantages of AI in medical education as well as the challenges that have been hindering the widespread implementation of AI in the medical education community. This section will discuss the main findings.

Current Use of Artificial Intelligence in Medical Education

A review of the curriculum is an administrative and arduous process, which strongly speaks to the need for machine automation to ease the process. Interestingly, only one of the reviewed articles [30] described the use of AI for medical curriculum review. There is a lack of use of AI in curriculum review despite the advantages AI may have over traditional methods, such as the use of a logistic regression model. Examples of these advantages include the ability of ANNs to solve multidimensional problems, provide greater classification accuracy, and establish strong relationships between variables. One plausible reason for the lack of adoption of AI in curriculum review is the limited digitalization in medical education learning management systems, which is essential for creation of a curriculum map. The digitalization of the curriculum is not possible across all institutions, mainly due to financial constraints [49]. Notably, in Canada and the United Kingdom [50], the majority of medical schools are building curriculum maps. Evidently, as shown in the Results section above (Figure 4), a large pool of data is required to adequately support the development of the model for an AI system. Currently, there are two main approaches to obtaining data—accessing records from prior digitalization of the curriculum and transferring hard copy data into a soft copy, which is a time-consuming process. The latter may well explain the lack of interest in the application of AI with respect to the curriculum in medical education.

The majority of the articles reviewed (32/37) centered around learning and knowledge development. Here, the main reason for AI use (Table 2) was its ability to provide immediate feedback. As highlighted by Hattie et al [51], feedback is critical for identifying learning goals and knowledge gaps. Students need to know how they are performing in order to take measures to improve themselves. However, the provision of feedback is a challenging task in clinical contexts. In a study conducted by Hewson et al [52], 80% of the residents surveyed reported never having or infrequently receiving corrective feedback on their performance. An expert system, on the other hand, can provide immediate and formative feedback on students' performance. Interestingly, the question remains: Would that compromise the quality of the feedback received? Useful feedback should essentially assist students in identifying conceptual misunderstandings, critique their performance, and be structured enough to help students achieve their learning objectives [53]. One of the limitations of automated and immediate feedback provision with AI is limitation in the quality of the feedback [18], as the feedback generated is based on the knowledge base and model of the AI system, which, as of now, has room for improvement.

In the subgroup analysis of the articles on learning, medical undergraduates were the primary target audience (21/32) with a lesser focus on CME. This is an exciting finding because undergraduate education forms only a small proportion of a doctor's professional development. A plausible reason for this finding is the lack of a structured curriculum for CME, with a strong emphasis on professional self-regulation [54]. The development of an AI system requires expert domain knowledge to equip the system with the appropriate curriculum knowledge for contextually driven education.

Without a structured curriculum, it is difficult to select a knowledge base for the AI system, which may, in part, explain the lower prevalence of AI use in CME as compared to that in medical undergraduates. Another possible reason for the preferred focus of AI in undergraduate medical education is that it enables shaping of students' learning at an earlier point of their medical career. A study by Shin et al [55] demonstrated that undergraduates who adopted problem-based learning are more up to date in medical information as compared to their counterparts who experienced a traditional curriculum. The use of AI enhances problem-based learning, because it provides step-by-step guidance with the appropriate feedback, possibly explaining the preference for targeting medical undergraduates.

Similar to the use of AI in curriculum delivery, only a minority of the articles (4/37) discussed its use in assignments, which begs the question: Why? There are many advantages to using AI in assessments, not the least of which is the ability to provide immediate and formative feedback to students (2/4), which is also the most common reason for the use of AI in learning (21/32). However, the reason for its lack of use is also likely related to the lack of digitalization, explained above in the reasons for the lack of current use of AI for curriculum review. There are many forms of examination in medicine, the most common of which is the written examination and the Objective Structured Clinical Examinations [56]. These methods of assessment are usually conducted offline using pen and paper.

Table 2. Overview of the current uses of artificial intelligence in medical education identified from review of 37 full-text articles.

Focus and advantages of use	Total number of articles
Curriculum	
Comprehensive analysis of the curriculum	1
Learning	
Feedback for learning	21
Evaluation of the learning process with guided learning pathway	18
Decreased costs	8
No harm to patients	6
Less teacher supervision required	3
Assessment	
Quicker assessment	4
Objective assessment	3
Feedback on assessment	2
Decreased costs	1

Lately, there has been a move to conduct these examinations online. However, there are still several challenges that need to be addressed, including the issue of secured communication and avenues for cheating [57]. Without the digitalization of examinations, it remains an arduous task to transfer hard copy examination results into soft copy to meet the data pool requirements necessary to develop an AI system. In addition, the sensitive nature of summative assessments and examinations limits the use of AI: A malfunction or improper coding of the AI system may cause the results to be incorrect, which may have dire consequences on the students involved. In this regard, AI may be better used in areas in which human performance would increase when assisted by AI and when humans are unable to perform by themselves, such as in adaptive assessment and programmatic assessment. In adaptive assessments, the selection of the questions to follow depends on the user's answer to the previous questions, such that the difficulty of the questions is tailored to each individual [58]. Programmatic assessment involves the use of an AI system to design an assessment program tailored to optimize learning outcomes and ensure curriculum quality at a systemic level [59]. These are two alternative uses of AI that may be considered part of augmenting assessment in medical education. This is in addition to AI's role in the marking essays, as described in the reviewed articles.

Challenges of Implementation of Artificial Intelligence in Medical Education

This section will discuss the two main groups of challenges hindering the implementation of AI: (1) limitations in the perceived usefulness of AI and (2) the technical difficulties with the development of AI applications.

Difficulty in assessing the effectiveness of the AI application was the most commonly reported challenge (14/34). To prove the effectiveness of the AI system, an ideal approach would involve scientific rigor and the ability to explore what AI does ("explainability"). The issue of "explainability" is specific for deep learning, which is a subset of AI. Due to the nonlinear nature of deep learning, there is often no explanation of how the AI system arrives at the answer or prediction [60]. However, an explanation of the thought process is crucial for students' learning, especially in medical education, where clinical reasoning forms the foundation of a doctor's professional development.

What is clinical reasoning? It was initially described by Barrows [61] as "the cognitive process that is necessary to evaluate and manage a patient's medical problem." Clinical problems are often ill-structured and multifaceted, which explains the need for a comprehensive history from a patient. These factors are then taken into consideration, and a clinical impression is formed, which then enables the construction of differential diagnoses. As this is a much more complex process than providing a simple diagnosis label based on the symptom complex of a patient, the use of deep learning reaches the cognitive limits to aid in medical education. In addition, to objectively prove the effectiveness of AI, studies need to compare the use of AI with traditional methods of teaching. These studies require a large sample size for the results to be probabilistic. Clear surrogate markers such as pretest and posttest scores are fundamental to analyze the results objectively. Study subjects should also have a similar level of understanding of the topic taught before any intervention. As a result, limited studies [40] have been conducted to assess the effectiveness of AI in medical education.

An essential aspect of developing an AI system is the need for a multidisciplinary team (included in 4 of 34 studies; Figure 4), including educational experts, data scientists for management of the large pool of data, physicians for ensuring the clinical relevance, and accuracy of the AI system. Engineers and data scientists are more focused on the accuracy of the AI system to determine how likely the system is to predict a result correctly. However, this still may have little clinical and educational relevance. If this relevance is to be attained, the medical domain and educational experts will increasingly need to work in concert with data scientists in order to develop AI systems that are both accurate and effective in medical education.

The Learners' Data Integrity

Worth noting is that only two of the reviewed articles [16,34] raised the issue of privacy and confidentiality. In the world of digitalization, data protection is paramount. This is seen in the rise of statutory laws such as the Data Protection Act 2018 (United Kingdom) [62] and the Personal Data Protection Act 2012 (Singapore) [63]. Data are protected, especially if AI practice is conducted in commercial settings where companies profit from gathering data. Concurrently, there is a need to develop novel models that allow access to educational data for the development of AI applications [64].

For example, data of learners undergoing CME may be used as a factor for determining performance. Any leakage or manipulation of these data may adversely affect the promotion of doctors. The lack of a robust data protection measure places learners' data (which is often used to train AI algorithms) at risk and may well lead to societal rejection of the use of AI in medical education, a key element in the Diffusion of Innovations theory. It is therefore necessary to consider data security in addition to the perceived usefulness and technical difficulties of an AI system.

The Ability of Artificial Intelligence Systems to Address Ethical Issues

Medical education emphasizes on the importance of ethical judgment. Students need to be taught about how to approach ethical issues as well as the need to have informed discussions regarding the approach to ethical issues and decision making. In this era of increasingly complex health care and patient-centric care, clinical decisions should not be made solely on technical and medical grounds [65]. Other factors ranging from patients' expectations and values to resource allocation and medical futility also need to be addressed. However, ethical decisions are often difficult to make even for highly trained and experienced doctors. This calls for the development of clinical ethics committees [66] that aim at addressing ethical issues that arise within patient care scenarios. In the context of ethical issues, which are multifactorial and highly situational, the use of AI in medical education can be limited in some contexts. For example, an intrinsic limitation underlying the use of AI is the inability to show concern [67]. Wartman and Combs emphasize on the importance of empathy among physicians toward their patients. If AI targets medical students early in their medical education, there is a commensurate need to balance the teaching and learning they receive from both health professionals and AI systems in order to ensure these students experience an appropriate and balanced exposure to the "art of medicine."

Introduction of Artificial Intelligence Into the Medical Profession

One of the difficulties experienced in the implementation of AI in medical education is the gap in knowledge between physicians and engineers (Figure 4), which leads to this question: Should AI be introduced to medical professionals and trainees, and if so, how? This is the ideal situation that would solve one of the significant difficulties of implementing AI. This has been recently discussed by Kolachalama and Garg [47]; the current medical school curriculum is unable to accommodate AI due to two main reasons—insufficient time and lack of expertise. Although we acknowledge the difficulty of teaching AI in the short 5-6 years of medical school, tweaks can be made to the curricula to introduce the concepts of AI alongside traditional medical school teaching. For instance, AI applications such as CARDIO-LOGOS (Table 1) can be introduced to teach clinical students the diagnostic approach of reading electrocardiograms, but students can also be simultaneously taught the algorithm the machine uses to maximize their learning when introduced to the application. Other techniques to introduce AI include abstinence from jargon and highlighting the application of AI in the diagnosis and management of real patients [47]. Another factor that has been raised earlier is the lack of expertise to teach AI in the medical profession. An easy way to do so is to collaborate with engineering and computing faculties and seek their professional opinions. Interfaculty collaborations and competitions can also be held in universities to promote interaction between students and peers and allow the sharing of expertise across different fields such as health care hackathons, which have been increasing in recent years [68].

Future Research

Based on the findings from our review, we propose that future research should focus on assessing the effectiveness of AI in medical education. Only one study that reviewed expert-led training in rheumatology has thus far shown the benefit of the use of an AI-driven system as compared to traditional methods. Given that the diagnostic approach varies across specialties, intensive and time-consuming research is still needed in every subspecialty to truly determine the success of AI systems as compared to traditional approaches.

With the increased use of AI systems made possible through the evolving digitalization of the medical curriculum and collaboration between data scientists and physicians, the issue of data protection will need to be researched with an emphasis on how best to improve data security and increase users' confidence of the use of AI applications.

As technology continues to advance, the potential uses of AI will continue to increase in medical education. One such development will be the use of AI, combined with immersive technologies such as virtual reality and augmented reality. As presented in our results, such studies have already been reported. Further research should explore more complex adaptations of AI in medical education.

Limitations

The scope of this review covers a broad spectrum of the current applications of AI in medical education. In the field of medicine, where the practices of each subspecialty vary tremendously, the use of AI in education may also vary. It may therefore be too early to make an overarching statement about the benefits of AI in medical education. One limitation in the interpretation of the results is the high proportion of articles on the use of AI as a support for learning, as compared to its use in support of the development and review of the curriculum. Another is in the summative assessment of learners' performance. Although these may be representative of the current uses of AI, the conclusions drawn from the uses of AI in the curriculum and assessment may be inconsequential due to the low number of studies reviewed.

Conclusions

This review identified the current uses of AI in medical education, which include curriculum assessment and improvement of students' learning, with research mainly existing on the latter. The studies also highlighted the main challenges hindering the implementation of AI in medical education, which relate to how best to assess the effectiveness of AI and to manage the technical difficulties associated with the effective and productive development of an AI system.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Data used to generate Figures 3,4 and list of articles for each aspect presented.

[PDF File (Adobe PDF File), 94KB - mededu_v5i1e13930_app1.pdf]

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Abbreviations

AI: artificial intelligence
ANN: artificial neural networks
CME: continuing medical education
CPT: Current Procedural Terminology
CVREA: computational VR environment for anesthesia
ECG: electrocardiogram
ICD: International Statistical Classification of Diseases and Related Health Problems
KBIT: knowledge-based inference tool
PG: postgraduate
SVM: support vector machine
UG: undergraduate
VR: virtual reality

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Original Paper

Increasing Access to Medical Training With Three-Dimensional Printing: Creation of an Endotracheal Intubation Model

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Abstract

Background: Endotracheal intubation (ETI) is a crucial life-saving procedure, where more than 2 failed attempts can lead to further complications or even death. Like all technical skills, ETI requires sufficient practice to perform adequately. Currently, the models used to practice ETI are expensive and, therefore, difficult to access, particularly in the developing world and in settings that lack a dedicated simulation center.

Objective: This study aimed to improve access to ETI training by creating a comparable yet cost-effective simulation model producible by 3-dimensional (3D) printers.

Methods: Open-source mesh files of relevant anatomy from BodyParts3D were modified through the 3D modeling programs Meshlab (ISTI-CNR) and Blender (Blender Foundation). Several prototypes with varying filaments were tried to optimize the ETI simulation.

Results: We have created the novel 3D-printed pediatric ETI model for learners at all levels to practice this airway management skill at negligible costs compared with current simulation models. It is an open-source design available for all medical trainees.

Conclusions: Revolutions in cost and ease of use have allowed home and even desktop 3D printers to become widespread. Therefore, open-source access to the ETI model will improve accessibility to medical training in the hopes of optimizing patient care.

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KEYWORDS

medical education; printing, three-dimensional

Introduction

Background

Endotracheal intubation (ETI) is a major component of advanced airway management. It involves the insertion of a semirigid plastic tube into the trachea to maintain a patient's airway in cases where this may be compromised or, as a last resort, to administer drugs [1]. It is a crucial life-saving procedure, which, like all technical skills, is subject to a learning curve [2]. It is essential for medical trainees to practice these skills as unsuccessful ETI or more than 2 failed attempts may lead to further health complications and even death [2]. A 2016 systematic review found that students need to perform 1 to 43 ETIs in a clinical setting for a greater than 80% success rate within 2 attempts during elective procedures under optimal conditions [2]. For a greater than 90% success rate within 2 attempts, at least 50 ETIs per student had to be performed [2]. Therefore, to perform successful ETI in nonelective settings, where the incidence of difficult intubation is 20 times higher than in elective settings, medical trainees must exceed 50 ETIs [2].

Although there is a clear suggestion of a positive correlation between practice and successful ETI, accessibility to training is limited. First, many learners will not be able to practice ETI on human subjects until they reach a certain level of competency in their training. To address this barrier, simulation models have been developed and have shown to be comparably effective in training learners. However, these simulation models are expensive and, thus, difficult to access, particularly in developing areas. Priced at an upwards of Can $2000, many training facilities are limited in the purchase and provision of these important learning tools [3].

Objective

The objective of this study was to design and develop a 3-dimensional (3D)–printed ETI simulation model that can be printed at a low cost. The hope is that improved accessibility to cost-effective training tools will provide more opportunities to practice performing difficult yet important procedures such as ETI.

Methods

Design

The foundation for the model design was acquired through BodyParts3D and modified for the needs of the ETI model. As part of an academic project at the Tokyo University Database Center for Life Science, BodyParts3D was built as a repository of free and open-source anatomic models digitized from an actual patient computed tomography (CT) scan [4]. Using clinical images obtained from CT as well as anatomical textbooks and atlases, artists at BodyParts3D have created downloadable 3D model files for disseminated use [4]. Multimedia Appendix 1 outlines the files used to create this model.

The individual .obj files were imported into the 3D modeling software Meshlab and Blender for necessary modifications and manipulation into the human head and neck model. They were exported as .stl files for ease of transfer between workers. The design of facial structures, including the face, eyes, and hair, was outsourced and built upon the foundation of the skull mesh.

Overall, 3 prototypes were made for this model. Prototypes 1 and 2 were scaled down to check for the feasibility of the print (Figure 1). Once the prints were satisfactory, prototype 3 was printed as a life-sized pediatric model.

Material Selection and Print

The head, mandible, throat piece, and tongue were created as separate .stl files for ease of printing and manipulation. Filaments selected to print these models varied depending on intended function and cost. The filaments used throughout this project are compared in Table 1 [5]. Prototypes 1 and 2 were printed through a Makerbot Replicator 2X with double extrusion. These were printed with polylactic acid or acrylonitrile butadiene styrene filaments, and the scaffoldings, designed for support throughout the print, were dissolved with limonene solution. Polyethylene terephthalate glycol modified (PETG) and Ninjaflex were the materials used to print prototype 3. Details on printing prototype 3 will be further discussed.

Figure 1. Left: prototype 1 (8.5x6x7.5 cm); right: prototype 2 (11x7.5x8.5 cm).

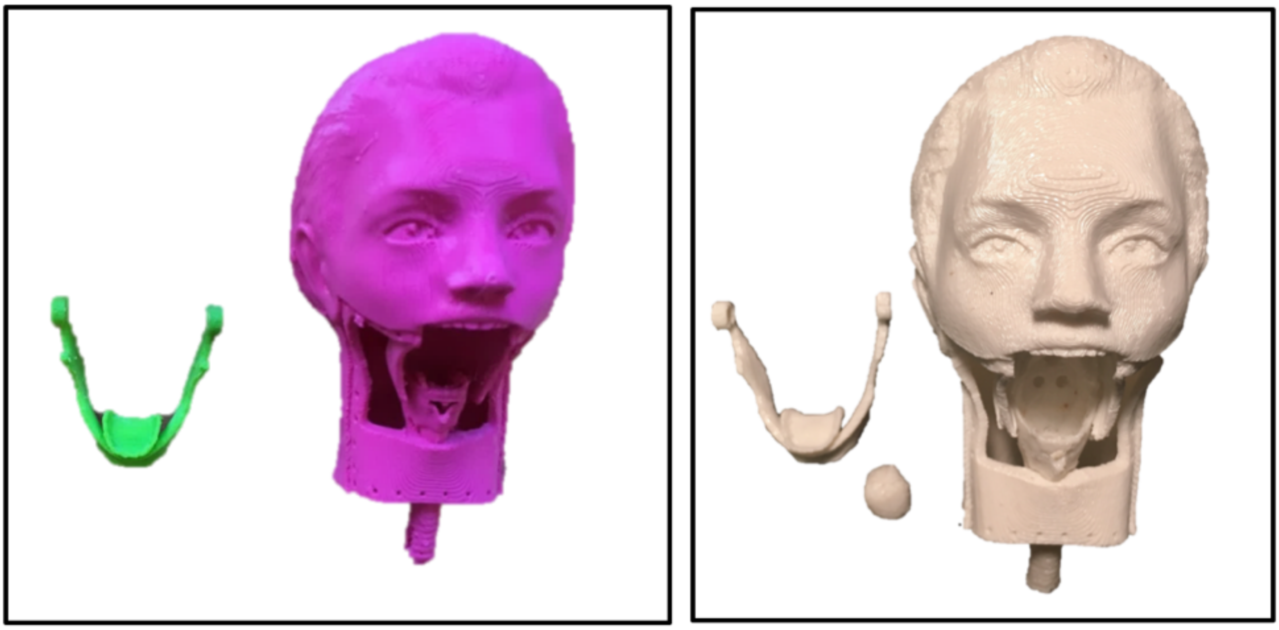

Table 1. Comparing 3-dimensional printing filaments.

Material	Pros	Cons
Polyethylene terephthalate glycol modified	Highest durability, impact resistant, and good layer adhesion—less likely for prints to be warped or to shrink	Requires specific 3-dimensional printing parameters
Polylactic acid	Easily extruded and cost-effective	Less durable
Acrylonitrile butadiene styrene	Most cost-effective, durable, flexible, and easily extruded	Requires higher temperature to reach melting point, more likely for prints to be warped or to shrink, and dangerous fumes during printing
Ninjaflex	High flexibility	Difficult to print

Part 1: Head

The head is the foundation onto which all the other pieces are assembled (Figure 2). There is a connective piece that continues downward from the maxilla, which provides a base for the throat (Part 2) to attach. Three pegs were created on this connective piece with corresponding holes on Part 2 to facilitate joining of the pieces (Figure 3). The head portion was printed using PETG filaments entirely. Due to the size of the print, the head was sliced along the coronal plane into 2 pieces for ease of printing (Figure 4).

Part 2: Throat and Tongue

This part includes the trachea, esophagus, and soft tissue, which are pertinent anatomy for learning ETI (Figure 4). The trachea was manually hollowed out to suit the needs of the model. To simulate the soft textures of the throat part, it was printed with Ninjaflex filament, and scaffolding was removed manually. The tongue was also printed with Ninjaflex material and was designed to fit the mandible (Figure 5).

Part 3: Mandible

The mandible was created separately to allow for articulation with the head piece (Figure 6). There is a hinge component with a corresponding attachment portion embedded on the head piece (Figure 6).

Assembly

Upon delivery of the 3D-printed pieces from a third-party vendor, they were assembled in a stepwise fashion (Figure 7). Ethylene-vinyl acetate copolymer was the adhesive of choice. It was used to bind the 2 coronal sections of the head together as well as the throat piece. The mandible was aligned with the corresponding attachment portion on the head and supported with elastic bands to simulate mandibular elevation, depression, and protraction.

Figure 2. Head piece, unsliced. Red arrow is the base for the soft tissue throat piece.

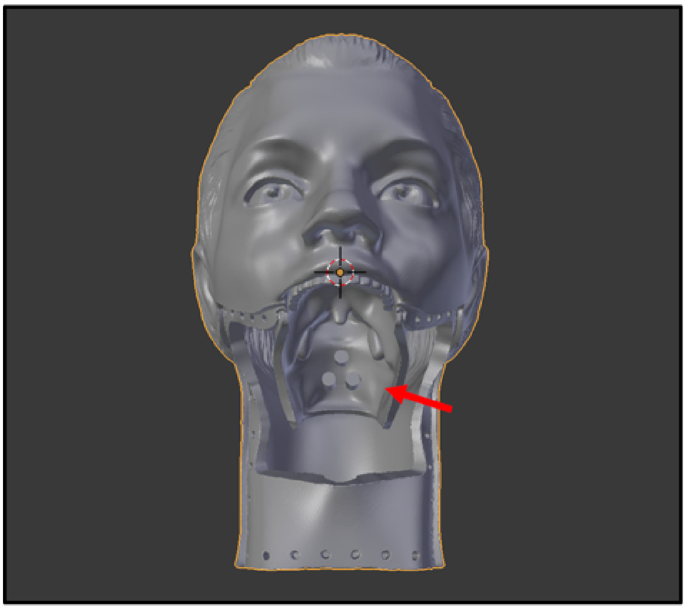

Figure 3. Throat piece. Left to right: anterior view, posterior view, lateral view, cranial-caudal view.

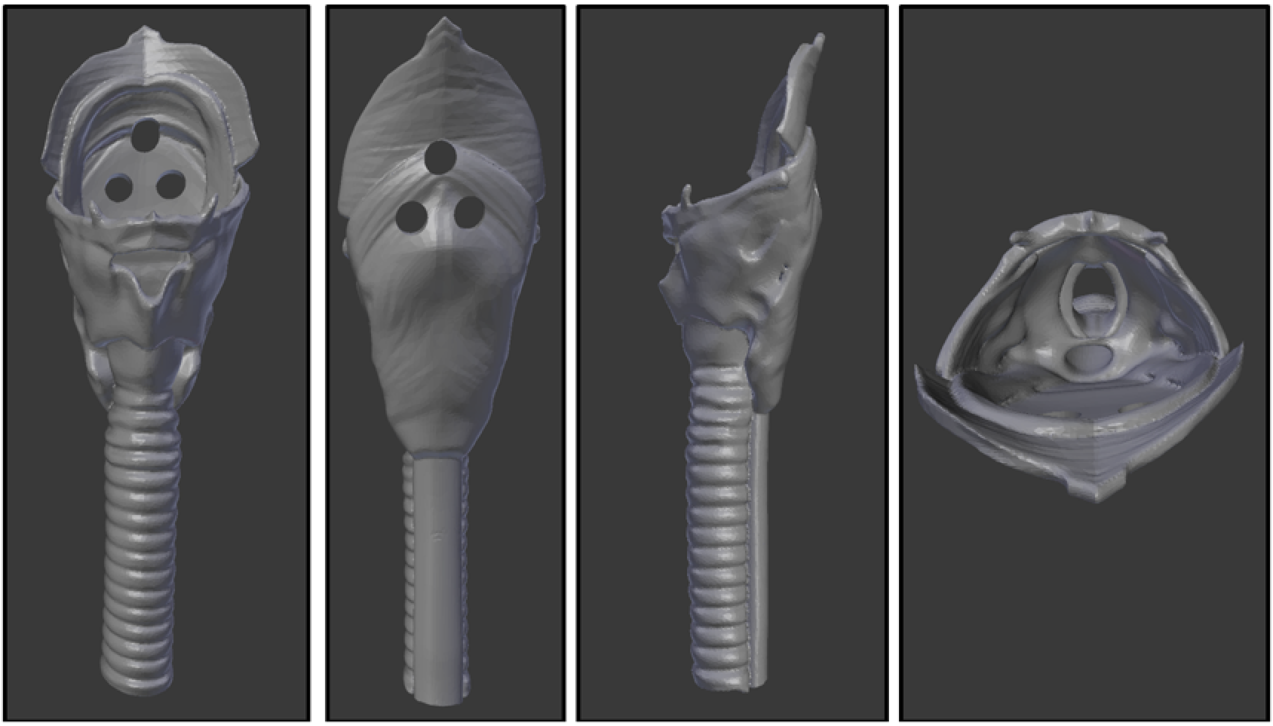

Figure 4. Coronal slices of the head piece, anterior view.

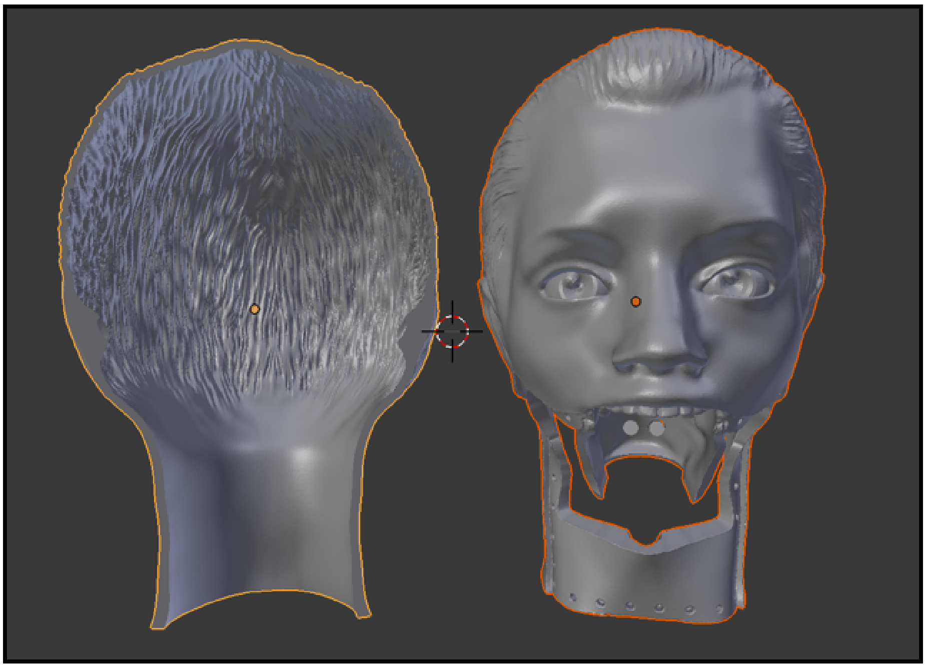

Figure 5. Tongue.

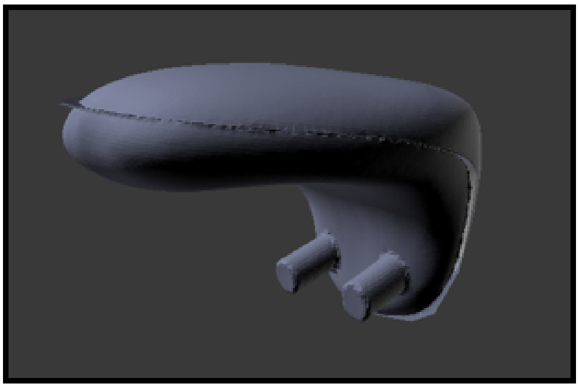

Figure 6. Left: Mandible with hinge. Right: Head piece with corresponding hinge compartment.

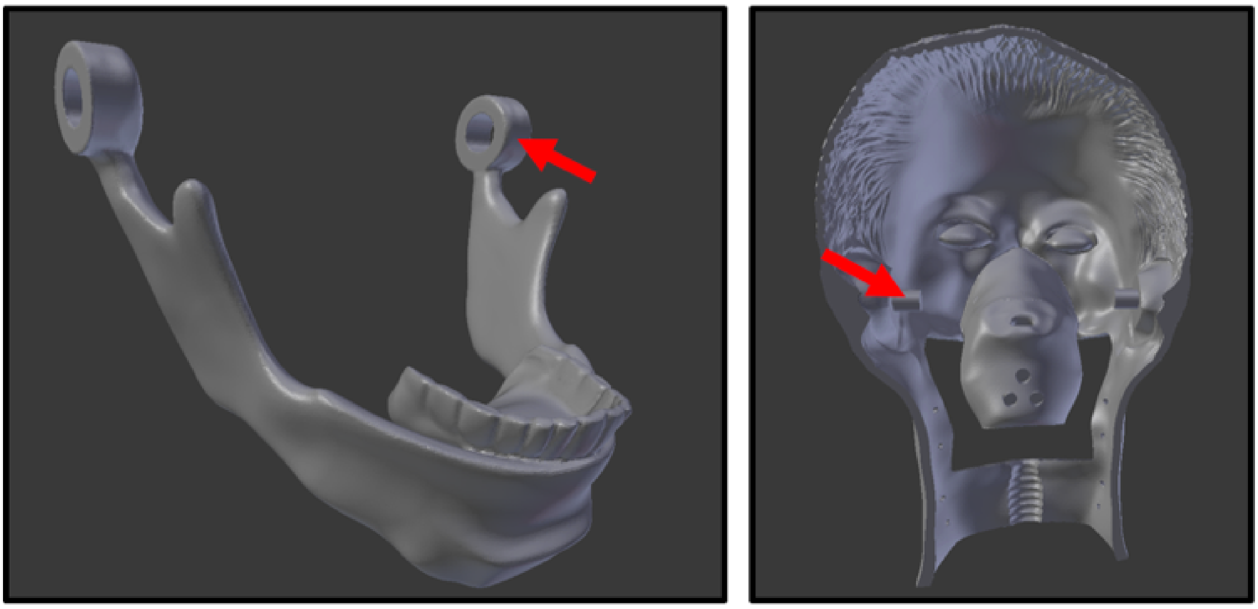

Figure 7. Three-dimensional–printed pieces from left to right: mandible and tongue, throat, head coronal cut 1 and 2. Dimensions: 25.5x16x21 cm.

Results

The 3D-printed pieces were combined to create the novel pediatric ETI simulation model (Figure 8). All parts of the model, besides the elastic bands used to support the mandible, were produced by a 3D printer.

Printing the Model

Prototype 3 was printed by a third-party vendor. The cost to print the entire model from a third-party vendor was approximately Can $130 including taxes and front-door delivery. It was printed through a highly modified Folger Tech FT-5 at-home printer on the following print settings: 6-mm nozzle, 15-mm layers, and 60-mm/s print speed. The entire print took about 60 hours, and around 2.7 lb of generic PETG filament was used. The raw materials used cost around Can $53.90. Assembly took 1 hour and a full day for the adhesive to set.

Using the Model

The equipment used to practice ETI on this model is as follows: pediatric laryngoscope with miller blades, 5-mm endotracheal tube with stylet, and bag-valve ventilator. A balloon can be attached at the end of the trachea for inflation to signify proper intubation.

Figure 8. Assembled Endotracheal Intubation Model.

Discussion

Principal Findings

Limitations on learning opportunities for medical trainees can have impacts that ripple throughout their careers. It is important to improve such opportunities in quality and quantity, especially for training in procedures that require regular practice, such as ETI. Thus, we have explored a new and emerging avenue to increase accessibility to medical training.

Current literature that involves 3D printed models for use in medicine largely surrounds visualization and improved characterization of patient-specific anatomy for teaching or presurgical planning. Efforts to utilize 3D printing for the purposes of medical education, specifically skill building, are few yet emerging. One such example is the 3D-printed trachea for cricothyroidotomy simulation developed by Doucet et al [6]. Like the 3D-printed ETI model, Doucet et al’s trachea is a cost-effective medical simulation model intended to improve training accessibility. Unlike cricothyroidotomy, which is often the last resort in airway management, ETI involves training in head and neck manipulation as well as airway visualization [7]. Therefore, an ETI training simulator requires a full head and neck model in addition to the trachea. Although this increases the complexity of the model as well as the print time and cost, the greater use of ETI compared with cricothyroidotomy in clinical practice merits greater investment in these regards.

Limitations

There are several technical considerations for reproduction and use of the present ETI model. Of particular note is the significant amount of time required to produce it. In most cases, the print would be ordered through a commercial 3D printing business. However, the size and complexity of the model increase the time required to print, which in turn raises the cost of the model. Furthermore, time must be spent to assemble the parts once they are printed. The model was designed to make assembly as simple as possible. Due to the current technical limitations in 3D printing, the ETI model currently cannot be produced as the intended final product in 1 print. Another consideration is the difference in texture between a 3D-printed object and human anatomy. The PETG filament used for the head and mandible is hard plastic and does not resemble human skin. This is not concerning as the external skin is not a significant anatomical feature associated with performing ETI. However, the throat and tongue present as limitations. Ninjaflex was used to print these parts as it is the filament most comparable with soft tissue that is commercially available. Still, it is slightly unyielding compared with human anatomy, which impacts the accuracy of the simulation.

Future Directions

With rapid advancements in 3D printing and modeling technologies, there is ever-growing potential to enhance this model. Introduction of new filaments and rapid improvements of 3D printers may soon resolve the aforementioned technical considerations. Furthermore, certain aspects of the model can be modified to suit the needs of the learner. For example, to simulate particularly challenging airways, several premade tongue and mandible prints of varying sizes and abnormalities can be made available.

Future steps for the 3D-printed ETI model include model validation by demonstrating noninferiority compared with current commercial ETI simulation models. Trainees of all levels can be stratified to perform ETI in both the 3D-printed and commercial simulation models. A questionnaire may then be distributed to identify differences in ETI training between the 2 models. If areas for improvement are identified to optimize the model, these adjustments may accordingly be made to the open-source design for the user's needs.

Conclusions

The 3D-printed ETI model is a significantly cost-effective option for trainees to practice ETI compared to its current commercial counterparts. With the aforementioned instruments, ETI can be successfully performed with impressive comparability to the current simulation models. Therefore, as an open-source design, our model has the potential to increase accessibility for medical trainees to practice this challenging and important procedure. By improving training accessibility, the ETI model is the realized potential of 3D printing's impact on medicine. It stands as a precedent for future models that will similarly aim to improve clinical practice by addressing medical education needs for future health care providers.

Access to the open-source model is available on the Github website [8].

Acknowledgments

The authors report no external funding source for this study.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Files obtained from BodyParts3D.

[PDF File (Adobe PDF File), 13KB - mededu_v5i1e12626_app1.pdf]

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Abbreviations

3D: 3-dimensional
CT: computed tomography
ETI: endotracheal intubation

PETG: polyethylene terephthalate glycol modified

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Original Paper

Supporting Students With Electronic Health Record–Embedded Learning Aids: A Mixed-Methods Study

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Abstract

Background: Students often perceive workplace-based learning as disconnected from what they learn in medical school. Interventions that deal with this issue regularly involve feedback and/or learning aids. Feedback has frequently been encouraged in previous research, whereas the use of aids is less understood.

Objective: This study aims to investigate the added value of learning aids in making the connection and enhancing the transfer of learning between medical school and workplace-based learning.

Methods: First-year students in postgraduate general practice training participated in a mixed-methods study. Within a quasi-experimental design, two conditions were investigated: (1) students having access to electronic health record (EHR)–embedded learning aids and feedback and (2) students only receiving feedback. Semistructured interviews were conducted and analyzed according to the thematic analysis approach.

Results: Forty-four students participated in this study. No significant difference was found between the two conditions (t_{42}=–0.511, *P*=.61, 95% CI –4.86 to 2.90). Nevertheless, students used the aids frequently and found them useful. Given that the aids were familiar to students and contained practice-based instructions in an easily accessible format, they were perceived as feasible to use during workplace-based learning. They also appeared to stimulate transfer of learning, self-confidence, reflection, and interaction between student and supervisor.

Conclusions: Access to EHR-embedded learning aids offers additional support during, but also before and after, patient encounters. The aids can be easily implemented into workplace-based learning.

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KEYWORDS

integrated learning; transfer of learning; electronic health record; electronic performance support system; learning aids; workplace learning

Introduction

Education and training programs aspire to the transfer of learning, which is the continuing application of acquired competences in new situations [1-3]. Transfer of learning is important because the goals of training and education are not achieved unless students have the capacity to apply what they have learned in situations that are different from those in which these competences were acquired [4].

Ensuring the transfer of learning has long been recognized as one of the most difficult problems in education [5]. Even though students may do well on an assessment, they will not necessarily do so in a professional context [6]. It has become clear that medical students often encounter difficulties with the transfer of learning when transitioning between the classroom and the clinical workplace [7-10].

One of the principal problems is that students often perceive workplace-based experiences as disconnected from what they learned in classroom sessions (eg, during theoretical sessions, skills training, or simulation-based workshops) [7,8,11]. This lack of connection appears to be often due to two issues. Classroom-acquired competences generally cannot be directly applied in practice [12]. Within medicine, the difficulties in applying information from evidence-based guidelines to individual patients are well documented [13]. Additionally, there is often a delay between learning and the actual application of competences at the workplace and hence the acquired medical knowledge and skills are not so easily retrieved [14]. Consequently, reminders or refreshment of what has been learned before may benefit students.

Resolving these two issues and stimulating the connection between the classroom and clinical workplace has been the focus of many educational interventions [15]. Often these interventions involve a number of learning tools and/or feedback. Learning tools or aids used during classroom learning can support students performing consultations with real patients [14,16,17] to (1) refresh classroom-acquired competences, (2) stimulate deliberate practice at the workplace, and (3) provide just-in-time information during clinical work [15]. Learning aids that reach across both the classroom and workplace might indeed enhance the connection between the two settings and possibly promote transfer of learning [12,18]. Within the medical sector, the electronic health record (EHR) is a platform that can make such learning aids easily accessible across the two settings. Targeting the EHR may offer some benefits. The EHR is already available at the clinical practice and integrated into the workflow [19]. Moreover, the input of registered codes into the EHR generates links to relevant evidence-based information and resources.

Although the EHR plays an increasingly prominent role in health care delivery [20], little is known about offering students access to original classroom-based learning aids through the EHR at the workplace. Hence, in this research, we want to focus on the effect of providing access to EHR-embedded learning aids across both settings. Research shows that the use of learning aids strongly depends on the perceptions students hold about these aids [21]. Even carefully designed learning aids may be used by students in unintended ways or not used at all [22]. Gaining an insight into students' perceptions about learning aids is important because these influence not only their learning behavior [23], but also the effectiveness of the learning aids and might predict students' intention for continued use of these aids [21].

Feedback from medical doctors explaining their clinical reasoning can help students to better understand how classroom-acquired competences are translated to decisions in a particular case [24].

Although feedback (and providing support for supervisors' feedback) has frequently been investigated and encouraged in previous research, the use of classroom-based learning aids is less well understood. This study aims to investigate the added value of learning aids, which are also accessible at the workplace, in making the connection and enhancing the transfer of learning between medical schools and workplace-based contexts. Therefore, the following research questions were examined: (1) Does access to EHR-embedded learning aids in addition to feedback support from supervisors enhance the transfer of learning during medical students' workplace-based learning experiences? and (2) What are students' perceptions about using these EHR-embedded learning aids during workplace experiences?

Methods

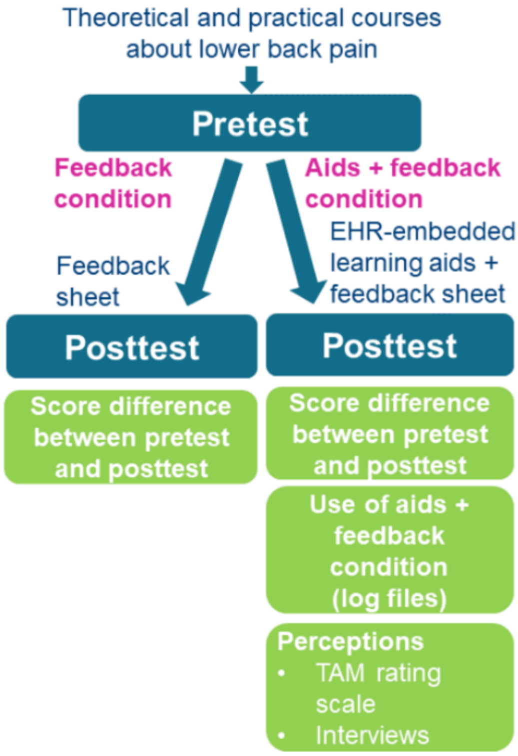
Participants

First-year students in postgraduate general practice (GP) training at the University of Leuven in Belgium were invited to participate in this study on a voluntary basis. The postgraduate GP training is for 2 years and starts after successful completion of the 6-year basic medical course. Students were eligible to participate if they were involved in an internship at a GP clinic between January and May 2016 and performed consultations on patients with acute lower back pain during that period. Recruitment was conducted via an electronic mailing list and face-to-face announcements. At this stage of their training, students participate in an integrated curriculum in which they spend approximately 23 weeks at the university, supplemented by a 6-week internship at a GP and a 14-week internship covering various disciplines at the hospital. The workplace supervisors of the participating students were informed about the study via a telephone conversation, an email, and a letter.

Study Design and Procedures

A mixed-methods approach was used, consisting of a quantitative section followed by a qualitative section (see Figure 1) [25]. This study was approved by the Social and Societal Ethics Committee of the University of Leuven (reference number: G-2016 01 437/G-2016 01 438).

Figure 1. Study design. EHR: electronic health record; TAM: technology acceptance model.



Quantitative Section

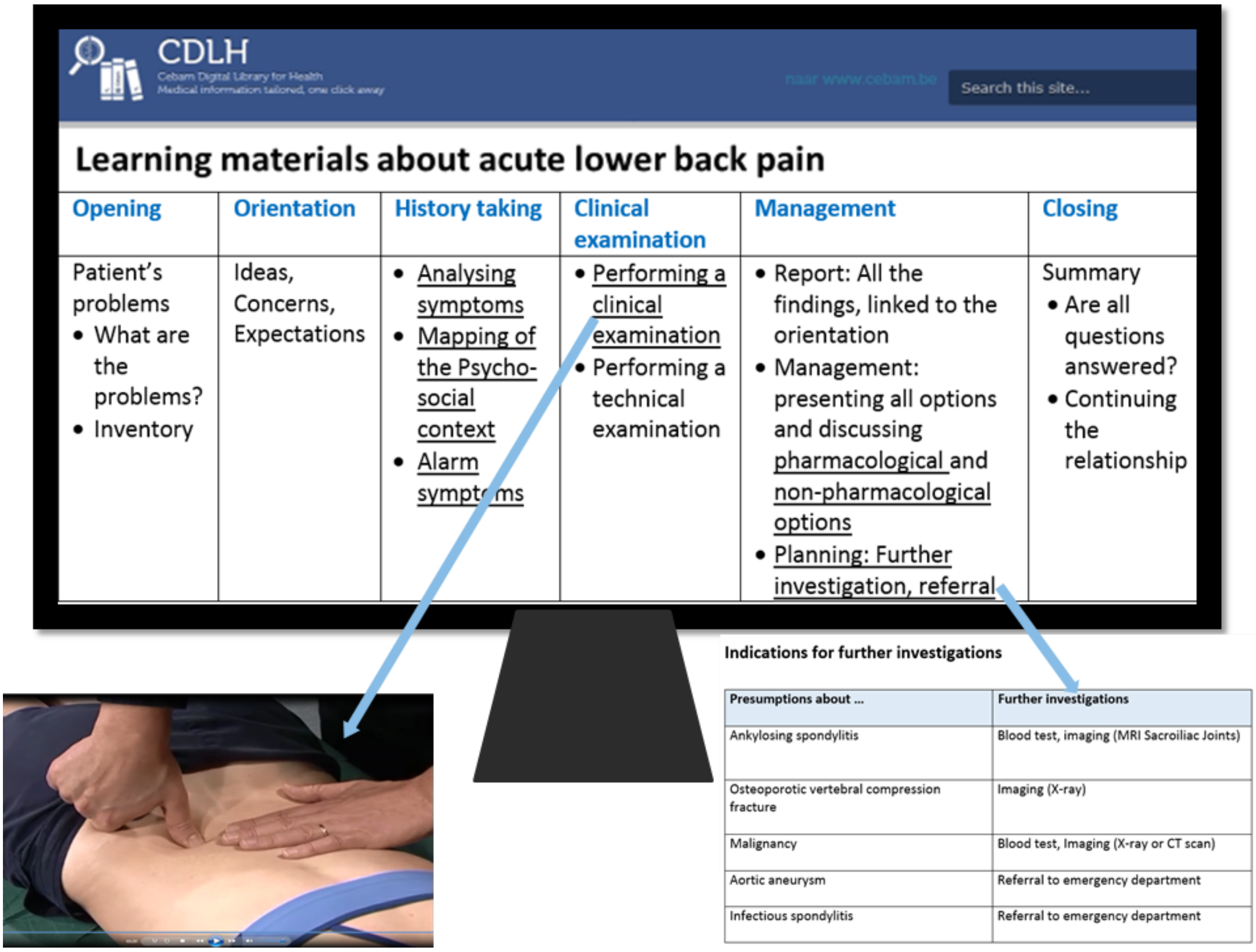
A quasi-experimental design was used. Participants were assigned to one of two conditions depending on the time of their registration for the postgraduate GP course. Random assignment to the conditions was not feasible in this case. One group of students was permitted access to EHR-embedded learning aids and a feedback sheet (aids plus feedback condition), whereas the other group only had access to the feedback sheet (feedback condition). Both groups of students had the same theoretical and practical courses prior to the start of the study. The preintervention test (pretest) took place on the first day following the course, the postintervention test (posttest) after 9 weeks. Students and workplace supervisors were not aware of the two different conditions and, therefore, did not know which one of the two conditions they were assigned.

All workplace supervisors in both the feedback condition and the aids plus feedback condition were asked via a telephone call, before the start of the internship, to allow the students to perform as many consultations as possible with patients suffering from acute lower back pain . Additionally, all supervisors of both conditions were asked to provide feedback on the students' performances. If possible, this feedback followed immediately after the consultation or at the end of the day. Given that the variability of feedback from various supervisors may influence the research findings of the learning aids, it was aimed to standardize the feedback with a feedback sheet, which was provided to all supervisors (see Multimedia Appendix 1) [26]. This feedback sheet contained a definition of feedback and questions that could facilitate the feedback process. It had been revised by three researchers and tested with a potential user.

Aids Plus Feedback Condition

The students in the aids plus feedback condition were permitted access to EHR-embedded classroom-based learning aids relating to acute lower back pain during their 3-week internship in GP. These learning aids supplemented the existing evidence-based medicine guidelines, already accessible via the EHR. The learning aids were designed by three medical teachers and an educational researcher. They were based on the principles of electronic performance support systems [14,27-29]. The aids consisted of brief, practical, and easily accessible information in various formats (eg, a flowchart, a brief list with procedures, and a short video demonstrating different steps). All the materials were presented according to the sequential phases of a consultation model [30] (see Figure 2), a design with which the students were already familiar. By selecting the hyperlinks, students were able to obtain the corresponding course information. The learning aids were introduced in two initial plenary sessions dealing with theoretical and practical considerations for treating acute lower back pain. Consequently, students were familiar with the aids before the start of their internship. Moreover, the students were trained how to use the EHR and given a demonstration of how to access the EHR-embedded learning aids. During the internship, information could be accessed based on the students' individual needs and preferences. The aids could be retrieved after registering the potential diagnosis of acute lower back pain in the EHR. Workplace supervisors were also able to access these aids. In contrast to the supervisors in the feedback condition, supervisors in the aids plus feedback condition received an additional letter with a sticky note summarizing their role in the research via postal mail at the beginning of the internship and a reminder via email halfway into the internship due to a holiday period.

Figure 2. The presented structure of the learning aids.



Feedback Condition

Students in the feedback condition were able to use the EHR in a regular way but were not granted access to the tailored aids via the EHR. Although this student group was permitted access to the learning aids through the course notes, these were not easily accessible at the workplace.

Outcome Measurements and Instruments

The effect of the EHR-embedded learning aids on the transfer of learning was assessed by the score difference between the performance on a pretest (a few days before the intervention) and a posttest (5 weeks after the intervention). During both tests, students performed one consultation with a standardized patient suffering from acute lower back pain. Each consultation contained three parts: (1) history taking, (2) clinical examination, and (3) management. There were three scenarios for the pretest and three different scenarios for the posttest. Students were randomly allocated to one of these scenarios. Three medical teachers validated the content and the degree of difficulty of all six scenarios. The standardized patients had more than 5 years' experience performing such roles and were trained to participate in each consultation in a standardized way. The students could not access the EHR-embedded learning aids during the pretest and posttest. In both tests, the consultation took place in a GP practice, and the students' performances were video recorded. Two observers (JH and JC), who were not aware of the students' assignment to one of the two conditions, scored the video recordings with a checklist derived from an objective structured clinical examination (OSCE) checklist (see Multimedia Appendix 2). The checklist consisted of 29 items and covered aspects of the whole consultation. The checklist was assessed for face validity and tested by three medical teachers and an educational researcher. The reliability analysis indicated a Cronbach alpha of .84 for the pretest and .72 for the posttest (McDonald omega of 0.84 and 0.75, respectively).

Both observers had many years of experience with scoring OSCEs. All the video recordings were analyzed independently by the two observers and scores were agreed on during a discussion. Moreover, demographic information of the participants and information about the internship (eg, How many acute lower back pain consultations did each perform during the study?) was retrieved via a short questionnaire to the students and the workplace supervisors. Two additional outcome measures were completed by the participants in the aids plus feedback condition. Firstly, the frequency of students' use of the EHR-embedded learning aids was recorded via log files. Individual student's use of the aids was linked to their performance on the pretest and posttest. Secondly, students' perceptions about the usefulness, perceived ease of use, and the intention for continued use of the aids were measured during the posttest via the technology acceptance model (TAM) 6-point rating scale [21,31]. Each item of the TAM rating scale was translated into Dutch and then revised by two researchers using the translation/back-translation method to avoid semantic problems [32].

Data Analysis

An unpaired *t* test on the difference between groups in pretest to posttest difference was performed using IBM SPSS Statistics for Windows version 24.0 (IBM Corp, Armonk, NY, USA). Additionally, a Bayesian unpaired *t* test was performed because conventional *t* tests (eg, statistical significance tests) may provide some evidence against a null hypothesis (eg, in the case of a statistically significant outcome), but cannot provide evidence in favor of a null hypothesis [33]. The Bayes factor hypothesis testing approach allows for comparing the likelihood of a finding under the null hypothesis with that under an alternative hypothesis [33,34]. The Bayesian analysis was performed in JASP version 0.8.1.1 [35].

Qualitative Section

Semistructured interviews were conducted with a voluntary sample of the students in the aids plus feedback condition. An attempt was made to gather a wide range of participants, both in terms of their demographics and their experience with the learning aids at the workplace.

The open-ended interview questions were based on three general questions: (1) What are your perceptions about using these EHR-embedded learning aids during clinical practice? (2) Why and how did you use these aids? and (3) What is the feasibility of using such aids at the workplace? The interview questions were revised by three researchers, and two pilot interviews were conducted to test the interview questions and to practice interview techniques. The interviews were recorded and transcribed verbatim. An iterative process of data collection and analysis took place [36]. The principle of data saturation was applied. The interviews were coded and analyzed independently by two researchers (AR and SP), using the software program QSR International's NVIVO version 11. Following the thematic analysis approach, the initial coding phase focused on small units of the transcripts to ensure that the most prominent ideas were identified. In the second coding phase, broader categories containing a number of conceptually related ideas were developed [37]. Discrepancies in coding were discussed until consensus was reached.

Results

Quantitative Section

Twenty-two students participated in the feedback condition. Two of those participants dropped out before the posttest. There were 28 participants in the aids plus feedback condition, of whom four dropped out before the posttest. The data from the participants who dropped out were not taken into account for the data analysis. Descriptive statistics are reported in Table 1.

The checklist to assess students' performances on the pretest and posttest contained 29 items (Multimedia Appendix 2). Items 28 and 29 were not included in the data analysis because the researchers realized that these two items were too general and difficult to score.

The unpaired *t* test on the difference between groups in pretest to posttest showed that participants in the aids plus feedback condition scored slightly higher than the students in the feedback condition, but this difference was not statistically significant (t_{42}=–0.511, *P*=.61, 95% CI –4.86 to 2.90). The Bayesian unpaired *t* test revealed a Bayes factor for the null versus the alternative hypothesis of 3.015, indicating some evidence in favor of the null hypothesis of no difference between the two conditions. Without the data of the student in the aids plus feedback condition who did not access the EHR-embedded learning aids, the conventional *t* test was t_{41}=–0.600 (*P*=.55, 95% CI –5.12 to 2.77) and the Bayes factor for the null versus the alternative hypothesis was 2.877.

The students' log files in the aids plus feedback condition showed that the EHR-embedded learning aids were used 451 times by students. Students in the feedback condition reported that they did not frequently access the aids through the course notes while on an internship (never: n=13; sometimes: n=5; usually: n=1; always: n=1).

Table 1. Descriptive statistics of participants (N=44).

Topic	Feedback condition (n=20)	Aids plus feedback condition (n=24)
Sex (female), n (%)	13 (65)	12 (50)
Age (years), mean (SD)	24.80 (1.44)	24.50 (0.60)
Number of acute lower back pain consultations, mean (SD)[a]	4.47 (3.37)	8.74 (6.22)
Number of feedback received after acute lower back pain consultations, mean (SD)[a]	2.79 (1.84)	4.61 (4.62)
Pretest scores, mean (SD)	17.00 (5.79)	16.13 (5.06)[b]
Posttest scores, mean (SD)	19.35 (4.10)	19.46 (3.72)
Score differences between pretest and posttest, mean (SD)	2.35 (6.79)	3.33 (5.96)

[a]Missing data from one student.

[b]One student did not access the learning aids. Without this student, the scores were pretest mean 15.78 (SD 4.88), posttest mean 19.30 (SD 3.72), and score difference between pretest and posttest mean 3.52 (SD 6.02).

Table 2. Students' perceptions about the learning aids in the aids plus feedback condition (n=24).

Students' perceptions about the learning aids	Mean (SD)	Cronbach alpha	McDonald omega
Perceived usefulness (4 items)[a]	4.78 (1.04)	.72	0.77
Perceived ease of use (4 items)[b]	4.90 (1.01)	.78	0.81
Intention for continued use (2 items)	4.94 (1.10)	.92	0.92

[a]For one item, there is missing data for one student.

[b]For two items, there is missing data for one student.

The students' perceptions about the learning aids are shown in Table 2. Students found the aids generally useful, easy to use, and they had the intention to continue using them. Yet, the standard deviation is rather large.

Although the learning aids were developed for the students, 12 of 24 workplace supervisors in the aids plus feedback condition reported that they also used the EHR-embedded learning aids.

Qualitative Section

Data saturation was reached after 16 interviews with students in the aids plus feedback condition. Table 3 shows a detailed summary of the qualitative findings. The data analysis indicated that all students reported having used the learning aids, but only a small fraction of them had done so during the consultation. The following reasons were given: low confidence or resistance to accessing the EHR during patient encounters, supervisor's influence (eg, time pressure), patient's influence (eg, patient's individual situation), practical limitations, small number of consultations performed with patients suffering acute lower back pain, and in some cases students knew the content of the aids already.

Students who used the learning aids during consultations mentioned that the aids were helpful to check if anything had been forgotten or to clarify uncertainties. Some participants explained that the aids helped them to feel a bit more self-confident. Students described that it was feasible to use the aids during consultations because they were familiar with them as they reflected what was learned before, contained brief and practice-based information with step-by-step instructions, and were presented in an easily accessible format. The beneficial characteristics of the learning aids were perceived to be missing in the general evidence-based guidelines available on the EHR. Although the learning aids were developed for use during consultations, the majority of students used them before and after consultations. Participants mentioned that they used the aids to refresh acquired competences before consultations because they were anxious about making mistakes or perceived weakness in this area of their practice. Some students explained that these aids helped them to be more aware of the learning content and to apply this in the workplace. Students also found it useful to check afterward whether they had performed the consultation correctly. Some students explained that they also used the aids to discuss their performance with their supervisor or to reflect on their supervisor's performance. The aids were even perceived as tools for supervisors' professional development.

Table 3. Summary of qualitative findings.

Categories and themes	Illustrative quotations
Reasons for limited or no use during consultations	
Low confidence or resistance to accessing (medical evidence through) the EHR (electronic health record) during consultations	"During the history taking, I definitely didn't go through all alarm signals...because you sometimes have the feeling that you spent too much time on your computer, reading rather than talking to the patient." (student 3)
Supervisor's influence: time pressure, performing part of consultation, asking clinical questions, mimicking habits	"I never decided on the duration of incapacity to work...because often the supervisor decided that." (student 3)
Patient's influence: patient knows back pain, resistance to EHR, patient's individual situation	"Often it was the patients who were known to have back pain...and knew themselves what was going on...You cannot tell each time the same thing to that patient." (student 1)
Practical limitations	"I didn't use it [aids] much...because I often couldn't access it due to problems logging into the EHR." (student 12)
Reasons for limited or no use in general	
Limited consultations; content was known	"I think that if I had more patients with lower back pain, I would have had more opportunities to use it [the aids]." (student 5)
Reasons for use of learning aids (before, during, and/or after consultations)	
To refresh acquired competences	"You can definitely not miss the alarm signals...and then you check that [the aid about alarm signals] an extra time." (student 13)
To check	"For me, it also serves as reassurance...because I've got a bit of stress about how you need to handle it...just because it is visible on my computer...it gives you something to hold on to...just to have some security...I find it really gives me peace of mind." (student 3)
Interested: curiosity, participation in study	"I was unsure of the management plan I proposed there [pretest] but if you check the aids, then you remember again how you should do it. That helped me." (student 6)
Characteristics of learning aids that stimulate transfer	
Content reflected what was learned before; practice-based information; user-friendly; easily accessible format; just-in-time information	"That you don't need to look at it for a long time...that you don't need to fully concentrate...I mean, you just read it and it comes back to you." (student 4)
Learned from the whole study design	
More independence; Pretest as extra practice moment; feedback sheet stimulated supervisors to give more feedback	"That we had to do that test [pretest], then you have repeated it [learning content] very well for yourself and then you spent much time on it...the fact that it is a test and it will be video recorded and it is with a simulation patient, you really would like to perform well." (student 7)

Discussion

Overview

Students thought it was very useful and feasible to use the EHR-embedded learning aids because they were familiar with them and they contained brief, practice-based, step-by-step instructions presented in an easily accessible format. Moreover, the aids were frequently used by students. This suggests that they addressed a need for this kind of support. Students described that the aids facilitated transfer of learning because they allowed them to refresh and check classroom-acquired competences at the workplace. Additionally, the aids appeared to give students more self-confidence, supported students' reflections, and stimulated interactions with supervisors. Yet, no significant difference was found between offering support for feedback with the additional access to EHR-embedded learning aids and solely providing support for feedback without the additional aids.

Comparison With the Literature

Participants in this study described that the learning aids often could not be directly applied in practice because they required tailoring to a patient's circumstances, as pointed out in previous research [8]. Transfer research emphasizes that transfer is not a simple "store and retrieve process" but involves active interpreting, modifying, and reconstructing the competences to be transferred [12]. To help students better understand how classroom-acquired competences are transformed into clinical decisions for a particular patient, feedback from the supervisor is essential [24,26]. Some participants mentioned that the feedback sheet stimulated their supervisors to give better feedback.

Additionally, students in this study mentioned that their use of the learning aids also depended on their supervisor. This is in line with previous research that shows that evidence-based medicine (EBM) decision-making processes are influenced by patient factors as well as general practitioner factors (eg, time pressure, attitude, and experience) [13]. Also, the GP supervisor's role as a model for students is important because their attitude toward the use of EBM and learning aids may be a barrier for students [38,39]. This is especially the case for GP students and trainees because they generally have just one supervisor [40].

Students in this study found the way in which the aids reflected previously acquired competences was beneficial for transfer of learning. This is in line with previous research that showed that spaced repetition of what was learned before promotes students' memory, problem solving, and transfer of learning [41]. Moreover, research indicated that familiarity with learning aids is one of the crucial elements for medical doctors and students to use these aids [19]. Among other reasons, familiar resources might help with finding answers to point-of-care questions more quickly than unfamiliar resources [19,42]. This is especially relevant for students because it allows them to focus on the application of classroom-acquired competences rather than losing time searching for the desired information [43]. Yet, the learning aids in this study may not be up-to-date after a period of time. Nevertheless, the aids were not intended as a replacement of evidence-based guidelines but rather as a supplement.

Participants in this study explained the added value of learning aids alongside evidence-based guidelines. The latter often consist of long passages of text and are perceived to be too complex to be useful, often requiring a lot of time for searching and reading [13]. Some advantages of the learning aids in this study were their brevity, practice-orientation, and step-by-step design in an easily accessible format.

Previous research indicates that practical tools can encourage transfer of learning [8,15]. Moreover, these practical tools or aids can be adjusted to students' individual needs or extended with students' personal documents so that they become "personalized learning aids" [29]. This allows richer and deeper personalized learning experiences [22,44]. Additionally, students can become actors to develop classroom-based learning aids themselves, which may be shared with other students [22,28,44,45]. Additionally, students and supervisors could work together on such projects to bring classroom and workplace learning closer together. Previous research indicated that collaboration between supervisors and students can take place by involving students in a shared project [12,42]. Moreover, learning aids could also be based on existing sources available at the workplace, such as evidence-based guidelines. Bringing such sources into the classroom more frequently might allow students to familiarize themselves with them.

The EHR-embedded learning aids have a lot in common with electronic performance support systems. These are electronic systems that offer support during performances at the workplace [29]. They are mainly used during workplace performances but can also be used prior to and after performance [29]. Rather than using the learning aids during patient encounters, as was the intention of the researchers, most participants of this study used the learning aids before and/or after patient encounters. This is in contrast with previous research that showed that students or trainees primarily seek answers to clinical questions during patient consultations [46,47]. Yet, it indicates that students' individual perceptions influence how they use educational support, as shown by previous research [21,22].

Limitations

A limitation of this study was the small number of participants and the limited intervention period. Nevertheless, the use of both a quantitative and a qualitative approach in the study design was a strength. This allowed investigation of students' competences and perceptions as well as more insight into students' use of the learning aids. Yet, interviews were only conducted with the aids plus feedback condition. Interviews with the feedback condition could have been informative too. Another limitation was that pretests were used although it is known that these are not learning neutral. They may stimulate learning to the test and affect performance on an identical posttest [48], which could have diminished the effect of the learning aids. Another limitation was that the pretest and posttest only contained one OSCE. Yet, it was a strength that the OSCE in this study was based on a whole consultation rather than short stations assessing clinical competences in isolation. The use of whole consultations and integrated competence assessments more closely reflect the real patient encounter [49]. Additionally, given that the OSCEs in this study were videotaped, it allowed the two observers to review elements that they were unsure of on the first viewing [50]. Regrettably, individual student use of the learning aids could not be linked to their performance on the pretest and posttest. Although it was the researchers' intention to do so, it was impossible due to a failure of the logging system. Another limitation was that there was no information regarding the duration of time in which students accessed the learning aids. This study focused on the use of EHR-embedded learning aids, but "use" does not automatically translate to the application in practice. Previous research indicated that using EBM (or learning aids) may be important, but alone it is insufficient to improve clinical practices or patient care [51]. It was a limitation of the study that the quality of the received feedback was not assessed. Yet, materials and instructions were provided to generalize its format. The study results showed that students in the aids plus feedback condition were able to perform more consultations and they received more feedback than students in the feedback condition, which may have influenced the results. It is possible that the extra reminder via email and postal mail for supervisors in the aids plus feedback condition plays a role, although this remains unclear. It might, for example, also be possible that students took more initiative because they had learning aids available in the workplace. Furthermore, random assignment to the conditions was not feasible in this study. Given that the students ended up in two groups by a mechanism (time of registration for the postgraduate GP course) unrelated to the two conditions, it was assumed to be sufficient. It was a strength of this study that participants were unaware of their assignment to one of the two conditions.

Practical Implications and Future Research

During patient encounters, there is often not much time to search for information in evidence-based guidelines [13]. This study showed that information that is easily accessible, user-friendly, and familiar to students facilitates the information search. This raises the question whether changing the format of evidence-based guidelines and implementing a design more in line with the characteristics of the learning aids in this study (practice-based, step-by-step instructions and easily accessible format) may be helpful. This study also indicated that students often consulted the learning aids before or after patient encounters, provided they were familiar with the aids. This implies that access should be possible at any time and available aids should be made familiar by using them in classroom-based learning activities. This study also showed that students felt restrained when using learning aids during patient encounters, although they perceived the aids as useful, easy to use, and an added value above the existing evidence-based guidelines. This study provides insight into the interfering factors in the transfer of learning, such as the supervisors' role model. Future research should explore how these interfering factors could be overcome (eg, the influence of supervisors' educational training).

Conclusion

Access to EHR-embedded learning aids, in addition to feedback, did not seem to enhance transfer of learning based on the results of the pretest and posttest. However, students perceived the aids as helpful in their transition from medical school to the workplace. They expressed that the learning aids offered additional support during, but also before and after, patient encounters. The learning aids can be easily implemented into workplace-based learning to assist both students and supervisors.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Feedback sheet and cognitive feedback.

[PDF File (Adobe PDF File), 311KB - mededu_v5i1e11351_app1.pdf]

Multimedia Appendix 2

OSCE checklist Acute Lower Back Pain.

[PDF File (Adobe PDF File), 375KB - mededu_v5i1e11351_app2.pdf]

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Abbreviations

EBM: evidence-based medicine
EHR: electronic health record
GP: general practice
OSCE: objective structured clinical examination
TAM: technology acceptance model

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Original Paper

YouTube Videos as a Source of Information About Immunology for Medical Students: Cross-Sectional Study

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Abstract

Background: The use of the internet as a source of information has grown exponentially in the last decade. YouTube is currently the second most visited website and a major Web-based educational resource for medical students.

Objective: The aim of this study was to evaluate the quality, accuracy, and attractiveness of the information acquired from YouTube videos about 2 central concepts in immunology.

Methods: YouTube videos posted before August 27, 2018 were searched using selected keywords related to either antigen presentation or immunoglobulin gene rearrangement. Video characteristics were recorded, and the Video Power Index (VPI) was calculated. Videos were assessed using 5 validated scoring systems: understandability and attractiveness, reliability, content and comprehensiveness, global quality score (GQS), and a subjective score. Videos were categorized by educational usefulness and by source.

Results: A total of 82 videos about antigen presentation and 70 about immunoglobulin gene rearrangement were analyzed. Videos had a mean understandability and attractiveness score of 6.57/8 and 5.84/8, content and comprehensiveness score of 9.84/20 and 5.84/20, reliability score of 1.65/4 and 1.53/4, GQS of 3.38/5 and 2.76/5, and subjective score of 2.00/3 and 2.00/3, respectively. The organized channels group tended to have the highest VPI and GQS.

Conclusions: YouTube can provide medical students with some useful information about immunology, although content wise it cannot substitute textbooks and academic courses. Students and teachers should be aware of the educational quality of available videos if they intend to use them in the context of blended learning.

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KEYWORDS

antigen presentation; education; immunoglobulins; immunology; learning; students

Introduction

Background

The use of the internet as a source of both general and specific information has grown exponentially over the years, with an estimated 54.4% of the world population having access to internet in 2018 [1]. Some of its major assets are the ease and efficiency with which new knowledge can be acquired. For this reason, the internet has also gained popularity among medical students and subsequently changed the way they learn [2,3]. Currently, 94% of medical students are actively participating in social media applications, compared with 79% of residents and 42% of physicians [4]. A recent review shows that university students spend increasingly more time on the internet for educational purposes [5]. This evolution is promoted by the numerous advantages of the internet, such as ease of access and adaptability to individual timetables and can lead to an increase in academic performance [5,6]. However, concerns have been raised about the accuracy and reliability of the available information on the Web [7-10].

Much of the information that medical students have to process is abstract and often requires visual representation for perfect understanding (eg, immunoglobulin gene rearrangement). YouTube, characterized by its audiovisual material, has become a major auxiliary source of information for students often complementary with their textbooks and academic courses [11]. YouTube is currently the second most visited website on the internet and has over 1 billion users, which equals almost one-third of the internet users [12,13]. Once created for entertainment purposes, the site nowadays also contains educational videos posted by individuals, professionals, organizations, and companies [13,14]. The content is accrescent, with an upload rate of 300 hours per minute and a watch rate of 5 billion videos per day [15].

There are, however, no checks and balances, and videos do not have to undergo the same review process as the publication of journal articles and textbooks, which results in variable content quality and uncertainty about sources and reliability [16]. At the same time, medical students may not always be able to accurately recognize ambiguous information [17]. Research is therefore needed to assess the reliability and accuracy of information presented in educational videos. This has already been conducted for some medical-related topics such as anatomy [11], pharmacokinetics [18], and physical examination [19].

Objectives

Immunology is an exemplary topic for the use of educational videos, as it contains multiple abstract concepts that benefit from a visual representation of complex physiological processes. YouTube provides the advantage of giving audiovisual information in a very accessible manner, but the quality of educational videos related to the field of immunology has not been investigated. This study focused on videos about 2 exemplary concepts that are part of the core curriculum in clinical immunology and are generally considered challenging by students: antigen presentation and immunoglobulin gene rearrangement. The aim was to assess the quality, accuracy, and attractiveness of these videos and to determine if YouTube can be a useful source of information for medical students.

Methods

Search Strategy

The search engine of YouTube was queried for 2 different subjects related to immunology: antigen presentation and immunoglobulin gene rearrangement. Videos about antigen presentation were searched using the keywords *MHC 1*, *MHC 2*, *MHC I*, *MHC II*, *MHC 1 and 2*, *MHC I and II*, *Antigen presentation*, *cross presentation*, *HLA class I*, and *HLA class II*. Videos about immunoglobulin gene rearrangement were searched using the keywords *VDJ recombination*, *immunoglobulin gene rearrangement*, *antibody diversity genetics*, *immunoglobulin heavy chain genetics*, *immunoglobulin variable region genetics*, *organization and expression of immunoglobulin genes*, *immunoglobulin genetics*, and *immunoglobulin gene organization.* These terms were optimized using a snowballing technique based on the sequential suggestions of the autofill function of YouTube and Medical Subject Headings terms of PubMed articles related to the subjects. Each term was searched in a separate YouTube search window on August 27, 2018 via the default settings and in an incognito browser window. The first 60 results for each term were considered, which has been shown to correspond to the amount of videos internet users usually screen [20]. Videos were excluded if they were irrelevant, the duration exceeded 60 min, the target audience was not students, the language was not English, or the video contained advertising. This search method simulates the actual search strategy of students. After exclusion, 82 videos about antigen presentation and 70 videos about immunoglobulin gene rearrangement were selected for analysis.

In addition, a cross-section of overall YouTube videos and biology-related YouTube videos was made using the pages *Entertainment – Topic* and *Biology - Topic*, respectively. These are pages that are autogenerated by YouTube and collect videos that have content related to a specific topic. Videos were registered based on similar exclusion criteria as described above (except specific target audience) until 100 videos for each list were collected.

Data Collection

The following characteristics of the YouTube videos were recorded: number of views, number of likes and dislikes, number of comments, duration, year of publication, and days since upload. The like ratio (like*100/[like+dislike]), view ratio (number of views/days), and Video Power Index (VPI; like ratio*view ratio/100) were also determined.

The videos were categorized into groups based on their source and educational usefulness. Categories based on the source were as follows: (1) student (authors were students posting individual videos), (2) organized channel (organized YouTube channels by tutors, teachers, or professors dedicated to producing educational videos), and (3) other (videos from textbooks and audiobooks, which have passed a review procedure). Categories based on educational usefulness were a function of the Global

Quality Scale (GQS) and categorized as “useful” (GQS>3) or “not useful” (GQS≤3), with “useful videos” being considered as those videos that contribute in a reasonable extent to the student’s knowledge and can be advised as qualitative learning material.

Video Evaluation

All videos were independently evaluated by 2 researchers for each subject (JVDE and PGD for antigen presentation and LVE and AC for immunoglobulin gene rearrangement, respectively) using 5 different scoring systems (see Multimedia Appendices 1-5). All videos were evaluated by medical students that had already attended the immunology course in their curriculum.

Understandability and attractiveness (U&A) was scored using an 8-point modified Patient Education Materials Tool (PEMAT) score, which was adapted for a medical student perspective from the original PEMAT tool for the assessment of audio-visual patient information by Shoemaker et al [21]. The 4-point reliability scoring was based on the Journal of American Medical Association benchmark criteria for reliability and accuracy [16,22]. The content and comprehensiveness scorings (C&C) were composed by using recent review articles from high-impact journals: a 22-point score for antigen presentation [23,24] and a 26-point score for immunoglobulin gene rearrangement [25,26], which were both normalized to a 20-point score for statistical analysis and data representation. The overall quality of each video was rated using the 5-point GQS, which was developed as an evaluation tool for the assessment of the flow and ease of use of information on health-related websites [14,16,27]. Finally, a subjective score was attributed to the videos according to the pleasantness of watching them, consisting of 3 points: (1) unpleasant to watch, (2) pleasant to watch, and (3) very pleasant to watch. Videos with different scorings were reassessed until a consensus was reached.

Statistical Analyses

The Shapiro-Wilk test was used to evaluate normality of data. Continuous variables are expressed as mean (95% CI), and an intergroup comparison was carried out using the nonparametric Kruskal-Wallis test or parametric 1-way analysis of variance according to data distribution. Respectively, Dunn test or Fisher least significant difference test were used as a post hoc test for multiple comparison if 3 groups were compared; Ryan-Einot-Gabriel-Welsch and Quiot test was used as a post hoc test when more than 3 groups were compared. Categorical variables are expressed as frequency and proportion, and differences were assessed with the chi-square test. Spearman rho correlation analysis was used to assess correlations between parameters. Stepwise multiple linear regression models were constructed to predict C&C score based on audience interaction parameters and video source. All tests were 2-sided, and a *P* value less than .05 was deemed statistically significant. All analyses have been performed using SPSS software (SPSS Inc).

Results

Audience Interaction Parameters

The mean audience interaction parameters of overall YouTube videos, biology-educational videos, and the videos about antigen presentation and immunoglobulin gene rearrangement are represented in Figure 1. Numerical data and pairwise comparisons are given in Multimedia Appendices 6 and 7, respectively. Both immunological videos had equal audience interaction parameters. Overall, YouTube videos were substantially more popular than all other videos, and the educational YouTube videos also showed higher audience interaction parameters than the immunological videos in our analysis.

Of the 82 videos about antigen presentation, 28.05% (23/82) were categorized as *student*, 59.76% (49/82) as *organized channel*, and 12.20% (10/82) as *other* (Table 1 and Multimedia Appendix 8). There was a statistically significant difference in views, likes, dislikes, comments, days since upload, view ratio, length of video, and VPI. When pairwise comparisons were made, views, likes, dislikes, comments, view ratio, and VPI were significantly higher in the *organized channel* videos than in the *student* videos but not different from the *other* videos. *Other* videos had significantly more days since upload when compared with *student* videos but had a shorter duration when compared with *organized channel* videos. Videos were also categorized by educational usefulness, with 42.68% (35/82) of the videos classified as *useful* and 57.32% (47/82) as *not useful* (Table 2). Videos classified as not useful had significantly more days since upload and had a shorter length. Organized channels were most frequently categorized as useful, with 77.1% (27/35) of this source contributing to the useful videos.

Figure 1. Audience interaction parameters. Values in the Y-axis are given as mean and are provided with 95% CIs. VPI: Video Power Index.

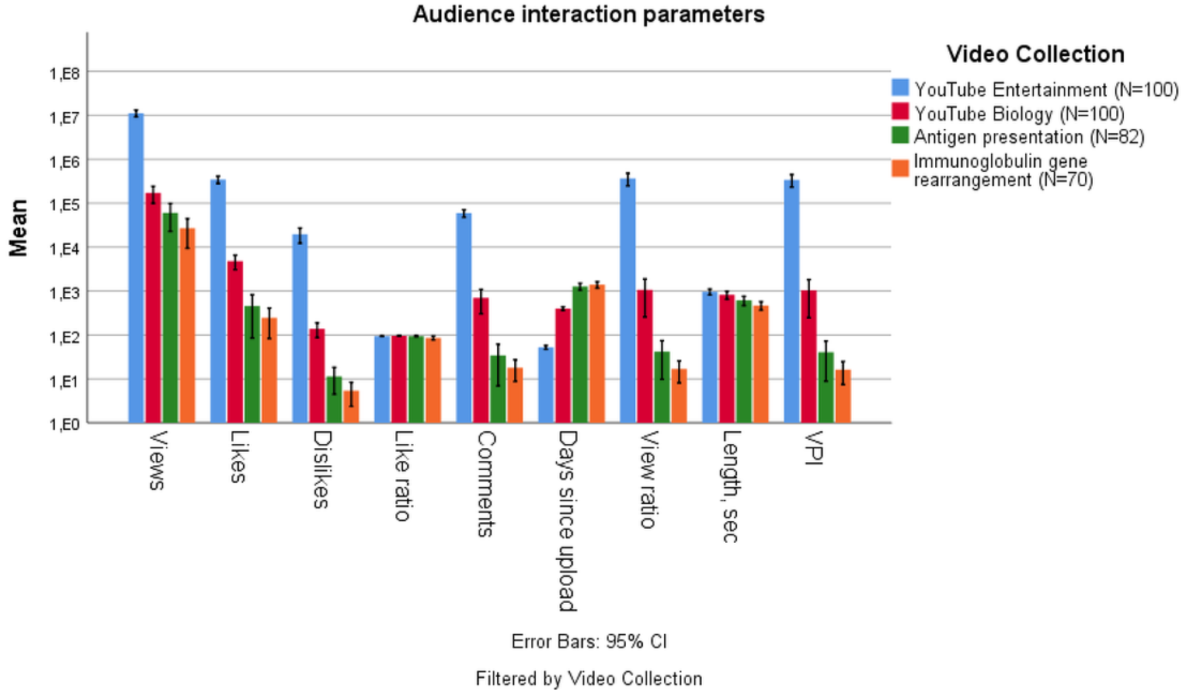

Table 1. Antigen presentation videos: categorized by source.

Variable	Student	Organized channel	Other	*P* value
Video number, n (%)	23 (28.1)	49 (59.8)	10 (12.2)	—[a]
Audience interaction parameters, mean (95% CI)				
Views[b]	8.2 (-1.2 to 17.6)	71.6 (17.6 to 125)[c]	70.1 (7.2 to 133)	.005[d]
Likes	35.4 (-0.09 to 70.9)	634 (66.3 to 1201)[c]	230 (3.6 to 456)	.01[d]
Dislikes	9.9 (-8.4 to 28.1)	11.6 (4.6 to 18.5)[c]	5.8 (1.4 to 10.2)	.01[d]
Like ratio	95.6 (91.3 to 100)	94.1 (89.4 to 98.8)	91.6 (79.4 to 104)	.31
Comments	2.6 (-0.05 to 5.2)	47.6 (7.5 to 87.6)[c]	11.0 (1.1 to 20.9)	.002[d]
Days since upload	959 (599 to 1318)	1168 (937 to 1399)	2252 (1312 to 3191)[c]	.02[d]
View ratio	6.5 (-0.9 to 13.9)	54.7 (7.7 to 102)[c]	22.2 (3.3 to 41.0)	.001[d]
Length, seconds	481 (306 to 656)	700 (512 to 887)	380 (-87.2 to 847)[e]	.003[d]
Video Power Index	6.0 (-0.3 to 12.2)	57.8 (7.3 to 108)[c]	23.8 (3.6 to 44.0)	.007[d]
Content, mean (95% CI)				
Reliability	1.4 (1.05-1.7)	1.7 (1.5-1.8)	2.2 (1.5-2.9)[c]	.01[d]
Content and comprehensiveness	8.3 (6.4-10.3)	11.0 (9.62-12.27)	7.9 (5.0-10.9)	.046[d]
Global quality score	3.0 (2.6-3.4)	3.7 (3.4-3.9)[c]	2.8 (2.2-3.4)[e]	.001[d]
Cinematography, mean (95% CI)				
Understandability and attractiveness	6.1 (5.6-6.7)	6.9 (6.6-7.2)	6.0 (4.5-7.5)	.06
Subjective score	1.9 (1.6-2.2)	2.08 (1.9-2.3)	1.9 (1.3-2.5)	.47

[a]Not applicable.

[b]These factors were divided by 1000.

[c]*P*<.05 versus *student*.

[d]*P*<.05 was considered significant.

[e]*P*<.05 versus *organized channel*.

Table 2. Antigen presentation videos: categorized by educational usefulness.

Variable	Useful	Not useful	*P* value
Video number, n (%)	35 (42.7)	47 (57.3)	—[a]
Global Quality Score, mean (95% CI)	4.3 (4.1-4.4)	2.7 (2.6-2.8)	—
Audience interaction parameters, mean (95% CI)			
Views[b]	30.7 (12.9-48.5)	70.7 (14.0-127.3)	.91
Likes	340 (140-541)	470 (-104-1044)	.18
Dislikes	7.4 (1.8-12.9)	12.5 (2.3-22.7)	.99
Like ratio	97.7 (96.6-98.9)	91.3 (85.5-97.2)	.23
Comments	28.03 (9.2-46.8)	32.3 (-8.08-72.7)	.20
Days since upload	969 (703-1235)	1445 (1141-1748)	.04[c]
View ratio	24.9 (11.9-37.9)	46.4 (-2.6-95.3)	.31
Length, seconds	922 (662-1181)	359 (278-440)	<.001[c]
Video Power Index	25.9 (12.1-39.6)	52.4 (-4.5-109)	.63
Content			
Reliability, mean (95% CI)	1.7 (1.5-1.9)	1.6 (1.4-1.9)	.17
Content and comprehensiveness, median (IQR)[d]	15 (13-19)	7 (6-10)	<.001[c]
Cinematography, mean (95% CI)			
Understandability and attractiveness	7.0 (6.7-7.4)	6.3 (5.8-6.7)	.02[c]
Subjective score	2.3 (2.07-2.5)	1.8 (1.6-2.01)	.002[c]
Source, n (%)			
Student	6.0 (17.1)	17.0 (36.2)	.02[c]
Organized channel	27.0 (77.1)	22.0 (46.8)	—
Other	2.0 (5.7)	8.0 (17.0)	—

[a]Not applicable.

[b]These factors were divided by 1000.

[c]*P*<.05 was considered significant.

[d]IQR: interquartile range.

Of the 70 videos about immunoglobulin gene rearrangement, 14.29% (10/70) were categorized as *student*, 51.43% (36/70) as *organized channel*, and 34.29% (24/70) as *other*. There was a statistically significant difference in days since upload and length between these groups (Table 3 and Multimedia Appendix 9). *Student* videos were observed to have significantly more days since upload than those of the other groups, and *organized channel* videos had a significantly longer duration. Videos were also categorized by educational usefulness, with 24.29% (17/70) videos classified as *useful* and 75.71% (53/70) as *not useful* (Table 4). Videos classified as not useful had a significantly lower number of views, dislikes, and comments. They also had a lower view ratio and a shorter length. There was no source that was categorized significantly more frequently as useful.

Table 3. Immunoglobulin gene rearrangement videos: categorized by source.

Variable	Student	Organized channel	Other	*P* value
Video number, n (%)	10 (14.3)	36 (51.4)	24 (34.3)	—[a]
Audience interaction parameters, mean (95% CI)				
Views[b]	4.9 (–1.6 to 11.4)	35.0 (10.7 to 59.3)	11.2 (–2.09 to 24.4)	.76
Likes	43.9 (–38.06 to 126)	304 (54.9 to 553)	103 (–15.4 to 221)	.48
Dislikes	1.3 (–1.4 to 3.9)	4.1 (1.3 to 6.9)	5.5 (–0.03 to 11.03)	.28
Like ratio	98.4 (95.4 to 101)	90.5 (80.5 to 100)	74.8 (55.4 to 94.2)	.06
Comments	6.2 (–4.1 to 16.5)	22.8 (9.4 to 36.1)	5.04 (0.4 to 9.7)	.47
Days since upload	1907 (1599 to 2215)	1199 (918 to 1480)[c]	1027 (668 to 1386)[b]	.02[d]
View ratio	2.3 (–0.4 to 5.03)	17.9 (6.2 to 29.6)	12.04 (3.2 to 20.9)	.42
Length, seconds	432 (257 to 608)	578 (446 to 711)	218 (128 to 307)[d]	<.001[d]
Video Power Index	2.3 (–1.08 to 5.7)	22.7 (5.9 to 39.4)	13.8 (2.9 to 24.8)	.24
Content, mean (95% CI)				
Reliability	0.9 (0.7 to 1.1)	1.9 (1.6 to 2.2)[c]	1.3 (1.03 to 1.6)[d]	.001[d]
Content and comprehensiveness	5.2 (2.4 to 7.9)	6.6 (5.1 to 8.07)	5.0 (3.09 to 6.9)[d]	.11
Global quality score	2.8 (2.06 to 3.5)	3.08 (2.7 to 3.4)	2.3 (1.8 to 2.7)	.02[d]
Cinematography, mean (95% CI)				
Understandability and attractiveness	5.9 (5.1 to 6.7)	6.1 (5.6 to 6.6)	5.4 (4.6 to 6.1)	.23
Subjective score	1.9 (1.5 to 2.3)	2.2 (1.9 to 2.5)	1.8 (1.4 to 2.09)	.10

[a]Not applicable.

[b]These factors were divided by 1000.

[c]*P*<.05 versus *student*.

[d]*P*<.05 was considered significant.

[e]*P*<.05 versus *organized channel*.

Table 4. Immunoglobulin gene rearrangement videos: categorized by educational usefulness.

Variable	Useful	Not useful	*P* value
Video number, n (%)	17 (24.3)	53 (75.7)	—[a]
Global quality score, mean (95% CI)	4.2 (4.01-4.5)	2.3 (2.07-2.5)	—
Audience interaction parameters, mean (95% CI)			
Views[b]	53.2 (5.2-101.2)	12.7 (3.8-21.6)	.03[c]
Likes	527 (6.5-1049)	94.6 (24.0-165)	.10
Dislikes	7.1 (1.5-12.8)	3.4 (0.7-6.2)	.05[c]
Like ratio	84.4 (63.7-105)	86.5 (76.9-96.0)	.77
Comments	34.8 (10.9-58.7)	7.2 (2.5-11.9)	.002[c]
Days since upload	1272 (814-1730)	1231 (1004-1458)	.94
View ratio	26.7 (4.4-49.05)	9.5 (4.04-14.9)	.009[c]
Length, seconds	812 (618-1007)	313 (243-382)	<.001[c]
Video Power Index	29.7 (2.7-56.8)	11.05 (4.0-18.1)	.22
Content			
Reliability, mean (95% CI)	1.89 (1.5-2.3)	1.4 (1.2-1.6)	.03[c]
Content and comprehensiveness, median (IQR)[d]	12 (10.5-21)	5 (3-7)	<.001[c]
Cinematography, mean (95% CI)			
Understandability and attractiveness	6.8 (6.3-7.4)	5.5 (5.08-6.0)	.001[c]
Subjective score	2.5 (2.2-2.8)	1.9 (1.6-2.07)	.005[c]
Source, n (%)			
Student	1.0 (5.9)	9.0 (17.0)	.06
Organized channel	13.0 (76.5)	23.0 (43.4)	—
Other	3.0 (17.6)	21.0 (29.6)	—

[a]Not applicable.

[b]These factors were divided by 1000.

[c]*P*<.05 was considered significant.

[d]IQR: interquartile range.

Content Analysis

The videos about antigen presentation had a mean reliability score of 1.65/4 (SD 0.760), C&C score of 9.84/20 (SD 4.653), and GQS of 3.38/5 (SD 0.911). Between the different groups based on source, there was a significant difference in reliability and C&C (Table 1). When pairwise comparisons were made, the *organized channel* videos had a significantly higher GQS than the 2 other groups, whereas *other* videos had a significantly higher reliability score. C&C and GQS were observed to be higher in *useful* videos (Table 2).

The videos about immunoglobulin gene rearrangement had a mean reliability score of 1.53/4 (SD 0.812), C&C score of 5.84/20 (SD 4.331), and GQS of 2.76/5 (SD 1.096). There was a statistically significant difference in reliability and GQS between groups based on source (Table 3). *Organized channel* videos had a significantly higher GQS than *other* videos and had the highest reliability score of all of the groups. C&C and GQS were observed to be higher in *useful* videos (Table 4).

Cinematographic Analysis

The videos about antigen presentation had a mean U&A score of 6.57/8 (SD 1.334) and subjective score of 2.00/3 (SD 0.737). There were no significant differences regarding cinematographic scorings between groups based on source (Table 1). U&A and subjective score were observed to be higher in videos classified as useful (Table 2).

The videos about immunoglobulin gene rearrangement had a mean U&A score of 5.84/8 (SD 1.585) and subjective score of 2.00/3 (SD 0.799). When comparing videos based on source, there were no significant differences regarding cinematographic scorings (Table 3). U&A and subjective score were observed to be higher in useful videos (Table 4).

Stepwise Multiple Linear Regression

The stepwise multiple linear regression analysis for the videos about antigen presentation revealed a significant regression equation ($F_{2,77}$=27.591; P<.001), with an R^2 of 0.264. The predicted C&C score is equal to 8.190 + 0.004 (length in seconds). The C&C score increased 0.004 points for each second a video lasted longer. All other audience interaction parameters and video source were excluded from the model as they were no significant predictors.

In the immunoglobulin gene rearrangement group, a significant regression equation with an R^2 of 0.407 was found ($F_{1,62}$=42.547; P<.001). The predicted C&C score is equal to 2.987 + 0.010 (length in seconds). C&C score increased 0.010 points for each second a video lasted longer. All other audience interaction parameters and video source were excluded from the model as they were no significant predictors.

The correlation between different scoring systems are given in Multimedia Appendices 10 and 11.

Discussion

Principal Findings

The main reason for this research was the assessment of YouTube as a Web-based educational source for medical students on major concepts in clinical immunology [12-14]. Due to its rich audiovisual content, the site is especially attractive in the context of blended learning where traditional classroom methods are combined with Web-based digital media. It enables students to control aspects of individual learning such as time, place, or pace. The availability of audiovisual educational material is especially important for the study of (patho)physiological processes that involve multiple regulators, complex sequences, and feedback loops. Such concepts may be difficult to comprehend for novices when they have to rely solely on a single presentation in the classroom and individual study using textbooks or review articles [11]. High-quality Web-based videos could facilitate the understanding of these subjects, especially if the local institution does not provide access to audiovisual educational material [28,29]. However, the publication of YouTube videos is not automatically subjected to the scrutiny of the classical scientific review process or the guarantee of the academic expert, resulting in variable quality and sometimes misleading information, which might not always be detected by students [16,17].

In this study, we selected 2 important immunological concepts where a visual representation of all the sequential and interacting processes is imperative for understanding. Both antigen presentation and immunoglobulin gene rearrangement are ideal *exemplar* concepts as they are part of the core curriculum in clinical immunology, are well defined, well studied, and not too novel to be present in Web-based educational videos. In our study, we selected movies based on keywords that medical students would use to search for relevant videos on these 2 topics. For every keyword, we scanned the top 60 videos as this is the maximum amount of hit the average internet user screens during a Web search [20]. After the final selection, we assessed content, cinematography, and demographic data of these movies by means of validated scoring systems. A total of 3 of our scoring systems quantify the scientific content either very objectively (reliability score and C&C, using a *gold standard*) or in a more subjective manner (GQS). We found that videos on both topics had mean C&C scores between 5.8 and 9.8 out of a total 20, reliability scores of 1.5 to 1.7 out of 3, and GQS of 2.8 to 3.4 out of 4. This suggests that YouTube videos about 2 central concepts in immunology are generally only of moderate quality and often provide insufficient information for a full “academic” understanding. These results are in line with what has been shown in previous research on medical-related YouTube videos [11,18,19,30,31]. This leads us to corroborate the hypothesis that YouTube resources should be dealt with carefully and should be subjected to critical assessments of accuracy and reliability.

We classified the selected videos by source, as we intended to see if videos made by academic experts scored better when compared with those made by students or other sources. More than half of the videos turned out to be made by *organized channels* (59.76% (49/82) for antigen presentation and 51.43% (36/70) for immunoglobulin gene rearrangement). Contrary to what we anticipated, these videos did not have a higher content score (C&C) or attractiveness score (U&A) compared with the videos of student origin or *other* sources.

In our selection, 3 recordings of academic lectures were found. These had a mean C&C of 17.0/20, a U&A of 7.3/8, a reliability score of 2.3/4, and a GQS of 4.3/5. These scores are significantly higher than those of the overall group, especially with regard to scientific content. These data are in line with other studies reporting that medical educational videos uploaded by universities and research institutes usually score higher on quality scales [18,19]. In sharp contrast to their clearly appropriate and verified content, the academic lecture videos in this study had a markedly lower VPI than the mean of all reviewed videos (4.3 vs 16.2). This illustrates what has already been reported by Desai et al [32] that the most qualitative videos often do not receive the most views.

Interestingly, when the data from the 2 biggest YouTube channels about antigen presentation in our analysis (Armando Hasudungan and Shomu’s Biology) were considered together, a mean C&C of 12.9/20, an U&A of 7.3/8, a reliability score of 1.6/3, and a GQS of 4.1/5 were observed. At the same time, these videos had a relatively high VPI (49.9). This suggests that greatly organized channels dedicated to the creation of high-quality educational videos provide the best Web-based resources for students and that they also are currently being used by these students in larger numbers. To engage students, videos should be appealing and illustrative [33,34]. This was also the case in these videos, which contained beautiful drawings of the pathways involved, making them at once entertaining to watch, something which is reflected in their subjective score of 3/3.

In our study, videos classified as *useful* were found to have higher U&A, C&C, GQS, and subjective scores. In the immunoglobulin gene rearrangement group, a higher reliability score was also observed in these videos as well as a higher number of views. This either suggests that YouTube users might judge about the quality of the information themselves and prefer to watch the more accurate and reliable videos or that the YouTube algorithm preferentially shortlists these videos based on these keywords. The latter is less probable as no significant difference regarding audience interaction parameters was seen in the antigen presentation group, which corresponds with the finding in previous studies assessing YouTube videos, namely that no relationship was observed between number of views, likes, or comments and usefulness [18,19,30]. In general, the majority of the videos from each source were classified as *not useful*.

On the basis of the findings in this study, a preferential search strategy to detect videos with the best and most comprehensive content can be derived. First of all, videos from *organized channel* sources tend to have a higher C&C score than the other sources and were more often classified as *useful*. Students could actively look for such organized channels. Furthermore, the multiple logistic regression model showed that the length of the video was the single most important predictor of the C&C score. It is clear that a relevant overview of these processes cannot be given in a video with a duration of 3 min. The age of the video did not influence the C&C score, most likely because the essentials of these immunological processes did not significantly change in recent years. Views, likes, and comments did not predict C&C score, probably because the search results also included several popular videos that were lacking adequate information or were meant for a lay audience. If students select their video using a relevant keyword and subsequently use the criteria of source and longer duration of the video, they will be more likely to find relevant educational videos on YouTube. Unfortunately, this strategy will never be foolproof. As an illustration, we listed the top 3 and bottom 3 videos (based on C&C score) for videos about antigen presentation and immunoglobulin gene rearrangement (see Tables 5 and 6). In the latter one, 1 of the top 3 videos is provided by a biotechnological company with a special interest in antibody technology rather than an academic institution.

Limitations

There are some limitations in our study, though. First, we only considered English-language YouTube videos showing up in the first 60 results of each search term but did not check links to videos from other educational websites or videos that were referred to within these videos. However, it has been demonstrated that 90% of all search engine users only click on results within the first 3 pages, which corresponds to our 60 YouTube results [20]. After all, our purpose was to simulate a regular search for educational resources, as would be conducted by a medical student. Furthermore, as 30 seconds of YouTube watching counts as a *view* [47], we were unable to determine whether users were engaged for the full duration of the video. Third, one could imagine that videos that were liked and viewed more in the past are also more likely to be liked and viewed in the future, thereby representing a self-enforcing feedback mechanism. However, this also corresponds to the way students will find and interact with videos during their search. A final limitation is inherent to any research assessing the quality of YouTube videos: we could only cover a single snapshot. YouTube is a dynamic and ever-growing website, and as a consequence, rankings and views are subject to change, with new videos uploaded at a very high pace.

Table 5. Top 3 and bottom 3 based on content and comprehensiveness for videos about antigen processing.

Video name	Source	Reference
Top 3		
Immunology Lecture Mini-Course, 4 of 14: Antigen Presentation to T lymphocytes	Albert Einstein College of Medicine	[35]
Major histocompatibility complex	Shomu's Biology	[36]
Mod-11 Lec-24 The Major Histocompatibility Complex: MHC class II pathway	NPTEL hrd	[37]
Bottom 3		
MHC Class I	CR King	[38]
MHC Class I Processing	Garland Science	[39]
Immune system: MHC proteins	Walter Jahn	[40]

Table 6. Top 3 and bottom 3 based on content and comprehensiveness for videos about immunoglobulin gene rearrangement.

Video name	Source	Reference
Top 3		
Models of immunoglobulin gene structure	Vidya-mitra	[41]
Immunology – antibody somatic (VDJ) recombination II	Armando Hasudungan	[42]
Antibody diversity rearragment	Creative Biolabs	[43]
Bottom 3		
Where does VDJ recombination occur?	Atunakai3a	[44]
Medical vocabulary: what does V (D) J recombination mean?	Botcaster inc. bot	[45]
“Immunology,” Immunoglobulin genes are rearranged in antibody producing cells	MyCyberCollege	[46]

Conclusions

In conclusion, this study focusing on immunology videos showed that YouTube can provide useful auxiliary resources for students, although it cannot substitute excellent academic lectures, validated textbooks, or state-of-the-art reviews when it comes to scientific accurateness. As most videos were found not to be educationally useful and references or bibliography were often missing, strong critical assessment skills remain imperative if these videos are used as complementary study material. Another important finding was that organized YouTube channels dedicated to Web-based educational videos provide the most qualitative and appealing resources. Students and educators alike should be aware of the quality of available videos, and increasing effort should be spent on collecting videos suited for medical students on channels with appealing, reliable, and accurate information.

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Authors' Contributions

JVDE, AC, PGD, LVE, and JT conceived the study. JVDE, AC, PGD, and LVE collected the data. JVDE analyzed the data, performed statistical analyses, and drafted the manuscript. DB, RS, and JT gave important intellectual contribution and critically revised the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Scoring system: Understandability and attractiveness.

[DOCX File, 13KB - mededu_v5i1e12605_app1.docx]

Multimedia Appendix 2

Scoring system: Reliability.

[DOCX File, 12KB - mededu_v5i1e12605_app2.docx]

Multimedia Appendix 3

Scoring system: Content and comprehensiveness, antigen presentation.

[DOCX File, 14KB - mededu_v5i1e12605_app3.docx]

Multimedia Appendix 4

Scoring system: Content and comprehensiveness, immunoglobulin gene rearrangement.

[DOCX File, 14KB - mededu_v5i1e12605_app4.docx]

Multimedia Appendix 5

Scoring system: Global Quality Score.

[DOCX File, 12KB - mededu_v5i1e12605_app5.docx]

Multimedia Appendix 6

Audience interaction parameters.

[DOCX File, 15KB - mededu_v5i1e12605_app6.docx]

Multimedia Appendix 7

Audience interaction parameters, pairwise comparison.

[DOCX File, 15KB - mededu_v5i1e12605_app7.docx]

Multimedia Appendix 8

Antigen presentation videos: categorized by source, pairwise comparison.

[DOCX File, 14KB - mededu_v5i1e12605_app8.docx]

Multimedia Appendix 9

Immunoglobulin gene rearrangement videos: categorized by source, pairwise comparison.

[DOCX File, 13KB - mededu_v5i1e12605_app9.docx]

Multimedia Appendix 10

Correlations between video scoring systems in the antigen presentation group.

[DOCX File, 13KB - mededu_v5i1e12605_app10.docx]

Multimedia Appendix 11

Correlations between video scoring systems in the immunoglobulin gene rearrangement group.

[DOCX File, 13KB - mededu_v5i1e12605_app11.docx]

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Abbreviations

C&C: content and comprehensiveness score
GQS: Global Quality Score
PEMAT: Patient Education Materials Tool
U&A: understandability and attractiveness score
VPI: Video Power Index

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Viewpoint

Video-Based Communication Assessment: Development of an Innovative System for Assessing Clinician-Patient Communication

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Abstract

Good clinician-patient communication is essential to provide quality health care and is key to patient-centered care. However, individuals and organizations seeking to improve in this area face significant challenges. A major barrier is the absence of an efficient system for assessing clinicians' communication skills and providing meaningful, individual-level feedback. The purpose of this paper is to describe the design and creation of the Video-Based Communication Assessment (VCA), an innovative, flexible system for assessing and ultimately enhancing clinicians' communication skills. We began by developing the VCA concept. Specifically, we determined that it should be convenient and efficient, accessible via computer, tablet, or smartphone; be case based, using video patient vignettes to which users respond as if speaking to the patient in the vignette; be flexible, allowing content to be tailored to the purpose of the assessment; allow incorporation of the patient's voice by crowdsourcing ratings from analog patients; provide robust feedback including ratings, links to highly rated responses as examples, and learning points; and ultimately, have strong psychometric properties. We collected feedback on the concept and then proceeded to create the system. We identified several important research questions, which will be answered in subsequent studies. The VCA is a flexible, innovative system for assessing clinician-patient communication. It enables efficient sampling of clinicians' communication skills, supports crowdsourced ratings of these spoken samples using analog patients, and offers multifaceted feedback reports.

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KEYWORDS

communication; crowdsourcing; health care; mobile phone; patient-centered care; video-based communication assessment

Introduction

Good clinician-patient communication is essential to quality health care and a key element of patient-centered care [1,2]. There is a substantial growing evidence base documenting the critical importance of effective clinician-patient communication for a variety of health outcomes [3,4]. Training in effectively communicating with patients and families is required for medical school and residency program accreditation [5,6], and competency in communication is a requirement for licensure [2,7]. Financial incentives for excellent clinician-patient communication and penalties for poor communication are becoming widespread [8-10]. Many practicing physicians are finding that a portion of their compensation is dependent on their patients' perceptions of their communication skills, and health care reimbursement rates are increasingly influenced by patients' ratings of communication [11-13]. In short, research evidence as well as societal and financial factors and policies have converged to influence health care systems and individual clinicians to value communication and seek to improve in this area.

Although the importance of high-quality clinician-patient communication is widely acknowledged, individuals and organizations seeking to improve in this area face significant challenges. Medical schools and some residencies utilize standardized patients and simulated encounters for formative and summative assessments, but these have significant development and labor costs and are time consuming [14]. For practitioners after training, patient satisfaction and experience surveys are widely used, but these typically entail delayed feedback, too few items assessing communication, and insufficient specificity to support improvement. This demonstrates the need for an assessment tool that is easy to access and can produce timely, specific, and individual-level feedback.

The National Board of Medical Examiners (NBME) is an independent, not-for-profit organization whose mission is to protect the health of the public through state-of-the-art assessment of health professionals. NBME has recognized the assessment of communication skills as a priority, as evidenced by recent efforts to enhance communication assessment within the United States Medical Licensure Examination [7]. In order to support continued development of communication skills beyond the point of licensure and in recognition of needs of busy practitioners, the NBME supported the development and creation of the Video-based Communication Assessment (VCA). This paper describes the VCA-development process and the system that was ultimately created.

Development

Concept Development

Our goal in creating the VCA was to develop an engaging, realistic, and affordable tool that was efficient and convenient for busy clinicians. It should be flexible with regard to content and include robust feedback integrating patient's perspective. Consistent with the NBME standards and practice, the system should result in assessments with strong psychometric qualities.

With these goals in mind, we developed a specific concept: A system that would be accessible via computer, smartphone, or tablet; would collect spoken responses; and would provide a means for gathering input from analog patients. Analog patients are naïve lay people asked to imagine themselves in the role of the patient [15,16]. We planned to gather analog patient responses using crowdsourcing—the practice of engaging people on the Web to complete a task or solve a problem. There are a variety of Web-based panels for this purpose; we utilized one of the largest and most studied—Amazon Mechanical Turk (MTurk) [17,18].

We created a prototype of the VCA that described three key elements: assessment, rating, and feedback (Figure 1). To begin, a user will log on to a dedicated website or download an app on a smartphone or tablet. The user will then be presented with brief clinical background information (in text), providing the context for a clinical encounter. The user will then click to play a brief video of the patient in the encounter. The video will end at a point where the provider will be expected to speak to the patient, and the user will be prompted to respond (ie, “What would you say next?”). The user will respond, speaking as if he or she is actually talking to the patient. This spoken response will be audiorecorded and stored. The sequence of reading a brief introduction, watching a short video, and responding as if one were talking to the patient in the encounter will be repeated for multiple vignettes. When a cohort of users completes the assessment, responses will be rated by analog patients using crowdsourcing. When ratings are completed, feedback reports will be created. These will include individual user’s ratings, comparative data on the user’s cohort; learning points derived from analysis of crowdsource raters’ comments on what will constitute a satisfactory response to the patient; and exemplary, highly rated responses that the user could compare to his or her own response.

Concept Testing

We created a brief presentation on the VCA concept and prototype and showed it to providers, educators, and health system leaders to make an early determination of the potential attractiveness and usefulness of the VCA. Reactions were strongly positive. Encouraged by this feedback, we proceeded to develop each of the three key elements.

We then created sample vignettes, writing a brief text to provide the clinical context and producing amateur videos. We integrated these two components and the stimulus question (“What would you say next?”) into PowerPoint and, using separate recording devices, collected spoken responses from a small convenience sample of 9 clinicians. We used crowdsourcing to gather ratings of these spoken responses through a Web-based survey administered via MTurk. We demonstrated that we were able to elicit spoken responses and obtain ratings within hours of posting on MTurk.

Creation of Video-Based Communication Assessment Content

Because the VCA is an assessment system rather than a single tool, vignette content can be created to assess diverse communication skills. For example, vignettes can be created to assess skills in providing information in a general medicine outpatient context or very specialized communication skills, such as offering an apology, delivering bad news, or describing medication side effects. We decided that the first set of VCA vignettes will be designed to assess communication skills broadly using clinical situations that would be familiar and relevant to providers from a variety of backgrounds.

To develop vignettes, we engaged a multidisciplinary panel of clinicians and educators to participate in a 1-day vignette-development workshop. The authors used an iterative process to refine the vignettes developed or suggested during the workshop and to generate additional vignettes. The resulting vignettes were reviewed by the authors, and corresponding videos were professionally produced. The video portrayals were assessed for realism and whether the produced vignette would be likely to appropriately stimulate a spoken response that could, in turn, be rated by analog patients. Screenshots of vignettes are presented in Figure 2.

Figure 1. Overview of the Video-Based Communication Assessment process.

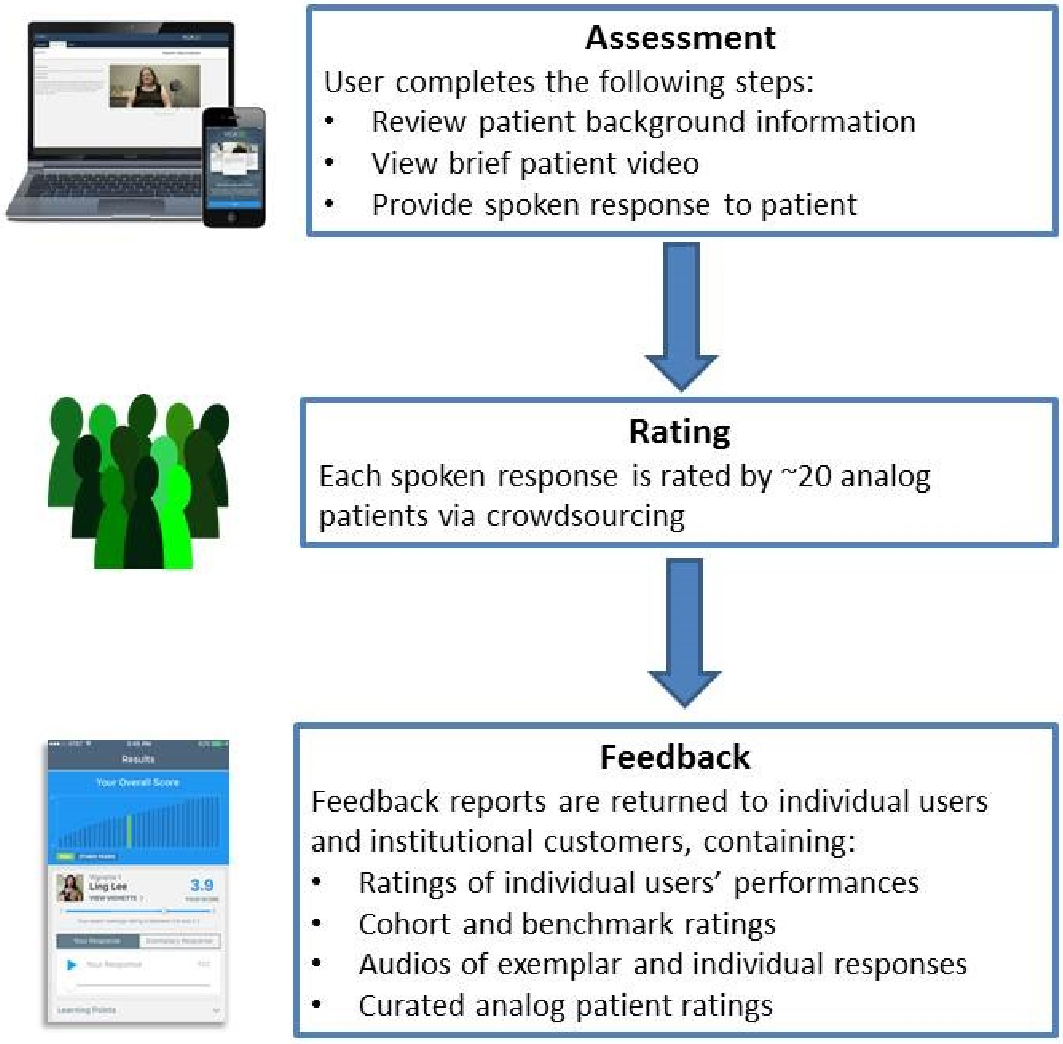
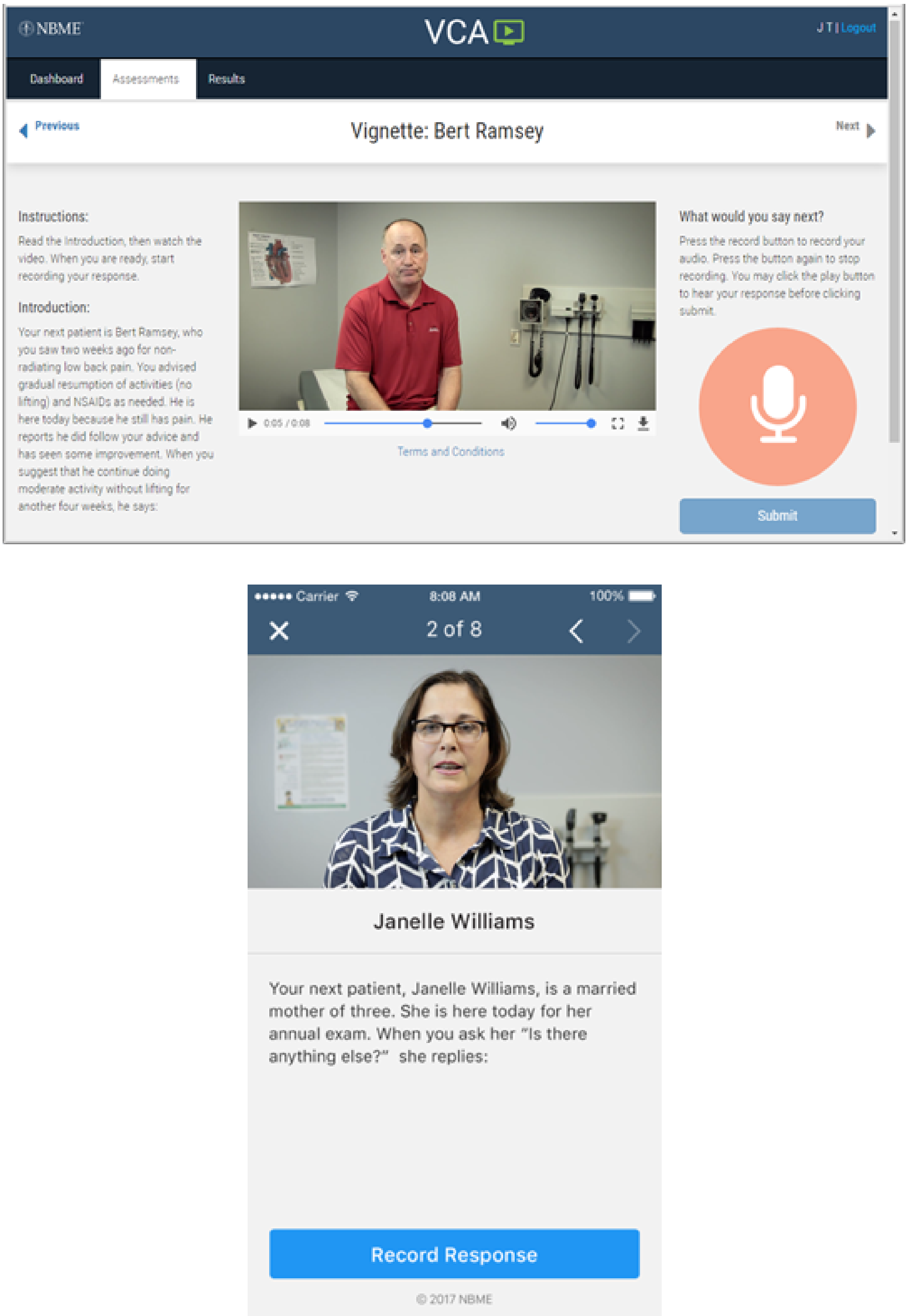


Figure 2. Screenshots of Video-Based Communication Assessment user interface via computer and app. (Source: Content created by National Board of Medical Examiners.).



Development and Operationalization of the Rating Process

Consistent with our intent to incorporate the patient's voice into the assessment, the VCA was designed to allow crowdsourced analog patients to rate users' spoken responses. As noted above, analog patients are lay people who take on the patient's perspective and rate the encounter as if they were the actual patient. A growing body of evidence suggests that analog patients' ratings are reliable and valid [16] and possibly even *more* informative than actual patients' ratings, as they avoid ceiling effects [15].

The VCA was designed to provide a seamless interface for recruiting analog patients using MTurk. MTurk is a widely used Web-based workplace that enables requesters to utilize crowdsourcing to complete specific tasks [18]. There is a growing body of literature describing demographic characteristics of MTurk workers, the quality of data collected via MTurk, and methods for improving data quality [19]. Requesters can constrain which workers may complete a task by specifying eligibility criteria (eg, workers who have consistently demonstrated a high degree of accuracy on prior tasks) or by assessing qualifications through screening questions. For instance, a requester might accept those who report that they have had a doctor's appointment for a specific condition in the prior year.

Analog patients recruited for the VCA will first be oriented to the task and instructed to imagine themselves as the patient in the situation to be presented. The analog patient will then view a brief text (in lay language) describing the clinical context for one vignette, followed by the video of the patient speaking to the provider. He or she will then listen to a recorded response, rate the response on 2-6 items, and then proceed to the next recorded response and repeat the process. The number of responses that will be bundled together (ie, a Human Intelligence Task, as termed in MTurk) is expected to vary between 10 and 20, with the optimal number or range to be determined empirically as data are collected. Each provider's spoken response will be rated by multiple analog patients; our prior work suggests that fewer than 15 analog patients will provide sufficient reliability [20], but the number of raters will also be determined empirically and with consideration of the purpose of the assessment. The number of analog patients needed may also vary depending on the specific vignettes used, the providers involved, and other factors; these influences will be explored in future research.

After rating all audio recordings in the bundle, the analog patients will be asked to respond to a single open-ended item, "What would you have wanted your provider to say if you had been in this situation?"

Development of Rating Items

Because the VCA process is very different from typical communication-assessment processes, the items that analog patients use to rate users' responses are of critical importance. We referred to three sources while developing draft rating items: (1) the 6-function model that provides the framework for communication assessment used by the NBME [7]; (2) the rating items that were used in an earlier communication assessment, which closely resembles the current VCA [20]; and (3) the Consumer Assessment of Healthcare Providers and Systems (CAHPS) item sets, which are an increasingly important point of reference for many providers and health care organizations [12]. A set of 6 items was created for pilot testing. Items will undergo extensive testing and psychometric analyses. An example of an item created for testing is "The provider explained things in a way I could understand."

Although we anticipate that analog patients using rating items developed and tested for the VCA will be the primary way that responses are scored, the VCA system is designed to accommodate other raters and rating items. For example, researchers have expressed an interest in using the VCA to efficiently collect samples of clinicians' typical ways of communicating with specific types of patients. Such responses could then be accessed and scored according to criteria specific to the research question. In this case, raters could be analog patients, trained research staff, or specialists selected for their expertise in the content area.

Development of Feedback Reports

Because we anticipate that the major application of the VCA will be formative assessment, feedback is of fundamental importance. Two types of feedback reports will be created: individual and organizational. Individual feedback reports will provide detailed rating results for a single user, with aggregate, deidentified cohort results provided for comparison. To support learning, individual feedback reports will allow the users to review the vignette, replay his or her response, listen to a highly rated response, and review learning points. Learning points will be based on a content analysis of analog patients' comments and included illustrative quotes and recommendations.

An individual user will be able to share links to his or her personal feedback report at his or her discretion. For instance, a user could choose to share a link with a trained communication coach who will work directly with him or her in one-on-one sessions discussing the feedback report, reviewing his or her responses, and comparing these to exemplary responses and comments.

Organizational level feedback reports will include summary results for an entire cohort. They will include all the components of the individual feedback reports, such as ratings, spoken responses, exemplars, and analog patient comments. In addition, these reports will allow supervisors to review the relative standing of individuals in a cohort. In the future, as the database of responses grows, multiple benchmarks will be available, showing, for instance, the average overall performance of Internal Medicine residents or Family Medicine physicians who have completed the VCA. At present, organizational level feedback reports do not contain the names of the individual users; however, this information could be included in future versions with the consent of users.

Future Research

We have identified a number of research questions related to both operational and psychometric considerations of the VCA (Table 1). Data collection related to research questions 1-4 is currently underway. The answers to these questions will inform the final design and implementation. However, because the VCA is a system rather than a single assessment form, most of the research questions will have conditional rather than absolute answers.

Table 1. Priority research questions and corresponding research strategies.

Question number	Research question	Research strategy
1	Does the VCA[a] (including the user interface, assessment process, and feedback reports) meet the needs of users and customers?	Brief postassessment surveys, user and customer interviews, market research
2	How many vignette responses, rating items, and raters will be needed to obtain a generalizability coefficient (g) of .80 or higher?	Generalizability studies
3	How does the wording of the items presented to analog patients affect ratings, and what items result in psychometrically sound scores?	Sequential testing of various items and response options, with independent samples of analog patients rating the same responses
4	To what extent are analog patient characteristics (eg, age, gender, race or ethnicity, education, geographic residence) associated with differences in ratings?	Statistical analysis of the impact of specific analog patient characteristics on ratings and assessment of the interaction between analog patient characteristics and vignette characteristics
5	Are scores on the VCA correlated with other measures of clinician-patient communication, patient experience, or patient satisfaction?	Correlational studies comparing users' scores on the VCA with scores on relevant items from measures collected in routine practice (eg, CAHPS[b] scores)
6	Does participating in the VCA contribute to improved provider performance?	Pre-post studies of VCA users scores on measures collected in routine practice

[a]VCA: Video-Based Communication Assessment.

[b]CAHPS: Consumer Assessment of Healthcare Providers and Systems.

Discussion

The VCA is an innovative system for assessing clinician-patient communication. We anticipate that it will be useful to individuals and organizations seeking to improve clinicians' communication skills, evaluate the effectiveness of training programs, or document proficiency in communication.

Both experienced and new clinicians can benefit from the VCA. Although current medical education incorporates communication skills into the standard curriculum, the addition is relatively recent. As such, there is a sizable cohort of long-practicing physicians who have never received any formal communication training and could benefit from this tool. Newer physicians have nearly all had exposure to communication basics; nonetheless, there is ample evidence from patients and families indicating that further skill building is needed [21-23]. This is particularly true around uniquely challenging topics such as end-of-life conversations, supporting and enhancing patient self-management of chronic conditions, and assisting patients struggling with pain management in the current context of pervasive opioid use disorder. Coupled with the widespread adoption of maintenance-of-certification mandates across medical specialties, clinicians have increased motivation and context for enhancing these skills.

In an organizational application, a hospital's Chief of Medicine might use VCA results to identify clinicians who are most in need of remediation or the most skilled clinicians in order to engage those clinicians as peer coaches. VCA results could also be used to identify particular areas of strength or weaknesses for a given clinician; for example, a clinician might be identified as needing additional support regarding ways to disclose medical errors. Initial feedback on the VCA suggests that such inferences and decisions are relevant and important to hospital leaders, residency directors, and others in similar positions.

The VCA has important implications for the research setting, as it enables efficient, remote, and targeted assessment of clinicians' communication skills in the context of descriptive and intervention studies. Vignette-based surveys have been widely used in research to explore how clinicians respond to variations in clinical situations and patient characteristics and how patients respond to variations in clinicians' communication strategies [24]. Most often, the vignettes presented are text-based and the responses are collected via rating scales. Although some studies, particularly those using analog patients, have used video vignettes as stimuli, we are not aware of any studies, with the exception of our own prior work [20], that have captured spoken responses. There are important differences in spoken and written communication [25]. The VCA will allow researchers to efficiently study not only what clinicians say but also how they say it and how patients respond to these communicative acts. Rigorous research in this area could ultimately provide new insights into what constitutes good communication from the patient's point of view as well as a more complete understanding of the extent to which patients' perceptions of communication vary according to their personal characteristics.

There are a number of unanswered questions about the VCA and its impact. Specifically, further work is needed to determine whether the use of the VCA and the feedback reports, in particular, result in behavior change; whether any positive impact is obtained through the use of the report alone; or whether the support of a coach or teacher is required. Another uncertainty relates to the potential for the widespread adoption of the VCA. Although our preliminary conversations with potential customers and users were positive, it is not yet known whether institutions, organizations, programs, and individuals will find this tool attractive or useful.

Despite its many attractive features, the VCA has some limitations. The use of very brief vignettes of communication behaviors allows efficient assessment, but the lack of sustained interactions might also be considered a limitation. Our decision to use this approach was, in part, pragmatic: Doing so allows efficient assessment using a variety of vignettes in a relatively short amount of time. We recognize that this approach does not provide an assessment of clinicians' ability to adjust their communication skills over the course of an interaction or to develop a relationship with a patient over time. At the same time, prior research suggests that this approach will result in valid and reliable scores [20] and that even brief samples of communication behaviors are informative and predictive of important outcomes [26]. We plan to conduct a series of studies to investigate the properties of VCA scores.

In summary, the VCA is a flexible, innovative system for assessing clinicians' communication skills. Research is currently underway to provide insights into the reliability of VCA scores under various conditions and to examine the impact of rater characteristics. We believe that the properties of the VCA will enable this new system to make a substantial contribution to the assessment of communication skills and ultimately, to improving clinician-patient communication.

Conflicts of Interest

None declared.

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Abbreviations

CAHPS: Consumer Assessment of Healthcare Providers and Systems
NBME: National Board of Medical Examiners
MTurk: Amazon Mechanical Turk
VCA: Video-Based Communication Assessment

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Original Paper

Impact of an Electronic App on Resident Responses to Simulated In-Flight Medical Emergencies: Randomized Controlled Trial

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Abstract

Background: Health care providers are often called to respond to in-flight medical emergencies, but lack familiarity with expected supplies, interventions, and ground medical control support.

Objective: The objective of this study was to determine whether a mobile phone app (airRx) improves responses to simulated in-flight medical emergencies.

Methods: This was a randomized study of volunteer, nonemergency resident physician participants who managed simulated in-flight medical emergencies with or without the app. Simulations took place in a mock-up cabin in the simulation center. Standardized participants played the patient, family member, and flight attendant roles. Live, nonblinded rating was used with occasional video review for data clarification. Participants participated in two simulated in-flight medical emergencies (shortness of breath and syncope) and were evaluated with checklists and global rating scales (GRS). Checklist item success rates, key critical action times, GRS, and pre-post simulation confidence in managing in-flight medical emergencies were compared.

Results: There were 29 participants in each arm (app vs control; N=58) of the study. Mean percentages of completed checklist items for the app versus control groups were mean 56.1 (SD 10.3) versus mean 49.4 (SD 7.4) for shortness of breath (P=.001) and mean 58 (SD 8.1) versus mean 49.8 (SD 7.0) for syncope (P<.001). The GRS improved with the app for the syncope case (mean 3.14, SD 0.89 versus control mean 2.6, SD 0.97; P=.003), but not the shortness of breath case (mean 2.90, SD 0.97 versus control mean 2.81, SD 0.80; P=.43). For timed checklist items, the app group contacted ground support faster for both cases, but the control group was faster to complete vitals and basic exam. Both groups indicated higher confidence in their postsimulation surveys, but the app group demonstrated a greater increase in this measure.

Conclusions: Use of the airRx app prompted some actions, but delayed others. Simulated performance and feedback suggest the app is a useful adjunct for managing in-flight medical emergencies.

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KEYWORDS

in-flight medical emergencies; ground medical control; commercial aviation; simulation

Introduction

Epidemiologic evidence for in-flight medical emergencies from a ground-based medical support system estimated that medical emergencies occur in 1 of every 604 flights [1]. This is likely an underestimate because no mandatory reporting system exists, and uncomplicated issues often go unreported [2]. Air travel is increasing, with 895.5 million passengers flying in 2015 [3], leading to an increased frequency of in-flight medical emergencies. In one study, 42% of 418 health care providers surveyed reported being called on to give aid in an in-flight medical emergency [4].

The Federal Aviation Administration mandates that US-based airlines carry basic first aid kits stocked with bandages and splints, and at least one automated external defibrillator must be available [5]. Beyond the basic kit, no national or international standards exist, although there have been recent calls for consistency [6,7].

Health care personnel are also unlikely to be familiar with medical kit contents, flight crew communication, and medical emergency protocols [4]. Clinicians' expertise typically consists of their specialty training and life support courses. Emergency response training is often limited as emergency medicine is not a mandatory rotation in medical education [8]. Although helpful, ground-based medical consultation support services (ground medical control) still depend on volunteers to be their "eyes and ears" [1,9]. The assumption is that volunteers will find and report clinical information relevant to the presenting medical emergency [1,10].

Comfort attending to an in-flight medical emergency is likely to vary substantially across provider backgrounds. Thus, there is a need for education about the environment and scenario-based basic in-flight medical emergency response training. In recent months, the aviation and health care industries have recognized this and called for education in emergency stabilization and flight medicine at both graduate and undergraduate levels [11,12].

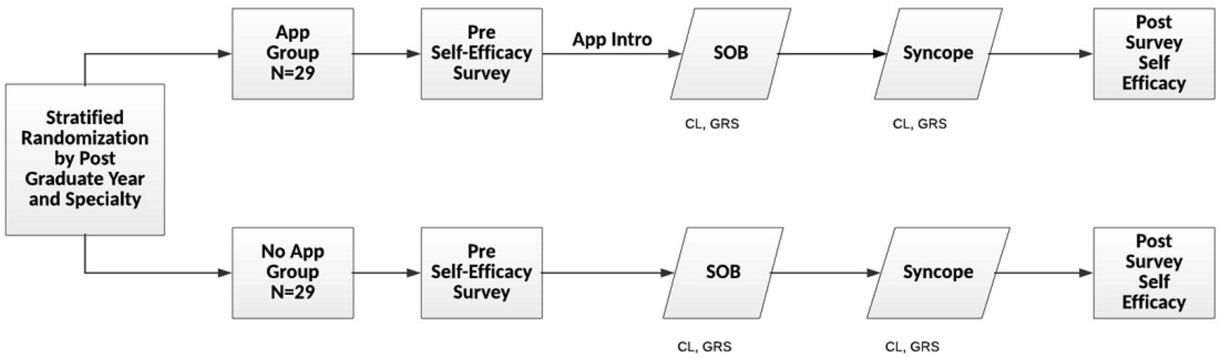
Although several authors have discussed the management of in-flight emergencies [13-18], little real-time decision support exists outside of ground medical control. Normal emergency response mobile phone apps or cognitive aids may not take the environment into account. In response to this perceived need, a mobile phone app was designed by emergency, aerospace medicine, and radiology physicians (airRx) [19] to assist licensed health care personnel in dealing with the most common in-flight medical emergencies. The app offers complaint-specific recommended actions, care algorithms, and in-the-moment information regarding the likely available medications. While serving as a real-time decision support reference, the app also provides a method of just-in-time training (JITT) [20]. Pertinently, the JITT approach has been successful in on-the-job training for first responders in unfamiliar situations [21]. Studies have also shown that mobile phone-based cognitive aids promote adherence to protocols in both real and simulated clinical scenarios [22-24]. Therefore, a JITT-based mobile phone cognitive aid or app is a reasonable approach to delivering focused learning during an in-flight medical emergency. The objective of this study was to determine the usefulness of the airRx mobile phone app in responding to simulated in-flight medical emergencies. Our secondary objective was to examine whether access to the airRx app would increase confidence to respond to an in-flight medical emergency.

Methods

Design

This was a prospective randomized controlled trial. Fifty-eight participants were block randomized by postgraduate year and specialty area to simulated in-flight medical emergencies with and without access to a smart device app. Although block randomization was used to assign participants to each group, the assessment and treatment of the two chief concerns—shortness of breath and syncope—were not randomized. Anticipating a case order effect, all simulations were run in the sequence order depicted in Figure 1 (overall study flow), with the shortness of breath case preceding the syncope case. This study design was approved by the University of Illinois–Peoria, Peoria, IL, Institutional Review Board.

Figure 1. Study design. Participants were debriefed after the postsurvey. CL: checklist; GRS: Global Rating Scale; SOB: shortness of breath; SYN: syncope.



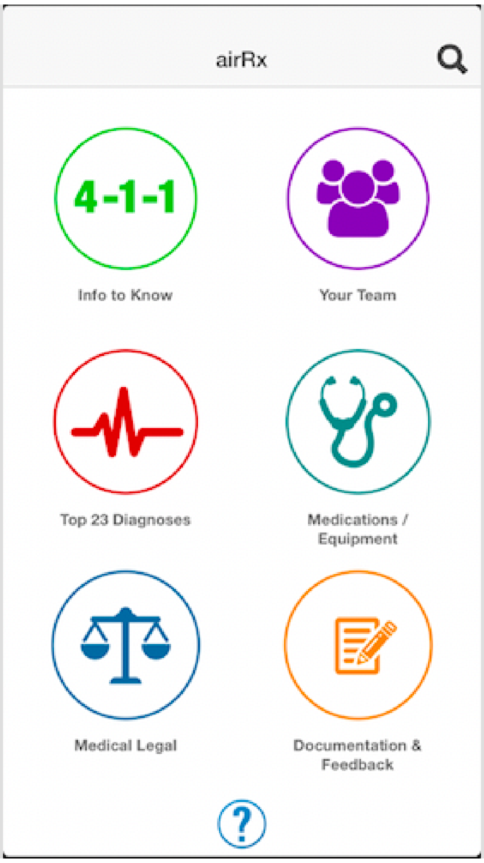
Participants

Participants were solicited from non-emergency medicine residency programs including diagnostic radiology, family medicine, internal medicine, pediatrics, psychiatry, combined medicine-pediatrics, and obstetrics and gynecology. Emergency medicine residents were excluded given their expertise and training in management of emergencies. Participants' performances were kept confidential. They were compensated through a US $25 gift card and a copy of the airRx app at no cost to them. Participants were instructed to keep the scenarios confidential to minimize the relay of scenario information to future participants.

Intervention

The intervention tested is an app known as airRx (Figure 2). It was initially funded by a nonprofit organization and is now freely available on both the iOS and Android mobile phone platforms. It was created by the authors (RRB, MDS, CJC) and nonauthors (Joshua Timpe, MD; Claude Thibeault, MD; Paulo Alves; and John Vozenilek, MD) and designed to help non-critical care, non-emergency health care professionals manage common in-flight medical emergencies. The app version (airRx version 1.2.1, 2016) [19] was kept constant during the study. The app has a section on "universal starters" for users to consider for any in-flight medical emergency. There are also sections on medications and equipment to expect on most US major airlines, a complaint-based set of algorithms for management, and medicolegal information.

Figure 2. Screenshot of the airRx app.



Case Development

Syncope and shortness of breath were chosen as our in-flight medical emergency scenarios because these are the top two commonly occurring in-flight medical emergencies noted in the literature [1,12]. Case development followed standard simulation case creation guidelines [22]. Real flight attendants (United Airlines, Chicago, Illinois) also participated in the process of scenario design and pilot testing to ensure content validity. Cases are available in Multimedia Appendix 1.

Simulation Environment

The study took place at a university hospital-affiliated simulation center. Space and movement limits that mimicked the floor distances of a Boeing 737 aircraft were created within a simulation laboratory with audiovisual recording capability.

The simulation center has a cadre of standardized participants who undergo general and scenario-specific orientation. The standardized participants went through dry runs of each scenario, received feedback on their performance, and were given earbuds for prompts in real time. In each scenario, there was one standardized participant passenger who became ill and one standardized participant passenger bystander who had relevant information if asked. Stable actor cohorts played these roles. Pathologic physical exam findings were given on cue through prewritten cards from the bystander standardized participant because healthy patient standardized participants could not mimic symptoms such as wheezing.

For each case there were also two standardized participant flight attendants who communicated with the investigators in the simulation control room ("pilot" and "ground medical support") and relayed responses to the participants. Real flight attendants trained standardized participants to portray flight attendant roles through direct observations of their performance in pilot simulations, video review, and discussion of planned responses to questions. To isolate participant performances, we instructed the flight attendants to be helpful and follow directions but wait to inform ground medical control until instructed. Thus, we controlled for variable airline protocols, flight attendant training, and individual responses expected in real life.

All participants were prebriefed on the general premise of the simulation, safe space principles, and learner contracts, and given the opportunity to ask questions via a standardized script by the same personnel. Both the control and intervention groups were allowed to use any other phone apps they had on their personal smart device that would be accessible during airplane mode. The app group had up to 15 minutes to familiarize themselves with the app.

Scenarios began with the participants sitting in the simulated cabin with a brief pause before flight attendants announced the in-flight medical emergency and called for assistance; these were run for 8 minutes. The length of the simulation was determined based on pilot simulation cases in which, on average, most critical actions were completed by participants by 8 minutes. At the end of the simulation, participants were debriefed based on comparison of their performance with the action checklist.

Main Measures

The main measures assessed were subject checklist completion rates, global rating scales (GRS), time to critical actions, and pre-post simulation confidence surveys.

Instrument Development

There are no existing performance expectations for in-flight medical emergency responders that can serve as an external validity check. However, after literature review, consensus discussions among flight attendants (MC), aviation (MDS, CT, and PA), and emergency medicine experts (NN, WB) led to the development of optimal performance expectations reflected in scenario-specific rating forms, including both checklists and GRS. These were cross-checked for content validity by having other team members (MDS, RB) review the checklist items. Items included history gathering, physical examination, basic management choices, and communications actions.

The 4-point GRS (1=needs further instruction, 2=competent but with close supervision, 3=competent with minimal supervision, and 4=competent to perform independently) measures competence in managing the scenario and is similar to the entrustable professional activities scale used in undergraduate medical education [23]. We ran four pilot simulations per case with a sample group of resident physician participants. This allowed us to train the standardized participants and refine our simulation cases and checklist items. Some items were reworded for clarity, and several were dropped.

We also created pre-post simulation surveys for participants to self-assess their readiness for in-flight medical emergencies, knowledge of resources, medicolegal concerns, crew integration, in-flight medical emergency communications process, and willingness to respond. Surveys were pilot-tested for clarity, and usability questions (app group only) were derived from a previously developed technology usability survey [24] and administered immediately before and after the simulations.

Observation, Rating Method, and Data Collection

Raters were physicians and nurses, with research expertise, who were trained on the checklists for the scenarios. Raters had no conflicts of interest. Participants in the app group often had the app in hand; thus, we could not blind the raters. Primary and secondary raters observed behind two-way glass in the control room. Due to scheduling logistics, secondary rating was occasionally performed using the audiovisual recording. Because this occurred in less than 5% of cases, we did not test interrater reliability between live and video ratings. All observations were captured on paper, transferred into survey software (Qualtrics), and then extracted to a spreadsheet program (Excel v2013, Microsoft Corp). Checklist items were marked as either "observed" or "not observed." Something could be "not observed" if it was not done, time ran out, the standardized participant patient prevented the action, or the observer missed the action. Five actions per case were timed. The number of these items was limited due to rater burden. Recorded times of the two raters were averaged together for statistical analysis.

Results

Sample size estimation was difficult due to unknown performance expectations, standard deviations, and effect sizes. However, we prospectively estimated our sample size to be 74 in total, or 37 per group, to have an 80% chance (power=0.80) of detecting a 20% improved performance overall in the checklist, with an assumed standard deviation of 30%. The study was stopped after interim analysis (29 participants per arm) due to resource constraints.

All statistical tests were performed against a two-sided alternative hypothesis with a significance level of 5% (α=.05) using R version 3.2.5 or latest version. Interrater reliability was calculated using Gwet's AC1 (agreement coefficient 1), which is capable of handling more than two raters and response categories. The proportion of participants to complete each action, treated as binary variables, were compared using chi-square analysis or Fisher exact test as appropriate. In addition, the percentage of applicable completed actions was averaged between raters and compared between groups using independent sample *t* tests. The Likert-type global competency ratings and response times for the timed critical actions were not normally distributed, so both were compared using nonparametric Wilcoxon rank sum tests. Demographics were analyzed between groups using chi-square or Fisher exact test as appropriate. Mean ratings on the pre- and postsimulation surveys were analyzed using a linear mixed model. A log transformation was used as needed to meet model assumptions.

Analysis of participant demographics did not show differences in specialty, level of training, experience flying, or experience with in-flight medical emergencies (Table 1) between the two groups. The mean interrater reliability across the entire case was 0.90 for the syncope case and 0.94 for the shortness of breath case.

Table 1. Participant demographics (N=58)

Category	App (n=29), n (%)	Control (n=29), n (%)	*P* value[a]
Specialty			.75
Internal medicine	8 (28)	8 (28)	
Medicine-pediatrics	5 (17)	9 (31)	
Pediatrics	4 (14)	3 (10)	
Family medicine	1 (3)	2 (7)	
Obstetrics and gynecology	2 (7)	2 (7)	
Other (radiology and psychiatry)	9 (31)	5 (17)	
Training level			.84
Postgraduate year 1	11 (38)	10 (35)	
Postgraduate year 2	9 (31)	8 (28)	
Postgraduate year 3	5 (17.2)	8 (28)	
Postgraduate year 4	4 (13.8)	3 (10)	
Direct high acuity care			.54
Rarely, if ever	2 (7)	4 (14)	
Infrequently	6 (21)	6 (21)	
Regularly, but not frequently	10 (35)	13 (45)	
Frequently	8 (28)	3 (10)	
Very frequently	3 (10)	3 (10)	
Announcement for medical professionals			.49
Yes	6 (21)	4 (14)	
No	23 (79)	25 (86)	
Average number of flights per year			.04
None	0 (0)	2 (7)	
1 to 2	11 (38)	14 (48)	
3 to 5	15 (52)	6 (21)	
6 to 10	3 (10)	7 (24)	
Experienced call for medical help			.19
Once	1 (17)	3 (75)	
2-3 times	5 (83)	1 (25)	
Responded to call for medical help			.99
Never	3 (50)	2 (50)	
Once	1 (17)	1 (25)	
2-3 times	2 (33)	1 (25)	
Actively provided care			.99
No, other provided care	1 (33)	0 (0)	
Yes, I actively provided care	2 (67)	2 (100)	

[a]Used Fisher extract test for *P* values.

Table 2. Counts and proportion of completed checklist items (both raters).

Checklist item	Completed checklist item, n (%)		*P* value
	App (n=29)	Control (n=29)	
Shortness of breath checklist items			
Introduces self and role	47 (81)	43 (74)	.37
Acknowledges patient by name and identifies family members	45 (78)	18 (31)	<.001
Asks patient for bystander for insight	58 (100)	57 (98)	.99
Request flight attendant assistance	35 (60)	19 (33)	.003
Informs/updates the cabin crew	17 (31)	5 (11)	.01
Asks patient basic history	55 (95)	57 (98)	.62
Asks patient allergies	17 (30)	17 (29)	.99
Asks patient about home oxygen use	10 (17)	12 (21)	.64
Elicits COPD[a]/asthma history	12 (21)	12 (21)	.99
Examines heart and lungs through auscultation	46 (79)	54 (93)	.03
Examines neck	2 (3)	2 (3)	.99
Examines for pedal edema	6 (10)	8 (14)	.57
Obtains vitals (BP[b], HR[c])	13 (22)	13 (22)	.99
Reassesses patient	56 (97)	58 (100)	.50
Administers steroids	18 (32)	4 (7)	.001
Administers albuterol treatment	56 (97)	56 (97)	.99
Requests for emergency medical kit	58 (100)	58 (100)	.99
Requests ground medical control consult	26 (45)	11 (19)	.003
Repeats vitals	38 (66)	52 (88)	.002
Administers high flow oxygen	49 (85)	40 (69)	.048
Syncope checklist items			
Introduces self and role	45 (78)	44 (79)	.90
Acknowledges patient by name and identifies family members	27 (47)	18 (32)	.10
Asks patient for bystander for insight	57 (98)	53 (91)	.21
Requests emergency medical kit	58 (100)	58 (100)	.99
Informs the cabin crew	39 (71)	18 (40)	.002
Requests ground medical control	29 (50)	16 (28)	.02
Asks about patient’s allergies	9 (15)	14 (25)	.23
Asks about patient’s symptoms	54 (93)	57 (100)	.12
Asks about palpitations	11 (19)	2 (4)	.01
Asks about chest pain	33 (57)	27 (47)	.31
Asks about dyspnea	35 (60)	22 (39)	.02
Asks about arrhythmia history	15 (26)	11 (20)	.40
Asks about gastrointestinal bleeding history	0 (0)	3 (5)	.12
Asks patient basic history	58 (100)	54 (95)	.12
Requests flight attendant assistance	24 (41)	5 (9)	<.001
Auscultates heart and lungs	42 (72)	43 (74)	.83
Examines abdomen	2 (3)	2 (3)	.99
Examines patients neck	2 (3)	3 (5)	.99

Checklist item	Completed checklist item, n (%)		*P* value
	App (n=29)	Control (n=29)	
Requests the AED[d]	20 (35)	12 (21)	.12
Obtains vitals	51 (88)	51 (88)	.99
Repeats vitals	17 (29)	24 (41)	.17
Reassess patient	56 (98)	52 (90)	.11
Positions the patient	48 (84)	32 (56)	.001
Administers oxygen	28 (52)	8 (14)	<.001
Administers fluids	54 (93)	56 (97)	.68

[a]COPD: chronic obstructive pulmonary disease.

[b]BP: blood pressure.

[c]HR: heart rate/pulse.

[d]AED: automatic external defibrillator.

The app group had a significantly higher mean percentage of total completed checklist items (mean 58.0, SD 8.1) compared with the control group (mean 49.8, SD 7.0) for the syncope scenario (t_{56}=4.15, P<.001) and the shortness of breath scenario (mean 56.1, SD 10.3 versus mean 49.4, SD 7.4 for control; t_{56}=2.82, P=.007).

For both cases, the app group demonstrated significantly greater requests for ground medical control, flight attendant assistance, and communications to inform and update the cabin crew. For the shortness of breath case, the app demonstrated significantly greater administration of steroids, administration of high flow oxygen, and communications to inform and update the cabin crew. However, the control group completed the cardiac and pulmonary exams and reassessed vitals more frequently. For the syncope case, the app group asked about dyspnea and palpitations, positioned the patient supine, and administered oxygen more frequently compared with the control group (Table 2).

For timed actions, the app group had significantly shorter response times for the “alert ground medical support” checklist item compared with the control group, and this was statistically significant for both cases (*P*=.01; Table 3). However, the control group for the shortness of breath case had a statistically significant shorter response time for the “obtains vitals” checklist item (*P*=.006; Table 3).

Comparing the performance of learners across the two groups, there was no significant difference in the GRS for the shortness of breath case; however, the app group was rated significantly higher (mean 3.14, SD 0.89) for the syncope case compared with the control group (mean 2.6, SD 0.97; *P*=.003; Figure 3). Additionally, although not statistically significant, there seemed to be a trend with upper postgraduate levels performing slightly better, and certain specialties (internal medicine) performing better than other ones (radiology).

Table 3. Timed critical actions for shortness of breath and syncope cases.

Timed critical actions	App (n=29), mean (SD)	Control (n=29), mean (SD)	*P* value
Shortness of breath			
Albuterol	264.6 (104.4)	239.9 (95.2)	.35
Oxygen	268.0 (127.0)	294.0 (157.7)	.59
Ground medical crew	369.8 (143.4)	452.2 (78.2)	.01
Emergency medical kit	106.1 (35.5)	108.5 (36.0)[a]	.74
Vitals	336.5 (125.9)	249.0 (113.6)[a]	.006
Syncope			
Emergency medical kit	101.7 (40.5)	82.7 (33.5)	.05
Ground medical crew	352.4 (155.0)	441.5 (87.0)	.02
Vitals	265.2 (107.7)	228.2 (122.9)	.05
Supine position	282.8 (139.5)	321.4 (167.8)[a]	.32
Give fluids	314.1 (107.4)	260.3 (83.3)	.05

[a]n=28.

Figure 3. Global ratings for shortness of breath and syncope. IFME: in-flight medical emergency; SOB: shortness of breath; SYN: syncope.

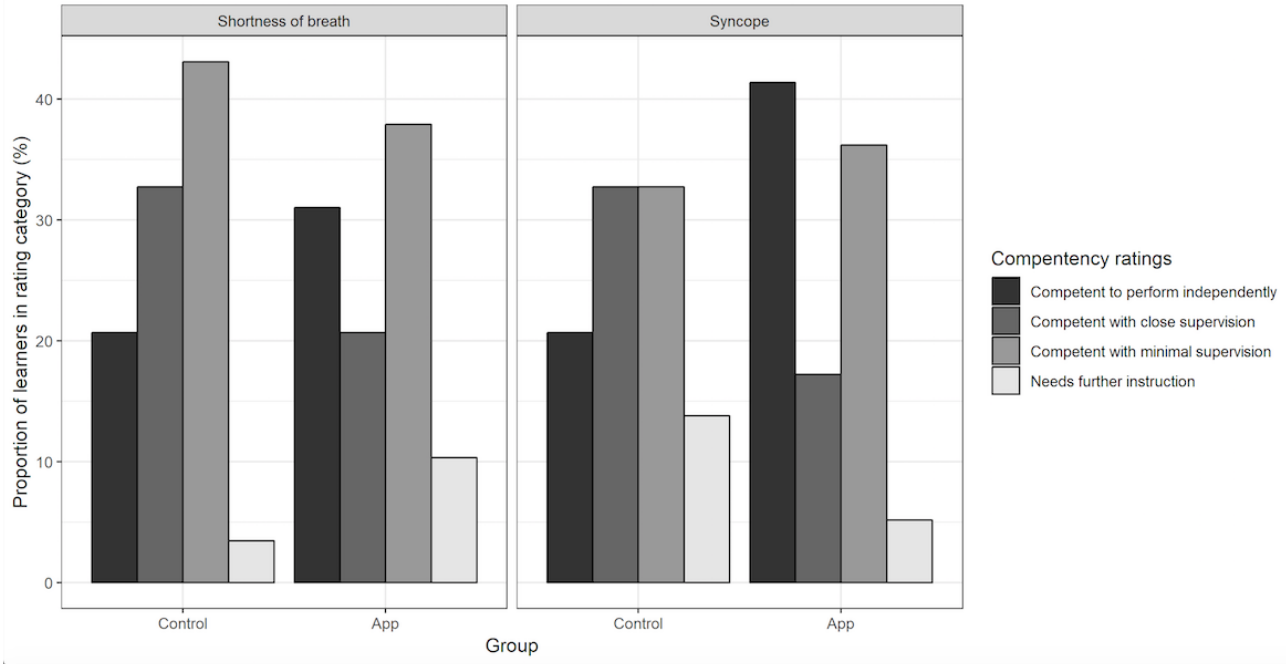
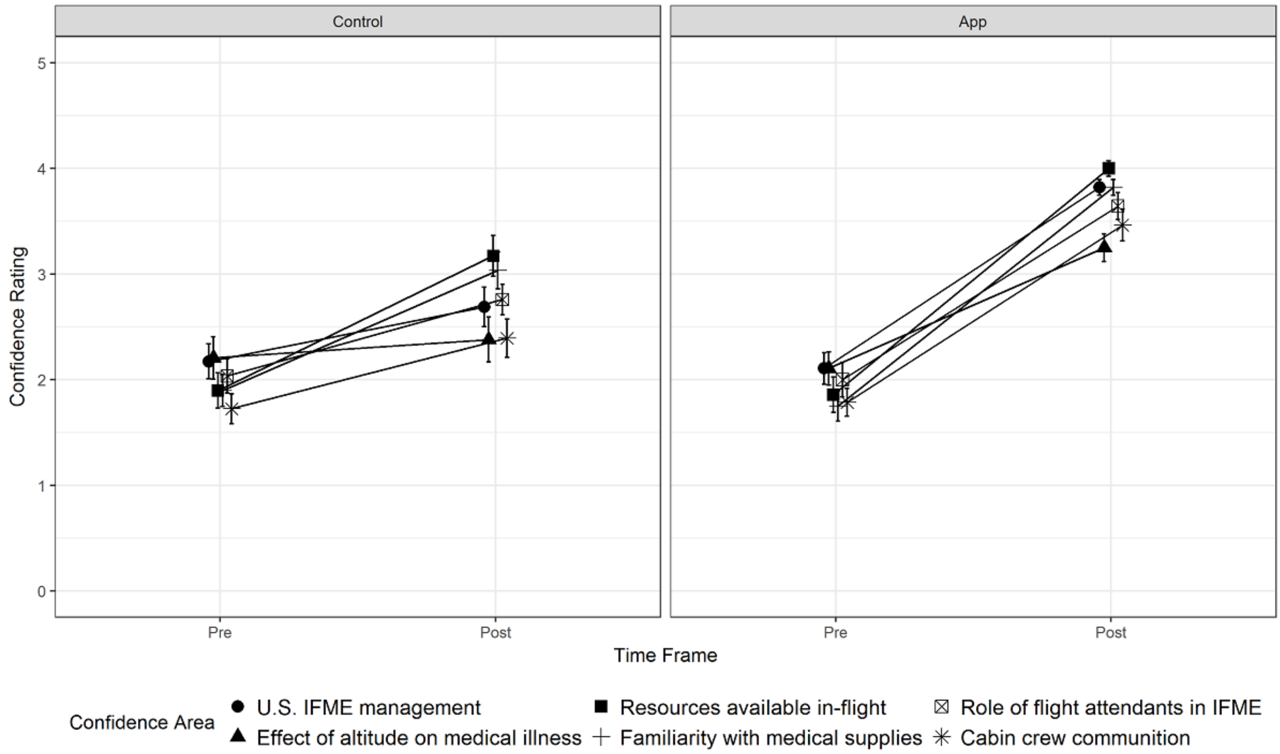


Figure 4. Pre- and postsimulation learner confidence in managing in-flight medical emergencies (IFME).



Postsimulation surveys (Figure 4) were associated with higher ratings from both the app and control groups relative to presurvey. However, the app group demonstrated increased confidence compared with the control group.

Discussion

Principal Findings

Availability of medical care during an in-flight medical emergency is a passenger safety prerogative. To address this need, most US airlines mandate first aid and basic life support training for flight crew and contact with ground-based medical consultation services, generally staffed by emergency medicine physicians who provide protocol-driven treatment recommendations and help make decisions regarding plane diversion. Health care professionals are not obligated to volunteer, and factors influencing their willingness to respond include their specialty, ancillary training (eg, combat medic, paramedic), years of practice, and medicolegal concerns [25]. Our survey showed that confidence increased with training in this unfamiliar environment, but confidence to respond increased more in the app group. This increase in confidence should not be falsely reassuring of anticipated improved performance, but the user may be more likely to respond.

We successfully simulated in-flight medical emergencies by recreating space constraints, communications barriers, and equipment limitations present on a mobile aircraft. We noted improved performance in actions where the app encouraged communication with flight crew and ground medical support. The app helps ensure that the proper questions are asked of patients, which may yield more fruitful conversations with ground medical control and improve treatments administered. Effective communications with cabin crew and ground medical control are crucial so that ground medical control can advise the pilots on the need to divert for care. Such decisions are costly and affect the passengers on many levels [26].

The app both offers a cognitive aid similar to an Advanced Cardiac Life Support card, while simultaneously introducing an additional source of cognitive load [27,28]. We believe that certain actions or times could be positively or negatively affected by the app. For example, vitals or certain history or physical exam items might be delayed while the learner was reading the app. Although some reached statistical significance (auscultation favored control in the shortness of breath group), there was not a clear preponderance favoring the control group for these types of actions. The app makes it clear that high flow oxygen is indicated due to altitude, and we noted improvements in that choice. Similarly, we saw improvements in the supine positioning for the app group in the syncope case, which is prompted by the app. Overall, the app group completed a higher percentage of checklist items compared with the control group in both cases. However, we should caution that the app could delay times to basic physical assessment, including vital signs.

The literature has shown that checklists and GRS can be complementary [29]. GRS are sometimes better able to see subtle signs of expertise than checklists; however, checklists give raters very concrete items to view and thus may improve interrater reliability. In our study, we found that GRS did not show improved performance with the app in the shortness of breath case but did in the syncope case. Possible reasons for this include rating effects, practice effect with app (syncope case was always second), and additional preparation with the app during the approximately 10-minute break between simulation cases.

Limitations

Our limitations include the small amount of time learners interacted with the app before using it. We gave participants 15 minutes to familiarize themselves with the app, and chose this given average taxi-out times of 16.2 minutes [30]. Our simulation scenarios were relatively short at 8 minutes each, and extra time might have given either group a chance to meet missed checklist items. We did not control for the confounding variable of other app usage, and although we did not formally track this, we noted very little alternate health care app use. It is difficult to know how actual real-world performance would progress, but our gestalt was that the environment, cases, and witnessed performance were quite credible. Our relayed via cabin crew communication method for ground medical support was held constant and mimicked that found on many airlines, but there is no standard expectation. We expect changing technology and situational urgency will alter the method of communication. We also did not analyze for standardized participant effects, but we had nearly the same cohort throughout the entire project. We did not blind the raters because it was clear due to the app use in view. In hindsight, we could have given both groups the same device to create partial blinding. We anticipated a case order effect and we kept our case order the same for this reason. We did not take a G-theory approach to looking at the variability in case, case order, standardized participants, and raters, in part because sample size would have been prohibitively large. Our results are likely also subject to volunteer bias in that those who were more trained, able, and confident to perform likely self-volunteered for our study. Finally, our study focused on resident physicians; however, the electronic app being tested is also applicable to allied health professions or physicians some years out of residency training, which would make for an interesting future study.

Conclusion

We found that the use of a mobile phone app modestly improved performance of nonemergency resident physician participants during simulated in-flight medical emergencies. We caution that app use may delay or distract from basic physical assessments. The app improved participants’ confidence in in-flight medical emergency response more than simulation practice alone.

Future Directions

Future studies are needed to examine whether the app is used during real in-flight medical emergencies. It will also be interesting to examine the effect of introducing this electronic app to other health care professionals as well as attending physicians. Finally, we maintained the contents of our airline emergency kits as per Federal Aviation Administration guidelines; however, international flights may have considerable variations in medical kit contents. It might be useful to investigate the effects of different medical kits on the management of simulated in-flight medical emergencies.

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Conflicts of Interest

This work was conducted at Jump Simulation, a collaboration of OSF HealthCare and the University of Illinois College of Medicine at Peoria. The Illinois Corporation, AirRx, is a nonprofit foundation with 501-c3 status. AirRx owns the app, airRx, and supported the research by providing standardized patient meals and gift cards to participants. AirRx also received funds from the period of time when it was selling the app, which partially defrayed the costs of app development. The airRx app has subsequently become free on both Android and iOS platforms.

Multimedia Appendix 1

Overview of the airRx app.

[PPTX File, 992KB - mededu_v5i1e10955_app1.pptx]

Multimedia Appendix 2

CONSORT‐EHEALTH checklist (V 1.6.1).

[PDF File (Adobe PDF File), 114KB - mededu_v5i1e10955_app2.pdf]

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Abbreviations

AED: automatic external defibrillator
BP: blood pressure
COPD: chronic obstructive pulmonary disease
GRS: global rating scale
HR: heart rate/pulse
JITT: just-in-time training

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Original Paper

Data Collection Approaches to Enable Evaluation of a Massive Open Online Course About Data Science for Continuing Education in Health Care: Case Study

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Abstract

Background: This study presents learner perceptions of a pilot massive open online course (MOOC).

Objective: The objective of this study was to explore data collection approaches to help inform future MOOC evaluations on the use of semistructured interviews and the Kirkpatrick evaluation model.

Methods: A total of 191 learners joined 2 course runs of a limited trial of the MOOC. Moreover, 7 learners volunteered to be interviewed for the study. The study design drew on semistructured interviews of 2 learners transcribed and analyzed using Braun and Clark's method for thematic coding. This limited participant set was used to identify how the Kirkpatrick evaluation model could be used to evaluate further implementations of the course at scale.

Results: The study identified several themes that could be used for further analysis. The themes and subthemes include learner background (educational, professional, and topic significance), MOOC learning (learning achievement and MOOC application), and MOOC features (MOOC positives, MOOC negatives, and networking). There were insufficient data points to perform a Kirkpatrick evaluation.

Conclusions: Semistructured interviews for MOOC evaluation can provide a valuable in-depth analysis of learners' experience of the course. However, there must be sufficient data sources to complete a Kirkpatrick evaluation to provide for data triangulation. For example, data from precourse and postcourse surveys, quizzes, and test results could be used to improve the evaluation methodology.

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KEYWORDS

education, distance; education; teaching; online learning; online education; MOOC; massive open online course

Introduction

Background

Online learning in the form of massive open online courses (MOOCs) became internationally famous in 2011 when a Stanford University MOOC attracted learners from more than 190 different countries [1]. Although these courses have become heralded for their ability to attract a significant number of learners, their overall effectiveness is not well understood, especially considering most learners who start these courses do not finish them. MOOC evaluations can help analyze learning effectiveness and help improve their application [2]; however, there is a gap in the literature on MOOC evaluation methods [3]. Recent systematic reviews on MOOC research have concluded that there is a need for more research on methodologies used in MOOC research [4,5]. In addition, because of the diversity and heterogeneity of MOOCs, there is a need to focus on individual MOOCs and evaluate their effectiveness on a course level [6]. Current MOOC studies lack consideration of work-related skill development and organizational-level improvements [7]. A MOOC, especially one which focuses on practical skills development goals, should be assessed based on its quality of instruction, the inclusion of assessments, support of participation, instructional support, and enabling of continuous education [8]. Therefore, a MOOC evaluation should consider different aspects of the course instead of focusing on only limited aspects of learning.

Recent trends in MOOC research indicate there is an increase in using qualitative studies in MOOC research, which has been dominated by quantitative studies historically [7]. A quantitative approach tends to focus on course activity of the mass number of participants but without insight into individual activity. Qualitative methods and examination of individual learners provide contrasting data but are challenging to execute. Mixed-methods studies could enhance the methodological quality of this research by allowing for data triangulation from quantitative and qualitative data sources [4]. In addition, using more refined and sophisticated data collection and analysis methods such as interviews and focus groups and adopting thematic or social network analyses are highly recommended to improve MOOC evaluations [4]. There is a need for comprehensive and sophisticated data analyses methods to improve MOOC research.

Objectives

Health iQ created a pilot MOOC called “Data Science Essentials: Real World Evidence” with the aim to introduce learners to the concept of real-world evidence and demonstrate the application of these methods across various health care and life sciences industries [9]. As the online course was a pilot run, it had a limited trial audience. The target audience of the course was described as “undergraduate students in data science, an analyst or commercial manager working in life sciences pharmaceuticals, healthcare regulation, biotech and medical devices, especially those with an interest in the application of Information and Communication Technologies (ICT) within healthcare” [9]. In this investigation, we sought to explore the success of the course’s objectives regarding “reach” about intended audience and social networks, “efficacy” about knowledge/skill gain skill and attrition, and adoption and sustainability of social networks for continual learning in this emerging field.

The objective of this study was to trial data collection methods to inform course development and to reflect on evaluation methodology for future course runs. Although an initial goal of the study was to perform an overall evaluation of the course using the Kirkpatrick evaluation method, because of time constraints and lack of data, we were only able to perform thematic analysis of the semistructured interview data. The purpose of the study was centered on the way semistructured interviewing could be used to implement the execution of a Kirkpatrick evaluation. The purpose for establishing an evaluation model that could be used in future MOOC evaluations is to be able to address research questions centered on the course’s impact on learners knowledge, skills and attitudes, and its effect on learners’ work and workplace.

Methods

Overview

This section will first provide an introduction about the course being studied and give an overview of the participants, data collection, and the data analysis methods used. This study employed semistructured interviews to analyze learner perspectives. The interview data were analyzed using thematic analysis methods. The Kirkpatrick evaluation model was used to organize and structure themes identified from interviews. We have reported the study methods and results according to the Consolidated Criteria for Reporting Qualitative Research (COREQ) [10]. The completed COREQ checklist can be found in Multimedia Appendix 1. The study received ethical approval from the Education Ethics Review Process (EERP) at Imperial College London (EERP1617-030).

About the Course

Data Science Essentials: Real World Evidence was run twice, during August to September and October to November 2017. In total, 191 learners joined both runs of the course, where 56 were from the October cohort [11]. The course learning outcomes and facilitation have been described previously [11].

Participants

All course participants were invited to be interviewed for the study via email through purposive sampling. A total of 7 learners had expressed interest to be interviewed, out of which only 2 chose to participate following informed consent [11]. Participants who dropped out did not provide any reasons. Interviewed participants’ gender was 1 male and 1 female. Participants’ age was not recorded, but only adults older than 18 years were able to participate in the study. Both participants were professionals working in health care–related fields, a medical doctor working in the pharmaceutical industry and a health care economist working in a consultancy organization.

Data Collection

The interviews were conducted in December 2017 through conference calls [11]. Only the participant and interviewer were present in the interview [11]. An interview guide with the key topics and questions was used to help focus on the topics of interest. The guide included the interview questions and possible follow-up questions. Questions were centered on the participant’s background, reasons for taking the course, participant’s use of the learning in the workplace, participant’s interaction with other learners, and participant’s opinions about the different materials and tools used to deliver the course. Each interview lasted approximately 20 to 40 min and was audio recorded. Interview transcription was performed by the researcher as a way to start data familiarization [12]. The interviewees did not have any personal or professional relationship with anyone from the research team.

Data Analysis

Data analysis was completed by performing thematic analysis. Interview recordings were transcribed verbatim, anonymized, and analyzed [13-15]. The semistructured interview questions were grouped into 3 sections: learners' occupation and interests, learners' application of the learning, and learners' networking in the course. The participants were first asked about their background and their reasons for joining the course. The next questions were mainly focused on learners' behavior after the course. For example, learners were asked whether they were able to apply learning in their work or studies and whether the course affected their data analysis skills. Participants were also asked about their engagement with other learners and their engagement with the course, and their feedback about these aspects was collected to collect data about networking in the course. The primary author conducted the interviews and (a female research assistant with training in qualitative research) was the primary data coder. Thematic analysis of the data was carried out using Braun and Clarke's framework for thematic data analysis consisting of 6 phases: familiarization with data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and production of a report [13-15]. Revision and verification of the codes were carried out through discussions with the principal investigator in each phase of the coding.

Data management before coding included removing interview questions from the transcripts to keep the coder focused on the primary purpose of the research. Preliminary coding occurred through the transcription of the interviews, reading and rereading of the data, and systematically open coding the data [13-15]. Coding was performed manually using Microsoft Word, and preliminary codes were organized in an Excel sheet to be reviewed by the principal investigator. We have used inductive coding, meaning that the themes formulated were data-driven [16].

Thematic analysis is one of the most used methods in qualitative studies, and interpreting data by forming themes is "the most applicable" method of analysis for interview data [16]. Previous evaluations of educational and training programs have used thematic analysis for the interpretation of data such as interviews, surveys, and discussion posts [17-19].

Kirkpatrick Evaluation Model

The Kirkpatrick evaluation focuses on 4 levels of a training program: reaction, learning, behavior, and results [20]. This method could be used to evaluate participants' opinion about the course (reaction); whether the participants learned from the course (learning); whether they experienced any consequent changes in behavior (behavior); and how this impacted their studies, work, or broader community (results) [18]. Kirkpatrick evaluation provides a practical and systematic method for evaluating a training program, and it was used previously in MOOC evaluations [21-23]. The semistructured interviews can address some of the Kirkpatrick model's evaluation levels, but there is still a need for further data collection to fully validate the 4 levels of the model. In the following paragraphs, we describe the components of the model that could be covered using the semistructured interview data. Below we discuss the elements of the evaluation model that could be addressed by the semistructured interviews.

Level 1: Reaction

This level of the Kirkpatrick model evaluates participants' overall reaction to the course and their opinions about the delivery of the course. Information such as why the learners joined the course, what they liked or disliked about the course, and how much they have completed of the course could be reported in this level of the model.

Level 2: Learning

This level of the model evaluates learning gained from the course. It can evaluate how well participants acquired new information or new skills through the course.

Level 3: Behavior

This level of the model should evaluate the behavioral change that participants were able to adopt as a result of taking the course. For example, this level could evaluate whether participants were able to create change in their workplace as a result of taking the course, whether this change (if any) was sustainable, and whether they were aware of a shift in their behavior.

Level 4: Results

This level of the model assesses whether differences were made for the participants' workplace or organization as a result of the learning. This level of the model might be best evaluated after the course to allow time for the changes to occur.

Results

The thematic analysis resulted in the following themes: learner background, MOOC learning, and MOOC features [11].

Thematic Analysis Results

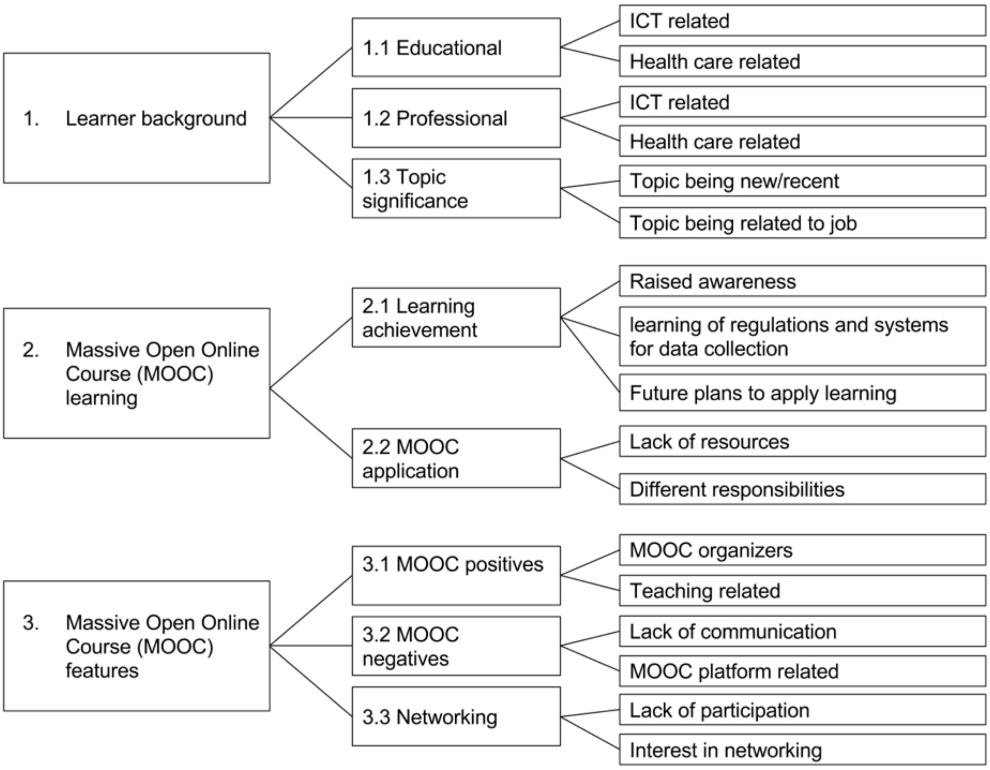
Analysis of the semistructured interview data gave rise to 3 central themes: learner background, MOOC learning, and MOOC features. Each of the themes and their subsequent codes from the thematic analysis of semistructured interview data (adapted from the study by Alturkistani et al [11]) are shown in Table 1. Figure 1 shows the themes, subthemes and codes developed through thematic analysis of interview data. Complete results of the thematic analysis can be found in Multimedia Appendix 2. The results were based on the 2 learners' responses. For that reason, it cannot be said that data saturation was reached; therefore, the study outcomes were limited to the view of the 2 learners only.

Table 1. Themes, subthemes, and codes from the thematic analysis of semistructured interview data.

Themes and subthemes	Codes
Learner background theme	
Educational	Information and communication technologies–related and health care–related
Professional	Information and communication technologies–related and health care–related
Topic significance	Topic being new/recent and topic being related to job
MOOC[a] learning theme	
Learning achievement	Raised awareness, learning of regulations and systems for data collection, and future plans to apply learning
MOOC application	Lack of resources and different responsibilities
MOOC features theme	
MOOC positive	MOOC organizers and teaching-related
MOOC negatives	Lack of communication and MOOC platform–related
Networking	Lack of participation and interest in networking

[a]MOOC: massive open online course.

Figure 1. Themes, subthemes and codes developed through thematic analysis of interview data. ICT: information and communication technologies.



Theme 1: Learner Background

Learners' educational background included undergraduate clinical medical training, a Masters in Economic Evaluation in Health Care, and Masters in Biostatistics, and their professional experience included working in the pharmaceutical industry and the health care sector and being involved with data science at work. The codes ICT–related and health care–related represent learners' educational and professional fields that were closely related to the course's field of interest, the intersection of ICT with health care.

Theme 2: Massive Open Online Course Learning

Participants expressed their learning through different methods such as expressing the different topics that they have learned through the course. They have also discussed how they were able or not able to apply learning in their work or studies.

Theme 3: Massive Open Online Course Features

Each participant had different opinions about what they liked and disliked about the MOOC and their experience in networking.

Reflection on the Kirkpatrick Evaluation Model

Level 1: Reaction

The reaction level of the model could be collected through the semistructured interviews. The participants' reaction to the course could easily be collected through the semistructured interview. Completion rates of learners could be collected through the interview but can also be recorded through the learning management system data, which can automatically report the completion rate of the different components of the course.

Level 2: Learning

Overall, it is possible to ask participants how much and how well they have learned in the course through the semistructured interviews. However, it may be useful to collect data through quiz or test scores, if possible, to triangulate and strengthen the interview findings.

Level 3: Behavior

It is possible to ask participants about the different behaviors they have changed as a result of taking a course. However, behavior change is one of the least studied outcomes in MOOC research, and it may be challenging to only record it through the semistructured interviews. When learners were asked if they have engaged in different projects as a result of taking the course, they have responded negatively. It may be useful to enhance the results of this level of the evaluation by collecting data through postcourse surveys possibly in 2 different time points, right after the course and 3 to 6 months after the course to allow some time for changes after the MOOC.

Level 4: Results

On the basis of the course description, the aim of the course was to teach learners how to "develop new methods for data analysis" and use of the data to "inform decision making in health care" [9]. Therefore, the potential impact of course would have been to demonstrate that new methods of data analysis were adopted and that the new data informed decisions in health care. The data for this level of the evaluation could be collected both through semistructured interviews and postcourse surveys.

Discussion

Principal Findings

This study gathered data to consider the use of semistructured interviews to inform a proposed evaluation method. Thematic analysis of semistructured interview data with learners of the pilot run of the course was completed to identify key themes for future development of the course. The Kirkpatrick evaluation model components were reviewed to assess whether semistructured interview data could help evaluate the course. The trial interview process revealed that the Kirkpatrick evaluation model could be used through the semistructured interview data in addition to other data sources such as surveys and quizzes. Semistructured interviews, while providing in-depth data about the learners' experience, may be a limited method to record objective data on things such as learning, behavior, and results.

A review of the recent MOOC literature (2013-2017) found that there is limited literature on studies focusing on learners' acquired practical skills from MOOCs [8]. In general, MOOC evaluations have not yet been able to measure the long-term impacts of MOOCs on learners [24]. However, the use of methods to measure course impact, including the Kirkpatrick evaluation model with its consideration of behavior change and results on the organizational level can help take learner skills and behavior change into account when evaluating the course. In a subsequent study, use of this method could be conducted by collecting pre- and postcourse surveys, quiz, and test results and possible discussion posts and triangulating this information with semistructured interviews data.

Our study's strengths are that it used qualitative data to assess the applicability of evaluating learning and skills of participants after the course. A recent systematic review (2018) of MOOC research recommended that methods such as interviews that offer an in-depth data of learner or participant experiences should be preferred to survey and "easily obtainable descriptive statistics" data [4]. It is believed that studying the success of an online learning course should focus more on the applicability of the information to the learners' day-to-day activities [25]. Our study suggests that evaluations should focus on how learning can affect that participant's behavior and work.

The limited qualitative data we collected informed us what factors need to be examined in more depth to evaluate the effectiveness of a MOOC and could help researchers consider factors beyond learners' knowledge to understand what can help improve the MOOC's applicability in real life. Future evaluations could include more data sources such as surveys, discussion posts, and quiz results when using the Kirkpatrick model [21] to increase the reliability of analysis. Furthermore, studies could use learning analytics data that are recorded through the host online course website of learners' use of the course (eg, login details and video viewing activity) to have a more comprehensive understanding of MOOC activity [26]. The main limitation of the study was the small sample size, which limits the generalizability of our study. The small sample size also meant that we were not able to fully address the study research questions. Due to the lack of data, we were unable to use any precourse measurements to compare participants' reaction before and after the course or report demographic information about the target population of the course. We also relied entirely on participants' self-reported data, which are subject to bias. However, this was a pilot study to inform our future course evaluations, and the limitations were taken into account when reporting the outcomes of the study.

Conclusions

The core themes that resulted from this study indicate that MOOCs could potentially be evaluated in terms of their impact on learners' behavior and skills acquired from the course through performing the Kirkpatrick evaluation. The study concluded that semistructured interviews can provide valuable, in-depth data about the course but should be used along with other data sources for data triangulation. Data sources such as pre- and postcourse survey data, quiz and test scores data, and possible discussion or social media thread posts could help create a comprehensive evaluation using the Kirkpatrick evaluation method.

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Authors' Contributions

The first author AA performed data collection and data analysis. Codes and themes resulting from the analysis were reviewed in discussions between AA and EM. EM provided feedback and oversight. AM, JC, DB, and GW reviewed the second and third drafts. AA incorporated and addressed the feedback from the authors. All authors approved the manuscript before submission. EM is the guarantor.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.

[PDF File (Adobe PDF File), 335KB - mededu_v5i1e10982_app1.pdf]

Multimedia Appendix 2

Thematic analysis results.

[PDF File (Adobe PDF File), 90KB - mededu_v5i1e10982_app2.pdf]

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Abbreviations

COREQ: Consolidated Criteria for Reporting Qualitative Research
EERP: Education Ethics Review Process
HEFCE: Higher Education Funding Council
ICT: information and communication technologies
MOOC: massive open online course

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Review

The Use of Social Media in Interprofessional Education: Systematic Review

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Abstract

Background: The implementation of interprofessional education (IPE) activities into health care education is a challenge for many training programs owing to time and location constraints of both faculty and learners. The integration of social media into these IPE activities may provide a solution to these problems.

Objective: This review of the published literature aims to identify health care IPE activities using social media.

Methods: The authors searched 5 databases (from the beginning coverage date to May 27, 2017) using keywords related to IPE and social media. Teams of 2 authors independently reviewed the search results to identify peer-reviewed, English language papers reporting on IPE activities using social media. They assessed the study quality of identified papers using the Medical Education Research Study Quality Instrument.

Results: A total of 8 studies met the review's inclusion criteria. Of these 8 papers, 3 had single-group, posttest-only study design; 4 had single-group, pre- and posttest design; and 1 had nonrandomized 3-group design. Qualitative and quantitative outcome measures showed mixed results with the majority of student feedback being positive.

Conclusions: Despite a need for additional research, this review suggests that the use of social media may aid the implementation of health care IPE.

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KEYWORDS

interprofessional education; interprofessional learning; medicine; nursing; social media, social networking

Introduction

The need to integrate interprofessional education (IPE) activities into health care education is a topic of growing importance. Members of the Interprofessional Education Collaborative, including national associations such as the American Association of Colleges of Nursing and Association of American Medical Colleges, value IPE and encourage institutions to create opportunities for health care trainees and practitioners from different disciplines to learn with, from, and about each other [1]. Although it is important to train health care professionals to work together effectively, many training programs have difficulty implementing IPE activities owing to schedule and location conflicts, lack of faculty support, and financial constraints [2].

The use of social media may provide a solution to many of the challenges inherent to IPE encountered by health care educators. Commonly used for personal social networking, social media tools provide a unique way for IPE learners to broaden their professional networks without the time and location constraints inherent to in-person networking [3]. In addition, these tools encourage a workforce prepared to adopt—with ease—new technologies for communication and care coordination [4]. Health care educators need to know the best ways to use social media in IPE to implement rigorous multidisciplinary learning. To address this gap in the literature, this review aims to identify papers describing studies of the use of social media in health care IPE and outcomes of social media use in IPE.

Methods

We searched the literature in 5 key databases (PubMed, Cumulative Index to Nursing & Allied Health Literature, Education Source, Education Full Text, and Academic Source Complete) from each database's beginning coverage date through our search date (May 27, 2017) for papers on the use of social media in health care IPE. The databases were selected because of their comprehensive representation of available peer-reviewed journals, as well as their dedicated scope in the relevant disciplines to this topic (eg, medicine, nursing, allied health, and education). Key search concepts were selected with their Medical Subject Headings terms and other controlled vocabulary equivalents, as well as related keywords—"social media" OR "social networking" AND "interprofessional education (IPE)" OR "interprofessional learning" (Multimedia Appendix 1).

We then transferred titles and abstracts identified by this search into a reference management system. Two authors (ANR and MSC) independently evaluated each abstract to determine whether the paper potentially met the following *a priori*-determined inclusion criteria: accessible full-text, English language, peer-reviewed journal, IPE learners, social media educational intervention evaluation, and focus on IPE. If either reviewer found the abstract to meet the inclusion criteria, the paper advanced to full-text review and its PDF version retrieved and attached within the reference manager. Two authors (ANR and MSC) then independently evaluated the PDF of each full-text paper for inclusion. If the paper did not meet the inclusion criteria, each reviewer specified the reason for exclusion. A third reviewer (MT) resolved discordant reviewer responses.

Two authors (ANR and MSC) independently extracted relevant data from the included paper. The original version of the Kirkpatrick Model was used to assess each study's outcome measures. Reviewers identified each study's Kirkpatrick hierarchy level [5] and, on the Web-based software platform Covidence.org, assessed the quality of each study using the validated Medical Education Research Quality Instrument (MERSQI) for Quantitative Studies [6]. Discordant reviewer responses for data extraction, Kirkpatrick hierarchy level, and MERSQI scores were resolved by consensus of the authors. Kirkpatrick's hierarchy was used to identify learning outcomes ranging from learner participation to changes in patient outcomes. In addition, Kirkpatrick's Learning Model evaluates training programs' impact on a hierarchy of 4 levels—perceptions (level 1) to outcomes (level 4). MERSQI scores were based on the study design, sampling, type of data, validity of an evaluation instrument, data analysis, and outcomes; scores could range from 5 to 18.

Results

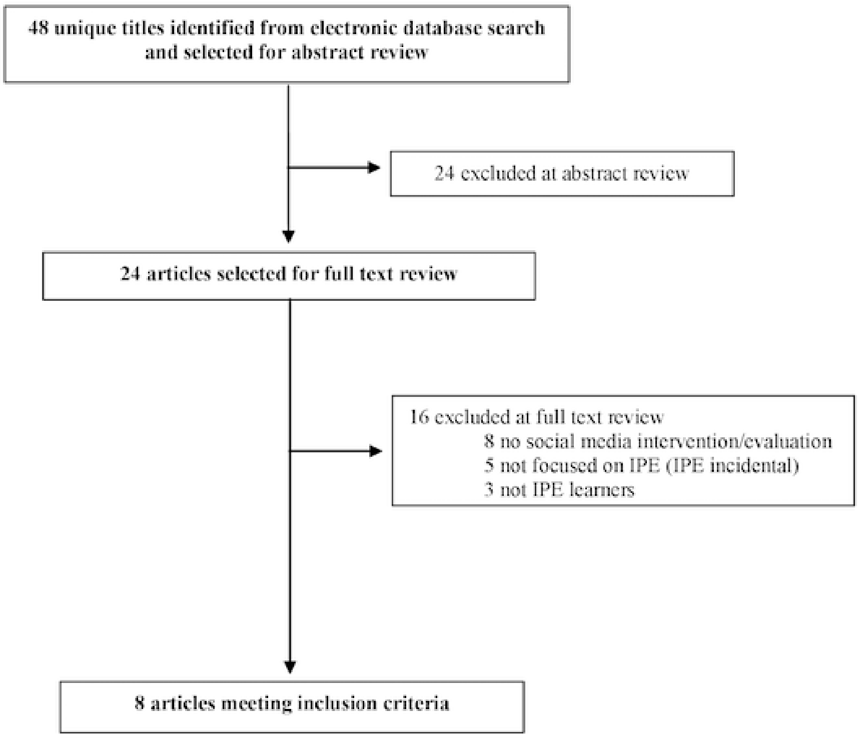
Our initial database search identified 48 unique titles, of which we selected 24 for full-text review (Figure 1). After full-text review, we determined that 8 papers met our inclusion criteria [2-4,6-11]. Of 8 studies identified by this review, 4 were single-group, posttest-only in design [3,4,10,11], 3 were single-group, pre- and posttest [7,8,9], and 1 was a nonrandomized 3-group study [2]. Multimedia Appendix 2 summarizes the results.

Study participants encompassed students from a broad range of professions as follows: nursing (7 studies), medicine (5 studies), pharmacy (5 studies), occupational therapy (2 studies), dentistry (2 studies), dental hygiene (1 study), physical therapy (1 study), radiography (1 study), and public health (1 study). A variety of social media tools and software were used as part of the educational intervention, with some studies using multiple tools as follows: blogs (2 studies), Wikis (2 studies), discussion boards (2 studies), Ning (1 study), and Second Life (1 study). Studies used quantitative (1 study), qualitative (4 studies), and mixed-method (3 studies) outcome measures. Most measured outcomes at the level of learner perceptions (5 studies), a few at the level of learner social media use behavior (3 studies), and none at the level of skills or patient outcomes. The included studies MERSQI scores ranged from 6 to 11.5.

The one single-group, posttest-only study that reported quantitative results found that 68% of students deposited information on (ie, contributed to) the Wiki, 42% edited the Wiki, and 20% visited the Wiki only to view content [10]. All remaining single-group, posttest studies reported qualitative results in the form of learner reflections. One study reported that students found the intervention to include respectful, engaging interaction among team members [3]. One study reported student reflections on learning, improvement, and innovations. These covered a range of topics, including culture, impact on practice, and module delivery [11], all of which received mixed student reviews. Furthermore, one study reported that the majority of student reviews were positive [4].

Of 3 single-group, pre- and posttest studies, only one compared learners' pre- and posttest on validated quantitative measures [Interdisciplinary Education Perception Scale (IEPS) and Readiness for Interprofessional Learning Scale (RIPLS)] [9]. We found no significant difference before or after the intervention (P>.10). Of the other 2 single-group, pre- and poststudies, one compared medical, nursing, and pharmacy students on quantitative social media use metrics and found significant differences in the duration of use in weeks 1, 2, and 4 between medicine and both nursing and pharmacy students (P<.05) [7]. In addition, 2 of the 3 single-group, pre- and posttest studies reported qualitative results [8,9]. One had all students respond to a postintervention survey instrument and found that they were fairly split on whether the intervention should be used again, although many students had positive remarks on the flexibility the intervention provided and the impact on their learning [9]. The other reported extremely positive feedback with all participants wanting to continue paired learning in their professional development [8].

Figure 1. The flow diagram of search methods and results of the review on social media use in interprofessional education.



Only one study, which received the highest MERSQI score, was designed to compare multiple interventions delivered to interprofessional groups of learners and found no significant differences in IEPS and RIPLS scores among the 3 groups, although no *P* value was reported [2]. In addition, these 3 groups did not significantly differ in their social media use metrics (the number of posts and time spent on site) showed (*P*=.47).

Discussion

Principal Findings

Many interprofessional learners are familiar with the personal use of social media, particularly the use of social networking sites. One study found that 90% of students used social media regularly, and many students report they engage in social networking despite a heavy academic load [9]. Social media tools, such as Facebook, Instagram, and Twitter, are often used for personal use with users developing informal personal networks [7]. Transitioning learners from personal to professional use of social media to establish interprofessional learning communities provides a unique path forward for IPE [7].

The included studies used a variety of methods to integrate social media into IPE activities and, thus, bring together learners from a wide range of health care disciplines. Paired learning, virtual simulation platforms, blogs, and Wikis were among the social media tools used. Health care educators developed IPE activities with the intention of increasing learner knowledge and clinical skills in an interprofessional environment. Competencies from the Accreditation Council for Pharmacy Education, American Association of Colleges of Nursing, and the Interprofessional Education Collaborative were considered in the development of learning activities [4,9]. The evaluation included qualitative and quantitative feedback, such as the IEPS and the RIPLS survey instruments [2], as well as pre- and postexperience survey instruments.

Feedback from learners was often positive, with many stating social networking activities provided a unique opportunity for collaboration, allowing them to gain unique perspectives from other disciplines in a flexible format [4,9,10]. Although most learners were more than willing to collaborate, some felt that the use of social networking platforms had a “laid-back” and less academic feel [9]. Creating social media activities embedded in core courses, containing practical or clinical purpose, and with adequate pedagogical supports are recommended [2].

Limitations

Although this review identified only a limited number of studies, this most likely reflects the emerging nature of the use of social media in IPE. More rigorous research on the effectiveness of social media tools, as well as future Web-based tools in IPE, needs to be conducted. A thorough discussion of this review in the context of IPE literature cannot be performed, as there are currently no published reviews on this topic. However, systematic reviews on social media use in medical and nursing education are available. The use of social media in these fields has been associated with improved knowledge, attitudes, and skills, as well as the promotion of learner engagement and professional development [11,12]. Although studies used a variety of social media tools, evidence as to which of these is the most effective in an IPE activity at improving learner behaviors and positively impacting patient outcomes is still lacking. Another limitation of this review is that the most updated version of the Kirkpatrick model (the New World Kirkpatrick Model) was not used, which may have affected the results.

Many studies in the review evaluated participant feedback rather than formally assessing the acquired knowledge. Although the papers mention the need to consider a variety of professional competencies in curriculum planning, limited information was available on how those learner competencies were evaluated. In addition, evaluation criteria were often informal and provided limited information on learning outcomes. The lack of consistency between methods used to evaluate learner outcomes is an inherent limitation of the review. Additional feedback, including how social media can be used to transform learning environments into a space that flattens professional hierarchical structure, would be valuable [2]. Moreover, information on how to engage and support faculty to create social learning experiences that have academic rigor would be helpful [13]. Although social media in IPE has been used to overcome time and space limitations, a gap in the literature exists on measurable improvement in overcoming these challenges.

Conclusions

This review provides valuable information on the variety of social media tools available and presents a good case for the use of social media to overcome many challenges with IPE learning activities, including schedules, meeting locations, and limited faculty and financial support. Overall, learner feedback was positive with many studies highlighting the flexibility of the learning environment. Although additional evidence is needed, these findings suggest that the integration of social media into interprofessional learning activities can be a valuable health care teaching method.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Search terms for review on social media use in interprofessional education (IPE).

[PDF File (Adobe PDF File), 21KB - mededu_v5i1e11328_app1.pdf]

Multimedia Appendix 2

Major findings and quality assessment of studies of social media use in interprofessional education identified by the review, grouped by the study design.

[PDF File (Adobe PDF File), 34KB - mededu_v5i1e11328_app2.pdf]

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Abbreviations

IEPS: Interdisciplinary Education Perception Scale
IPE: Interprofessional education
MERSQI: Medical Education Research Quality Instrument
RIPLS: Readiness for Interprofessional Learning Scale

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Viewpoint

Augmenting Flexnerism Via Twitterism: Need for Integrating Social Media Application in Blueprinting Pedagogical Strategies for Undergraduate Medical Education

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Abstract

Background: Flexnerism, or "competency-based medical education," advocates that formal analytic reasoning, the kind of rational thinking fundamental to the basic sciences, especially the natural sciences, should be the foundation of physicians' intellectual training. The complexity of 21st century health care requires rethinking of current (medical) educational paradigms. In this "Millennial Era," promulgation of the tenets of Flexnerism in undergraduate medical education requires a design and blueprint of innovative pedagogical strategies, as the targeted learners are millennials (designated as generation-Y medical students).

Objective: The aim of this proof-of-concept study was to identify the specific social media app platforms that are selectively preferred by generation-Y medical students in undergraduate medical education. In addition, we aimed to explore if these preferred social media apps can be used to design an effective pedagogical strategy in order to disseminate course learning objectives in the preclinical phase of a spiral curriculum.

Methods: A cross-sectional survey was conducted by distributing a 17-item questionnaire among the first- and second-year medical students in the preclinical phase at the Mohammed Bin Rashid University of Medicine and Health Science.

Results: The study identified YouTube and WhatsApp as the social media app platforms preferred by generation-Y medical students in undergraduate medical education. This study also identified the differences between female and male generation-Y medical students in terms of the use of social media apps in medical education, which we believe will assist instructors in designing pedagogical strategies to integrate social media apps. In addition, we determined the perceptions of generation-Y medical students on the implementation of social media apps in medical education. The pedagogical strategy designed using social media apps and implemented in the Biochemistry course was well accepted by generation-Y medical students and can be translated to any course in the preclinical phase of the medical curriculum. Moreover, the identified limitations of this study provide an understanding of the gaps in research in the integration of social media apps in a medical curriculum catering to generation-Y medical students.

Conclusions: 21st century medical education requires effective use of social media app platforms to augment competency-based medical education: Augmentation of Flexnerism in the current scenario is possible only by the adaptation of Twitterism.

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KEYWORDS

social media; medical education; twitter messaging; Web 2.0; curriculum

Introduction

Background

Abraham Flexner, a research scholar at the Carnegie Foundation for the Advancement of Teaching, shouldered the responsibility of pursuing an appraisal of medical education in North America, calling on all 155 medical schools in the United States and Canada. Flexner published his findings in 1910 in the form of a formal report. This report, generally referred to as the "Flexner Report," initiated a so-called "renaissance" in global medical education through the effectuation of "competency-based medical education," also known as "Flexnerism" [1]. Flexnerism advocates that formal analytic reasoning, the kind of rational thinking fundamental to the basic sciences, especially the natural sciences, should be the foundation of physicians' intellectual training [2,3].

Before the advent of Flexnerism, little to no attention was devoted to the idea of whether factual knowledge was required for the expansion of higher cognitive or metacognitive abilities or if the translation of this knowledge could be applied to patient care [4,5].

However, the complexity of 21st-century health care requires rethinking of current (medical) educational paradigms, since a sizeable majority of undergraduate and graduate medical trainees today hail from the "Millennial Generation," defined as persons born between the years 1982 and 2000 [6,7]. Millennials, also referred to as "digital natives" [8], the "instant messaging generation" [9], the "trophy kids" [10], and generation Y [11] are technologically informed, assertive, and, oddly enough, motivated by self-interest, yet intensely altruistic in sharing their personal information [12]. They are familiar with and able to integrate rapidly evolving technologies into every aspect of their lives. Therefore, generation Y medical students have a one-off outlook on education and different inclinations and expectancies than their forerunners [13]. Consequently, new pedagogical strategies need to be strategized, and the existing ones need to be fine-tuned or perfected, such that they can appeal to generation-Y medical students as well as concomitantly address the demands of the 21st century medical education paradigms. In other words, pedagogical strategies such as didactic teaching techniques need to be augmented by generation-Y medical student–centric pedagogical strategies and implementation milieus [14]. Thus, dissemination strategies of Flexnerism need to evolve and keep pace with the Millennial age Zeitgeist."

Social media apps refer to "websites and applications that enable users to create and share content, to interact with other users or to find people with similar interests." The term covers multiple platforms encompassing blogs/micro blogs (Twitter), Wikis, YouTube, and social network sites such as Facebook [15]. Integration of social media apps in pedagogical strategies for generation-Y medical students will not only address their learning needs but also appeal to the generation-Y medical students ' preferred learning style or strategy. The rationale for this is supported by the learning theory of connectivism.

Connectivism considers learning a multifaceted process catalyzed by technology and socialization [16]. The foundations of connectivism are fueled by chaos, connectivity, complexity, and self-organization theories. According to Downes, connectivism also finds its roots in connectionism, associationism, and graph theory [17]. The principles of connectivism, per Siemens [16,18], are as follows:

- Learning and knowledge rest in the diversity of outlook.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in nonhuman appliances.
- Capacity to know is more critical than what is currently known.
- Nurturing and maintaining connections are needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate and up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. Although there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.

Therefore, instructors, in a connectivist learning milieu, guide students to information (that can preferably be accessed with ease) and address queries as required, to encourage students' learning and sharing on their own accord through the creation of a learning community. Students are also spurred to seek out information on the Web, critique the information, and share their findings and opinions within the learning community that they have created.

Connectivism Through a Social Media App–Integrated Pedagogical Strategy

A working example of a pedagogical strategy founded on connectivist learning principles through social media apps targeting generation-Y medical students is presented below. In such a strategy, the instructor would perform the following tasks:

- Present the intended learning outcomes for a specific topic
- Conduct a short-didactic session to disseminate the baseline knowledge with regard to the intended learning outcomes
- Ask students to network and create a Learning Community using social media apps of their choice, where the instructor is also added
- Elaborate on the disseminated knowledge by directing students to social media app resources, where such information is available
- Encourage students to share and critique the information in the Learning Community using the social media app platform identified earlier
- Follow the discussion as a participant and address students' queries

However, with the plethora of social media app platforms available, it is essential to identify apps that should be employed in the design of generation-Y medical student–targeted pedagogical strategies. However, instead of instructors identifying a social media app for such a purpose, platforms preferred by the generation-Y medical students should be selected, *so that the creation of the Learning Community is facilitated and embraced*.

Study Landscape

We performed a proof-of-concept study at the College of Medicine and Health Sciences at the Mohammed Bin Rashid University (MBRU) to identify social media app platforms that should be employed/integrated in the design of generation-Y medical student–targeted pedagogical strategies as well as the perception of generation-Y medical students of the benefit of social media apps on different facets of undergraduate medical education. Our study involved students in the preclinical years, as this phase of undergraduate medical education in an integrated curriculum (refer below) builds up the corpus of knowledge that is translated to diagnosis and patient care in the clinical years. The obtained results primarily indicate that specific social media app platforms are preferred by generation-Y medical students in the undergraduate medical curriculum, integration of which in the design of pedagogical strategies will lead to favorable outcomes. We also present an example from the course of Biochemistry for undergraduate medical students at MBRU, where integration of social media apps in pedagogical strategies resulted in the positive feedback from generation-Y medical students.

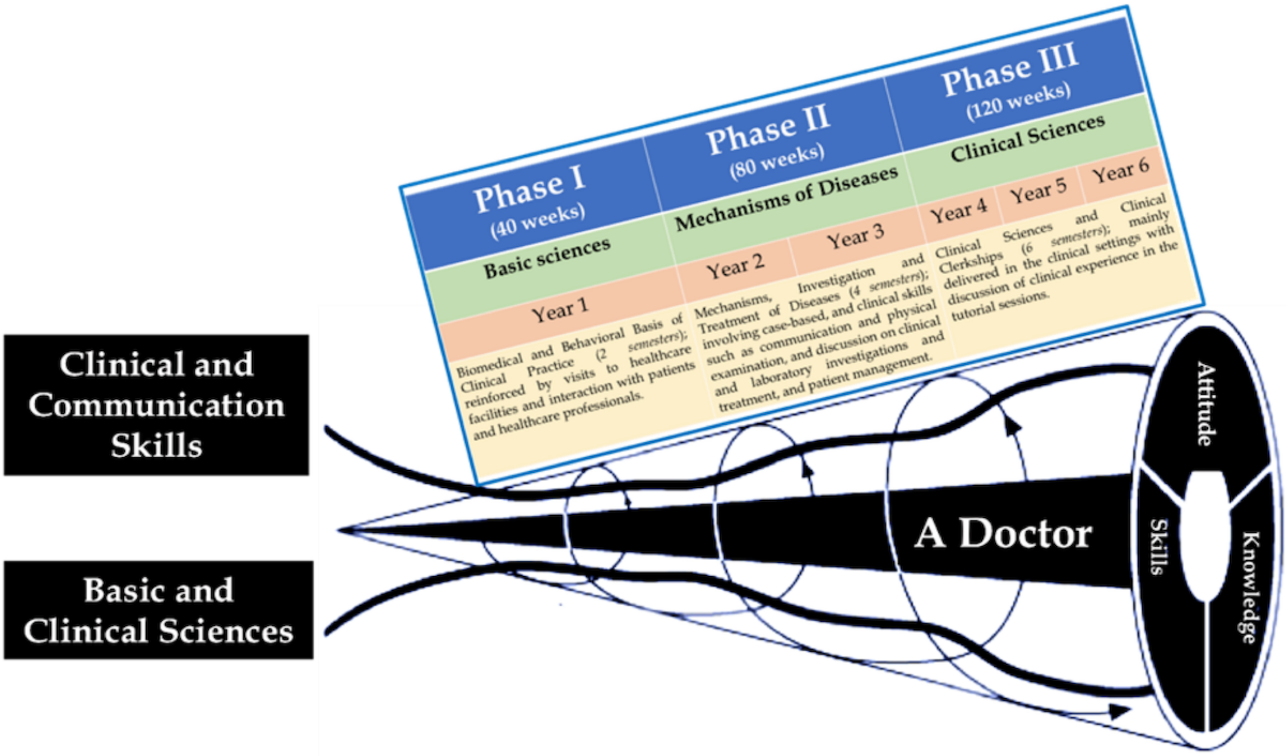
Methods

Study Milieu

MBRU is a new medical school, where the curriculum is founded on a competency-based educational model [19], in line with the tenets of Epstein and Hundert [20,21], and spans over 6 years. Therefore, the MBRU curriculum provides a milieu for a highly adaptive learning process rather than the traditional "one-size-fits-all curriculum" [22]. Furthermore, the MBRU curriculum aims to foster an erudition environment, where peer-assisted learning [23] and learning supported by social learning theories are facilitated.

The MBRU curriculum is divided into 3 phases (Figure 1). Each phase of MBRU's MBBS curriculum includes integrated courses and builds on the preceding one, such that the curriculum is "spiral" and the students repeat concepts pertaining to a subject, where with each successive encounter, concepts build on the previous one. (Figure 1).

Figure 1. The undergraduate medical curriculum at Mohammed Bin Rashid University of Medicine and Health Sciences. The curriculum is divided into three phases and spans over 6 years. Each phase of the undergraduate medical curriculum includes integrated courses and builds on the preceding one, such that the curriculum is a "spiral," and the students repeat the study of a subject, each time at a higher level of difficulty and in greater depth.



Hence, integration of social media apps in pedagogical approaches in such a curriculum is essential to facilitate and augment sharing of information, where learning will be guided by social constructivist principles of Dewey and Vygotsky, a variation of cognitive constructivism that emphasizes the need for collaboration in the learning process [24].

As our institution is in its third year of operation, where the preclinical phase is nearing completion, we believe it would be pivotal to identify social media app platforms preferred by generation-Y medical students as well as their perception on the use of generation-Y medical students in medical education, as courses can be updated to incorporate innovative pedagogical strategies where social media apps are used, such that future students benefit from this update.

Furthermore, the results of our study will benefit students in their clinical years, as the obtained results will allow instructors in the clinical phase to design innovative social media app–integrated pedagogical strategies to deliver the intended learning outcomes.

Approach

Data Collection

A blueprint of an online questionnaire was developed with cues from a questionnaire that has been used for a similar study, with modifications following gap analysis (see Table 1 for details and Multimedia Appendix 1 for the questionnaire) [25-27].

The study was approved by the institutional review board. Google forms were used to design the survey and collect data. The link to this form was distributed among the first- and second-year medical students in the preclinical phase of the curriculum at MBRU, through WhatsApp, Gmail, and Facebook Messenger, after obtaining prior consent from the participants between March 2018 and May 2018.

Questionnaire Design

The questionnaire was followed by an initial cover letter, which explained the purpose of the study to generation-Y medical students. It consisted of 17 questions followed by an optional comment section (overall response of the students to the comments section is summarized in Multimedia Appendix 2).

Table 1. Results of the gap analysis conducted through a literature review of seminal articles for designing the questionnaire.

Reference (year)	Title	Publication year	Abstract summary
Durga et al [28]	Social media: Portrait of an emerging tool in medical education	2016	The article examines social media use in medical education in commentaries and descriptive accounts versus evaluative studies to compare the relative prevalence of the two themes, challenges, and opportunities of social media in this context. The outcome reported a higher prevalence of challenges in commentaries and descriptive accounts.
Pander et al [29]	The use of Facebook in Medical Education	2014	This systematic review explicitly explores Facebook and its incorporation in Medical Education. Results indicate that most studies have looked into Facebook and digital professionalism. It has been well accepted among students for use for various learning interventions. Nonetheless, the study reports the absence of evidence to assess the effectiveness of Facebook as a learning method in advanced stages.
Hollinderbäumer et al [30]	Education 2.0—How has social media and Web 2.0 been integrated into medical education? A systematical literature review	2013	In this systematic literature review, the authors assessed how the combined use of social media and Web 2.0 has been implemented in medical education. It illustrated ways to enhance student reflection and allowed students to advance their knowledge.
Cartledge et al [31]	The use of social-networking sites in medical education	2013	This article focuses on the success rate of social media network sites in delivering educational content and determines if health care professionals and students utilize these sites for educational purposes. The article concluded that no professionalism issues arose with implementation of social networking sites and the study was received positively. However, it stated that there is not enough evidence to support the relative effectiveness of social networking sites over traditional methods.
Cheston et al [32]	Social media use in Medical Education: A systematic review	2013	This article aims to address the following questions: (1) How have interventions using social media tools affected outcomes of satisfaction, knowledge, attitudes, and skills for physicians and physicians-in-training? (2) What challenges and opportunities specific to social media have educators encountered in implementing these interventions? The results showed that implementation of social media contributed to enhanced outcomes of the elements mentioned in Question 1. The most common opportunity regarding implementation of social media was stimulating active learner engagement, and the most commonly faced challenge was technical issues.

The questionnaire focused on the different ways in which social media apps affect the education of medical students. These 17 questions can be classified into 4 groups:

1. *Group I questions* consisted of items that were related to students' consent and their personal information (year and gender).
2. *Group II questions* consisted of 5 questions related to the frequency of use of social media apps and the preferred social media app platform.
3. *Group III questions* comprised 7 questions regarding generation-Y medical students' perception about the effect of social media apps on their learning, communication, and association with regard to medical education.
4. *Group IV questions* included 2 questions in the questionnaire, which provided insight into generation-Y medical students ' awareness of the ethical issues associated with the use of social media apps.

The questionnaire was vetted by all the authors. Before circulating the questionnaire via the Google Forms Link, a mock Google Forms link was circulated to year 1 and year 2 generation-Y medical students at MBRU in order to ensure that their smart devices were compatible with the survey platform.

Respondents had to submit their responses before a specific deadline, which was set at 10 weeks after circulation of the questionnaire.

Statistical Analysis

Responses were drawn directly from Google Form into an Excel file. Descriptive statistical analysis was performed using Microsoft Excel (Version 14, Microsoft Corporation, 2010).

Results

Participants

A total of 75 MBRU students participated, of which 8 were excluded: 6 did not complete the questionnaire and 2 did not use social media apps in their education. Data collected from the remaining 67 students were further analyzed.

The study population included 48 female students and 19 male students, of which 61% (41/67) of the respondents were in the second year of medical school. In both year 1 and year 2, majority of the students (>69%) were female. This trend of having more female students in both year 1 and year 2 is not unusual. In fact, female students now outnumber male students in most medical schools in a ratio of about 3:2 [33].

However, despite this upturn in the number of female students, there are still insufficient women in some areas, especially clinical academia. The United Kingdom Medical Schools Council report of 2007 indicates that only 11% of the professorial staff in UK medical schools and 36% of clinical lecturers are women. The proportion of women decreases with increasing academic grade. An analogous situation exists in the United States, where only 15% of full professors and 11% of department chairs are women [34], despite of the fact that several recent studies of leadership indicate that women are good at inspiring others and virtuous team leaders [35]. In addition, women are not represented equally across the profession, especially in specialties necessitating more critical and on-call responsibilities and more technical skills [36]. Can this disparity be attributed to the way women learn, because positions associated with increased academic and administrative responsibilities require a more tailored pedagogical style specifically for the augmentation of metacognitive skills?

A study by Wehrwein et al showed that a majority of male students preferred multimodal instruction, specifically, 4 modes conveyed as “VARK”: visual (V; learning from graphs, charts, and flow diagrams), auditory (A; learning from speech), read-write (R; learning from reading and writing), and kinesthetic (K; learning from touch, hearing, smell, taste, and sight). In contrast, a majority of female students were tuned to single-mode instruction with a preference toward K [37].

Traditional pedagogical approaches such as the Sage on the Stage method involving didactic teaching cannot be tailored for preferential teaching/learning. However, a social media app–incorporated pedagogical approach can be tailored and moderated by both the instructor and learner . As the majority of our respondents are female, this study brings highlights the social media app preference of female generation-Y medical students, which, if suitably adapted in the design of pedagogical approaches, will cater to the learning needs/preferences of women in medical education, assuaging the gender disparity in the different domains of medicine in the long run.

Frequency of Social Media App Use by Generation-Y Medical Students for Medical Education

As shown in Figure 2, a majority (30/67, 45%) of generation-Y medical students used social media apps daily for their medical educational commitments. While designing the questionnaire, we assumed that by virtue of being generation-Y medical students, the participating respondents were regular users of different social media apps for noneducational activities (social interaction through group chat, blogging, information sharing, etc).

Therefore, our questionnaire focused on the use of social media apps by generation-Y medical students for educational purposes. The fact that there is a difference in the frequency of social media app use among the respondents in medical education most likely indicates a difference in their learning styles, which is common in medical schools and has been observed in other studies [38,39]. However, further elaborate studies need to be pursued to definitively confirm this conclusion.

The other aspect that may contribute to the observed difference is access to social media apps off-campus, because of various limiting factors such as restricted internet access and social pressure. However, as majority of our respondents spend 12-14 hours a day on campus (MBRU), where there is access to high-speed internet, we believe that the observed difference in the weekly use of social media app posits the likely differences in the learning styles of the respondents.

Social Media App of Choice of Generation-Y Medical Students for Medical Education

In the questionnaire (Multimedia Appendix 1), we asked generation-Y medical students about the use of 16 different social media apps in their medical education. Social media app platforms to be included in the questionnaire were chosen based on ease of access (determined from gap analysis using available literature; Table 1); platforms that are commonly used in the region; and compatibility with both desktop and electronic smart devices such as tablets, phablets, and smartphones.

We did not include modules related to the virtual learning environment or learning management system such as Moodle [40] (github.com/moodle/moodle), Blackboard (Blackboard Inc, Washington DC), or Sakai (Brock University, St. Catharines, ON) in our list because these modules are not as user-friendly as mobile instant messaging service apps such as WhatsApp in terms of hosting and moderating extended discussion sessions [41,42]. In fact, at MBRU, students and instructors regularly use D2L (D2L Inc, Kitchener, ON), where study materials such as slides and clinical cases to be discussed are uploaded by the instructor for the students to access and download. However, when it comes to sharing videos or pursuing a discussion with regard to a specific topic, especially in courses where social media apps are used as a teaching tool, students prefer the use of an mobile instant messaging service. This was confirmed by the authors informally. Moreover, before the study, one of the authors, who is a year 2 generation-Y medical student, informally enquired with the year 1 and year 2 students if they had access to at least one of the abovementioned electronic smart devices. All year 1 and year 2 students had access to one or more of the electronic smart devices.

Among the 16 social media apps platforms, YouTube and WhatsApp were the generation-Y medical students’ social media apps of preference for their medical education, as more than 50% of the respondents recurrently selected these social media app platforms (Figure 3).

Figure 2. The frequency of use of social media application by respondents in the study. The number of students in percentage is represented on the y-axis. The x-axis denotes the response selected by the generation-Y medical students. A=students using social media application once a week for their medical education; B=students using social medical application two times a week for their medical education; C=students using social medical application three times a week for their medical education; D=students using social medical application daily for their medical education (note: a total of 75 undergraduate medical students participated in this study, of which eight were excluded, as six of them did not complete the questionnaire and other two declared that they were not using social media application in their medical education).

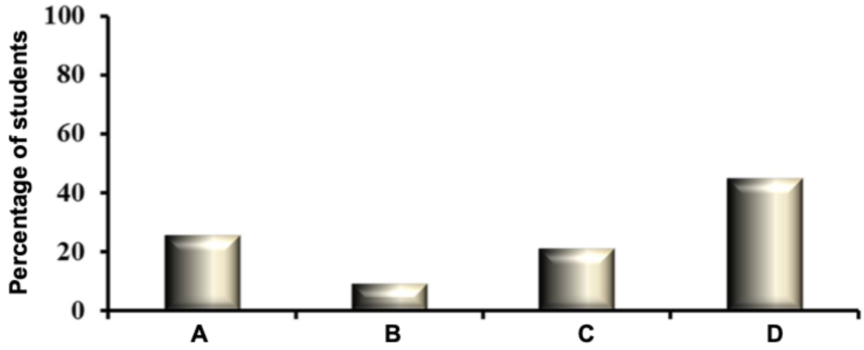


Figure 3. Comparison between different types of social media applications used by the students. Number of students in percentage is represented on the y-axis. x-axis denotes the response selected by the generation-Y medical students. (Note. YouTube was the most preferred social media application followed by WhatsApp among students).

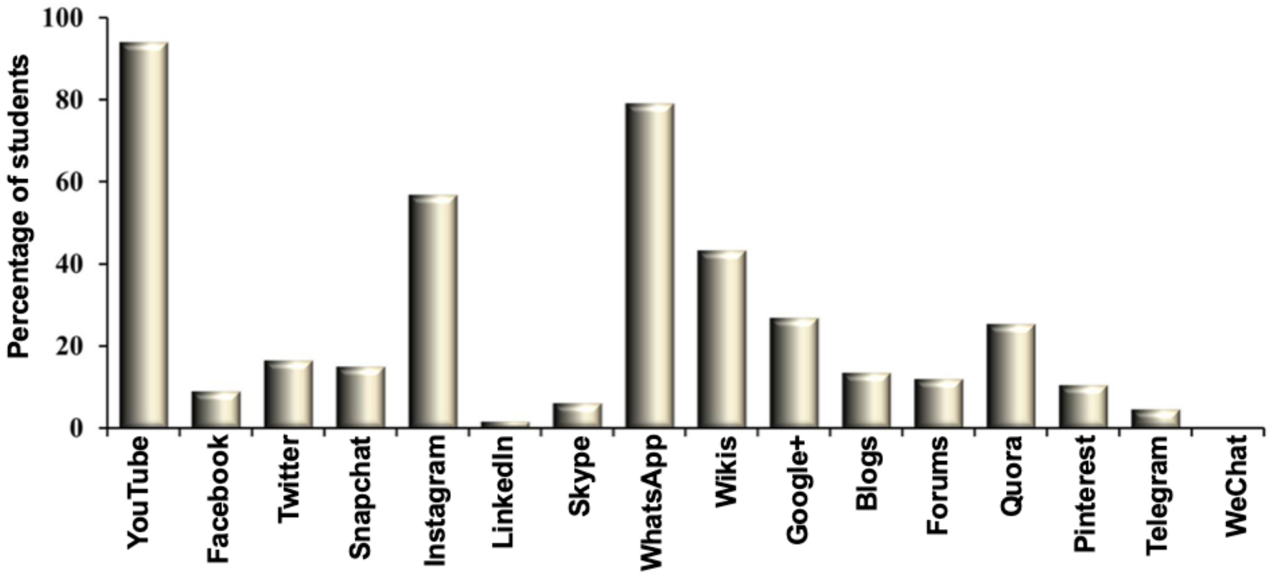
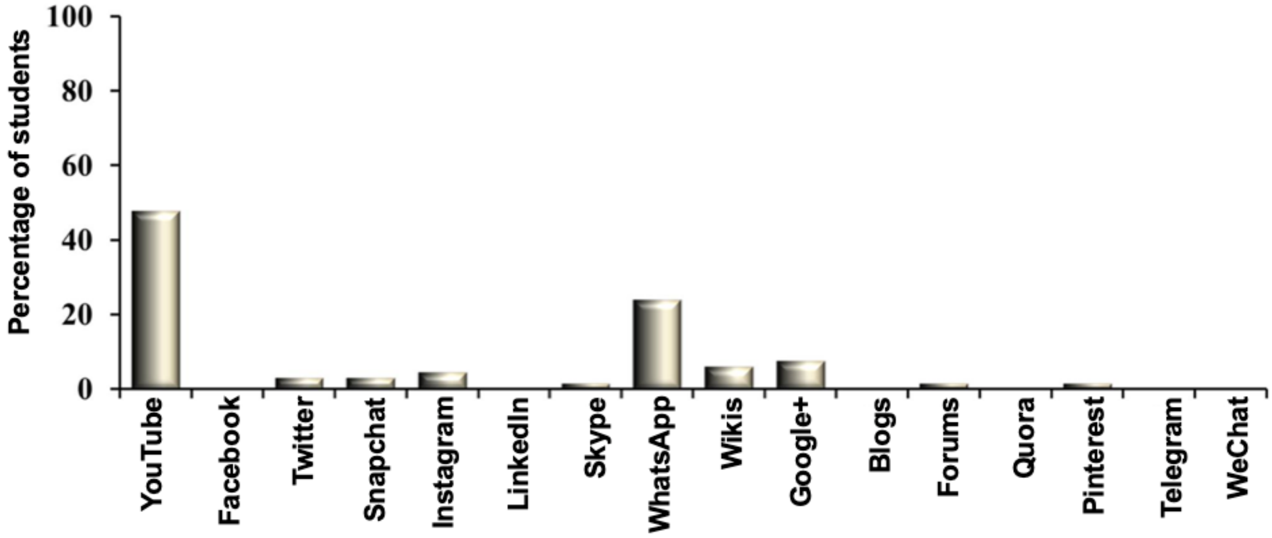


Figure 4. Frequency of use of a specific social media application platform in medical education by the generation-Y medical students.



We also investigated the frequency with which the respondents used a specific social media app. YouTube was the most preferred social media app, used most frequently by 48% of generation-Y medical students (Figure 4), followed by WhatsApp, which 23% of generation-Y medical students used in their medical education (Figure 4).

It is understandable that the use of YouTube is more frequent than WhatsApp. YouTube is the largest video-sharing platform on the internet, exceeding 1 billion users, with more than 300 hours of videos uploaded every minute [43]. Students in their preclinical years use it as a vital resource, in particular, for laying down foundations of basic sciences as well as obtaining insight into practical skills [44]. WhatsApp, on the other hand, is a platform for interactive discussion on a specific topic once the students are aware of the basic facts and figures pertaining to the topic [45].

The fact that generation-Y medical students exhibited a strong inclination to use YouTube provides a strong advantage to instructors who intend to integrate social media apps in teaching. It is well known that instructors delivering a traditional lecture with loads of content-heavy PowerPoint slides may confound what they teach with what students learn: The fact that an instructor has presented a specific segment of information does not necessarily mean that students have learned and assimilated that specific segment of information. In fact, cognitive load theory suggests that a learner's brain is restricted in the volume of information it can process at a time [46]. Due to these limitations, innovative pedagogical strategies have been introduced, one of which is the *Flipped Lecture* or the *Flipped Classroom* technique. In the Flipped Classroom technique, students prepare for class by performing prework outside the class, frequently in the form of a video lecture or screencast. They then attend a session to work out practice problems and important clinical cases, engage in group work, and gain know-how with researching answers in a mentored environment [47].

For a student, the *Flipped Classroom* technique provides a strategy, where learning is self-paced (one can go over a recorded lecture as many times as required) and promotes the development of metacognitive skills through group work and peer-assisted learning [48]. For the instructor, however, the *Flipped Classroom* technique requires extensive preparation, as the lecture material needs to be organized and the instructor then needs to record the lecture for which suitable facilities and equipment are required (which is not often the case, especially in medical schools with restricted funding). Furthermore, as medicine is an evolving science, one-time recording of lectures is not a practical solution. To resolve these limitations, YouTube provides a practical, cost-effective solution. One of the feasible strategies (elaborated below) is to direct students to specific YouTube videos related to specific content and then have small group discussions promoted through the use of clinical vignettes and scenarios. Such activities can be structured further through the use of instructional design strategies of Gagne and Peyton [49-53], as we have designed and successfully implemented recently in the preclinical phase at MBRU [54]. In brief, incorporating YouTube in designing pedagogical strategies can provide students with a learning experience similar to the *Flipped Classroom* technique, concomitantly easing implementation of social media apps in a course for the instructor. In fact, in a study comparing the content of standard textbooks, eMedicine (Medscape) articles, and YouTube videos on cardiovascular mechanism, Azer et al showed that YouTube videos surpassed not only on the user interface front but also the content and integration of information athwart molecular and clinical levels [55]. However, it is pivotal that the instructor vets a specific YouTube video before recommending it to students, as studies show that there are numerous videos on YouTube that are erroneous with no regulation of content [56].

Gender and Social Media App Preference

YouTube was the most preferred social media app among both male and female generation-Y medical students (Table 2).

Table 2. Preference of the 16 social media apps among generation-Y medical students.

Social media app	Female students, n (%)	Male students, n (%)
YouTube	23 (48)	9 (47)
Facebook	0 (0)	0 (0)
Twitter	2 (4)	0 (0)
Snapchat	2 (4)	0 (0)
Instagram	1 (2)	2 (10)
LinkedIn	0 (0)	0 (0)
Skype	0 (0)	9 (5)
WhatsApp	10 (20)	19 (31)
Wikis	4 (8)	0 (0)
Google+	5 (10)	0 (0)
Blogs	0 (0)	0 (0)
Forums	0 (0)	1 (5)
Quora	0 (0)	0 (0)
Pinterest	1 (2)	0 (0)
Telegram	0 (0)	0 (0)
WeChat	0 (0)	0 (0)

However, more diversity in the use of social media apps was observed in the female population, where the use of 8 of the 16 social media apps (YouTube, Twitter, Snapchat, Instagram, WhatsApp, Wiki, Google+, and Pinterest) was observed, whereas the male population used only 5 of the 16 social media app platforms (YouTube, Instagram, Skype, WhatsApp, and Forums).

Studies have shown that gender differences exist and affect how individuals engage in day-to-day activities. In fact, significant gender differences are observed between how men and women adopt and use technology [57,58]. A study by Chun has shown that women generally make comments and contributions that are more descriptive and lengthier when expressing themselves for knowledge management over different social media app platforms. Furthermore, women more frequently attempt to associate and integrate existing knowledge with the knowledge that they obtained during online discussions, thus creating new knowledge. The study also showed that the reason for the elaborate and more detailed responses by women can be attributed to their social assertiveness, establishing relationships and networks with other users of social media apps for knowledge management, thereby establishing a comfortable knowledge-sharing milieu with users with whom they had an established relationship [59]. Therefore, the use of social media app modules such as Snapchat, Instagram, and Pinterest is more common in women, as these modules support networking through elaborate discussions.

This finding has significant ramifications with regard to medical education in the region. Many medical schools, especially those in Saudi Arabia, have separate pedagogical sessions for male and female students [60]. On the basis of our findings, it can be concluded that a more diverse social media app–integrated pedagogical approach may appeal more to women than to men.

Generation-Y Medical Students' Perception of the Use of Social Media Apps in Mohammed Bin Rashid University

Generation-Y medical students' perception of the use of social media apps at MBRU was investigated using three items (Figure 5). These items were polar questions requiring the respondent to indicate Yes or No, in line with one's perception.

Effect of Social Media Apps on Communication Between Generation-Y Medical Students and Instructors

Only 37% of generation-Y medical students communicated with their instructors using social media apps (Figure 5). Most of the students used social media apps for their studies (Figure 3) on a frequent basis (Figure 2); the observed decrease in use may be because of the "digital divide" existing between generation-Y medical students and instructors, which has been observed in other studies as well [61,62]. Interestingly, more female than male students used social media apps to communicate with instructors (Table 3), which is in line with the social assertiveness of women elaborated above.

Students' Perception of Institutional Use of Social Media Apps and Their Ethical Awareness

Most generation-Y medical students (91%) indicated that the institution was employing social media apps for supporting their education (Figure 5). As patient-centered health care, social media, and the internet are closely associated in health care in the 21st century [63], we decided to investigate if generation-Y medical students are aware of ethical issues such as confidentiality and privacy, associated with the use of social media apps. Most generation-Y medical students (49/67, 73%) provided a positive response. However, as ethics is a critical domain in medicine and health care, we believe that instructors should stress on this aspect before engaging students in social media app–driven pedagogy. This conclusion is also stressed upon because in the questionnaire, we included an item, "Do you think it is important to have ethical guidance for using social media as medical students?" for which the majority of generation-Y medical students requested further guidance (Figure 6).

Furthermore, when we grouped ethical guidance awareness of generation-Y medical students according to gender (Table 4), we found that more female than male students were aware of the ethical considerations associated with social media app use. This may be because of the increased social assertiveness exhibited by female generation-Y medical students, as observed and elaborated above.

Generation-Y Medical Students' Perception of the Effect of Social Media Apps on Medical Education

To assess generation-Y medical students' perception on the effect of social media apps on medical education, we included 7 items in the questionnaire in the form of Likert scale questions (Figure 6). As indicated earlier, as ethical considerations associated with the use of social media apps are important, one of these 7 items reconfirmed if the generation-Y medical students required further guidance on the use of social media apps in medical education. Majority of the generation-Y medical students responded positively (Figure 6). This observation supports our abovementioned affirmation regarding instructors providing a preamble to generation-Y medical students about the ethical contemplations associated with the use of social media apps in medical education and health care.

Effect of Social Media Apps on Teaching and Learning

Item 8 in the questionnaire explored generation-Y medical students' perception about whether social media apps influenced teaching and learning positively. Majority (91%) of the generation-Y medical students concurred that social media apps constructively affected their scholarship. On categorization of responses according to gender, no significant difference was observed between female and male students (Table 5). This alludes to our early certitude of "digital divide," although both female and male generation-Y medical students used social media apps regularly (Figures 2 and 3) and considered social media apps to benefit their erudition (Figure 6). As compared to male generation-Y medical students, female students interacted with instructors more often using social media apps, because of the latter's higher and diverse electronic social presence (Table 2).

Figure 5. Generation-Y medical students' perception about the use of social media application in the institution.

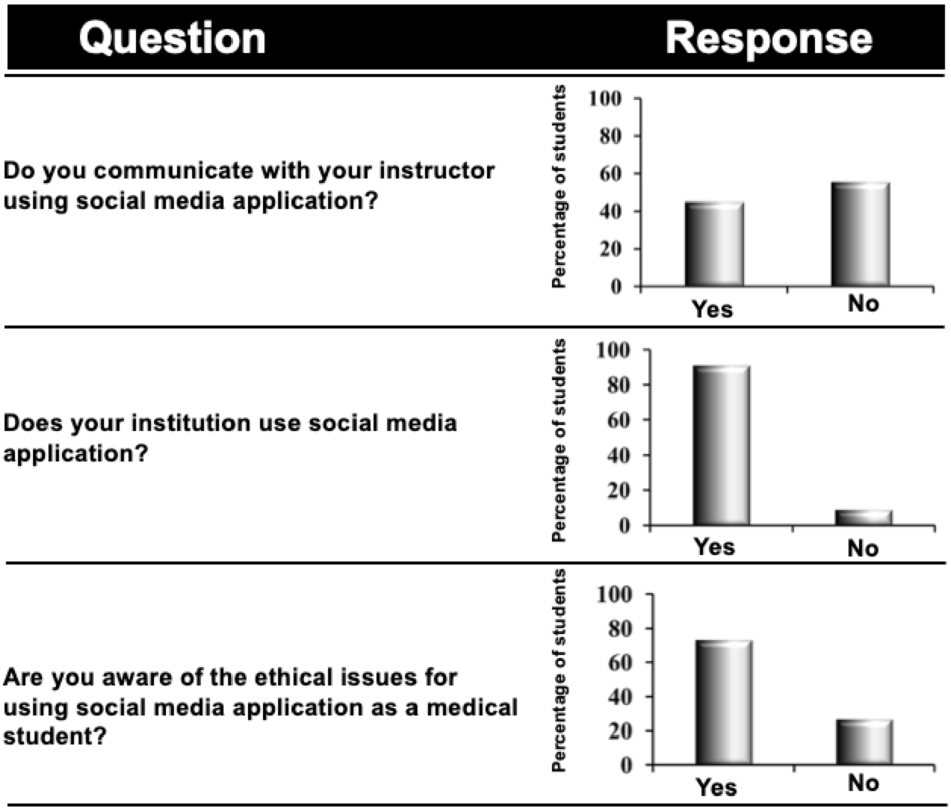


Table 3. Gender preference in the use of social media apps for communication between generation-Y medical students and instructors.

Response	Female students, n (%)	Male students, n (%)
Yes	23 (48)	7 (37)
No	25 (52)	12 (63)

Figure 6. Response of generation-Y medical students to the Likert-scale questions used in the study.1=Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree.

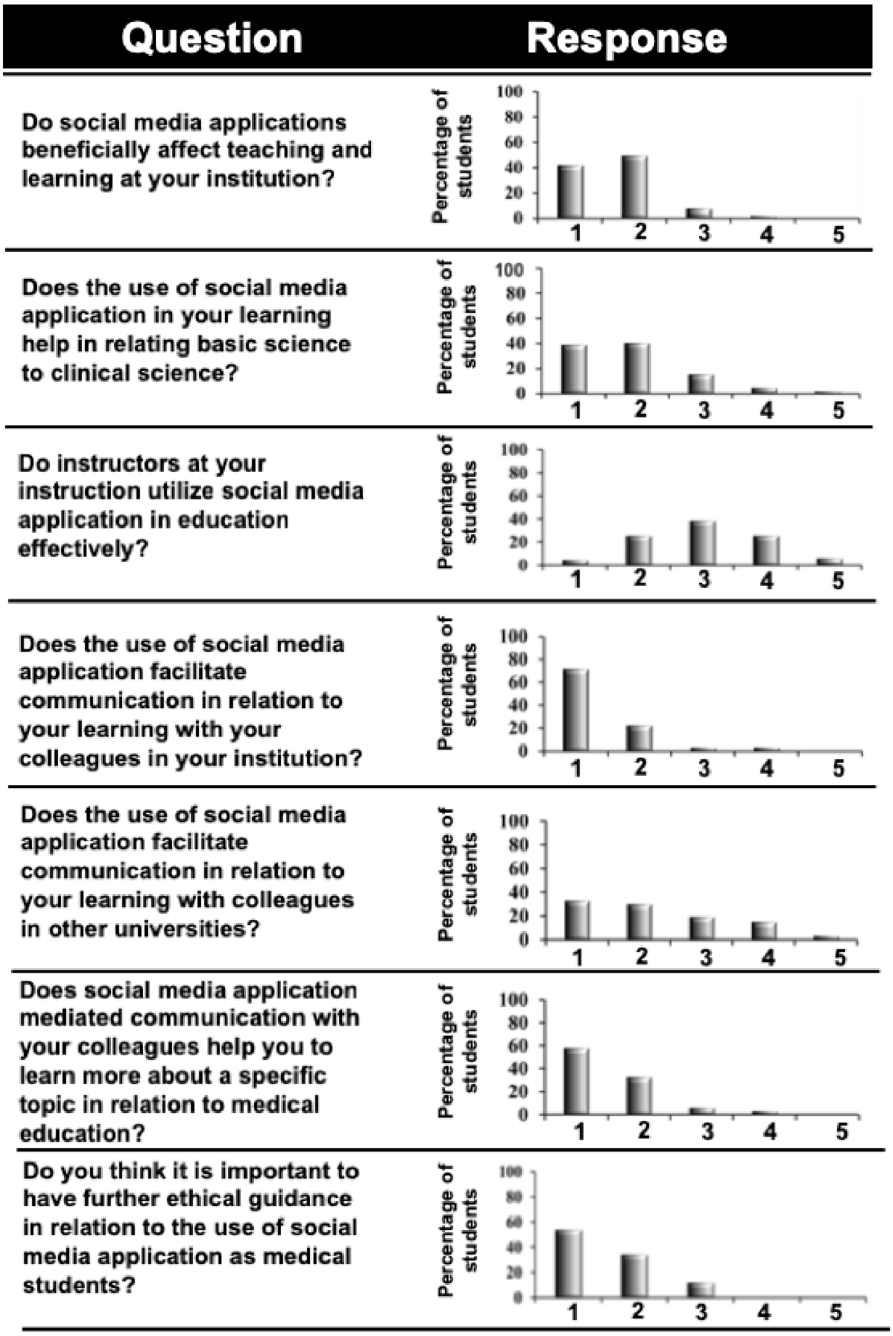


Table 4. Ethical guidance awareness associated with the use of social media apps, categorized according to gender.

Response	Female students, n (%)	Male students, n (%)
Yes	38 (79)	11 (57)
No	10 (21)	8 (43)

Interestingly, 5.3% of male generation-Y medical students perceived social media apps to have a detrimental effect on teaching and learning. “Digitally Shy” learners have been found to learn better when they are able to visually assert the expressions (facial expressions, body language, etc) of the instructor/fellow student during the learning process; in other words, these students learn better when they are emotionally involved [64]. Although a small proportion of generation-Y medical students in our study belong to this category, specific measures should be implemented to cater to the learning needs of such students. One of the ways is to blend social media app–integrated pedagogy with small-group teaching using team-based or problem-based approaches.

Generation-Y Medical Students' Perceptions of the Effect of Social Media Apps on Bridging the Basic Science-Clinical Science Divide

One of the key aspects of Flexnerism is that conventional basic sciences are considered the foundational sciences upon which the groundwork for medical practice is centered. The beneficence of the basic sciences to the so-called "ontogenesis of the medical practitioner" goes beyond mere accretion of factual information and serves to inform the critical thinking and decisional framework. In fact, clinical medicine is based upon the identification, categorization, and subsequent management/treatment of abnormal physiology (pathophysiology). However, most often, the pedagogical techniques employed in meeting the learning objectives of the basic science courses fail to identify strategies that can integrate these "facts and figures" to rationally solve clinical problems presented by patients, although they motivate students to rote memorize a corpus of clinically relevant "facts and figures." Does the use of social media apps by generation-Y medical students in medical education bridge the so-called "Basic Science-Clinical Science divide"? As indicated in Figure 6 and Table 6, a majority of respondents concurred that the use of social media apps helped in relating basic science to clinical science. Approximately 20% (13/67) of both female and male students found that the use of social media apps did not facilitate bridging the basic science-clinical science divide. This may be attributed to the type of social media app platforms that these students used for their medical education as well as the different learning styles of students in a medical school [65].

Generation-Y Medical Students' Perception of Instructors Integrating Social Media App in Teaching

One of the items in the questionnaire enquired about generation-Y medical students' perception of integration of social media apps by instructors at MBRU while teaching. A mixed response was observed (Figure 6). To obtain a better insight, we grouped the responses according to gender, where also a similar trend was noted (Table 7). MBRU is a nascent institution, and many of the faculty members, especially in the basic sciences, do not have extensive teaching experience, which may account for the low use of social media apps platforms in teaching. In addition, junior faculty members are often under pressure of clinical and research productivity, and as such, are un able to invest adequate time for the development of innovative pedagogical strategies. Our observations are in line with the results of Kim et al [66]. The other reason that may account for the mixed response may be attributed to faculty members' lack of understanding of how generation-Y medical students employ social media apps platforms in medical education, which may hinder integration of the generation-Y medical students–preferred social media app platforms in their pedagogical strategies/techniques, in turn creating a so-called "digital divide" between the generation-Y medical students and faculty members. Often, pedagogical approaches of instructors affect students' learning approaches [67]. Trigwell et al found that in classes where instructors portrayed their method to pedagogy as transferring knowledge, students were more likely to report surface learning approaches [68]. However, in a student-centered curriculum (as the one at MBRU), students have more responsibility toward their own erudition (what and how) [69]; therefore, pedagogical approaches that appeal to generation-Y medical students need to be designed. Both the above aspects indicate the need for a streamlined faculty-development program. One effective way will be to institute a faculty mentorship program per one of the models proposed by Lancaster et al [70].

Table 5. Generation-Y medical students' perception of the effect of social media apps on teaching and learning.

Response	Female students, n (%)	Male students, n (%)
Positive (strongly agree and agree)	44 (92)	17 (90)
Neutral	4 (8)	1 (5)
Negative (strongly disagree and disagree)	0 (0)	1 (5)

Table 6. Generation-Y medical students' perceptions of the role of social media apps in connecting basic science to clinical science.

Response	Female students, n (%)	Male students, n (%)
Positive (strongly agree and agree)	38 (79)	15 (79)
Neutral	7 (15)	3 (16)
Negative (strongly disagree and disagree)	3 (6)	1 (5)

Table 7. Generation-Y medical students' perception of instructors integrating social media apps in teaching.

Response	Female students, n (%)	Male students, n (%)
Positive (strongly agree and agree)	13 (27)	7 (37)
Neutral	21 (44)	5 (26)
Negative (strongly disagree and disagree)	14 (29)	7 (37)

Generation-Y Medical Students' Perceptions of the Use of Social Media Apps for Augmenting Peer-Assisted Learning

Peer-assisted learning propositions a valuable technique to augment the learning experience in medical school [71] and has been shown to remedy areas of weakness in knowledge and competencies, deliver a safe milieu for practice and strengthening of curriculum content, and nurture a sense of community among junior and senior peers [72]. Furthermore, peer-assisted learning is an efficient approach to engage students beyond a superficial level [73]. This "deep" approach to pedagogy is largely due to the aim of peer-assisted learning, which should be supplementary to, rather than separate from, existing pedagogical strategies [74]. The method is further aided by the ability of this approach to be more interactive [75], more targeted toward identified areas of interest or weakness [76], and less authoritative than traditional pedagogical strategies. What strengthens these characteristics of the teaching process is the superior understanding that senior peers have of the learning requirements and competencies of junior students as well as the curriculum and assessment necessities, compared with highly trained and veteran senior consultants. This propinquity in understanding defines the valuable social and cognitive analogy that senior students offer. This may contribute not only to students' appreciation of being trained by peers [77] but also to the critical mass and depth of learning achievable by a student when provided with suitable instruction, as indicated by Vygotsky's Zone of Proximal Development [78].

In line with the abovementioned benefits of peer-assisted learning, we wanted to assess generation-Y medical students' perspectives of whether social media apps augment peer-assisted learning in their medical education. Almost all students (both male and female; Table 8) strongly agreed that social media app platforms assisted them in their learning process by instituting an effective channel of communication between them and their colleagues. However, few female students disagreed on this aspect (Table 8). This may be attributed to social loafing, which is often observed in collaborative group activities/discussions [79]. However, further research is essential to determine whether instances of social loafing are observed in peer-assisted learning in undergraduate medical education as well as the effects of social loafing during peer-assisted learning on students' performance and whether this occurs across a range of group sizes.

Generation-Y Medical Students' Perception of the Use of Social Media Apps for Networking

Networking is an essential aspect of medical practice. In fact, doctors typically refer their patients to specialists that they know, creating an unofficial network. These so-called "informal networks" are pivotal to the excellence and cost of care that a patient receives from any individual doctor, hospital, or medical group. In a study employing 987,000 Medicare beneficiaries aged 65 years or older [80], across five states—Ohio, Pennsylvania, Tennessee, Washington, and Wisconsin—in the United States, Lawrence et al aimed to identify physician networks; to determine whether the rate of ambulatory care-sensitive hospital admissions varies across networks, even different networks at the same hospital; and to examine the relationship between ambulatory care-sensitive hospital admission rates and network characteristics.

The study identified 417 such informal networks, with a mean size of 129 physicians, and found that the rate of ambulatory care-sensitive hospital admissions (ie, potentially avoidable admissions of patients with chronic diseases such as congestive heart failure and asthma) varied significantly across the networks. Thus, it is essential to highlight the importance of effective networking to medical students.

As social media app platforms augment networking between generation-Y medical students at MBRU in relation to their medical education, we aimed to investigate if such networking was founded/strengthened between generation-Y medical students at MBRU and those at other universities as well as to appraise whether social media app platforms can be an effective mode for establishing informal networks among generation-Y medical students across different curricula. A mixed response was observed: The response varied widely between male and female students (Table 9).

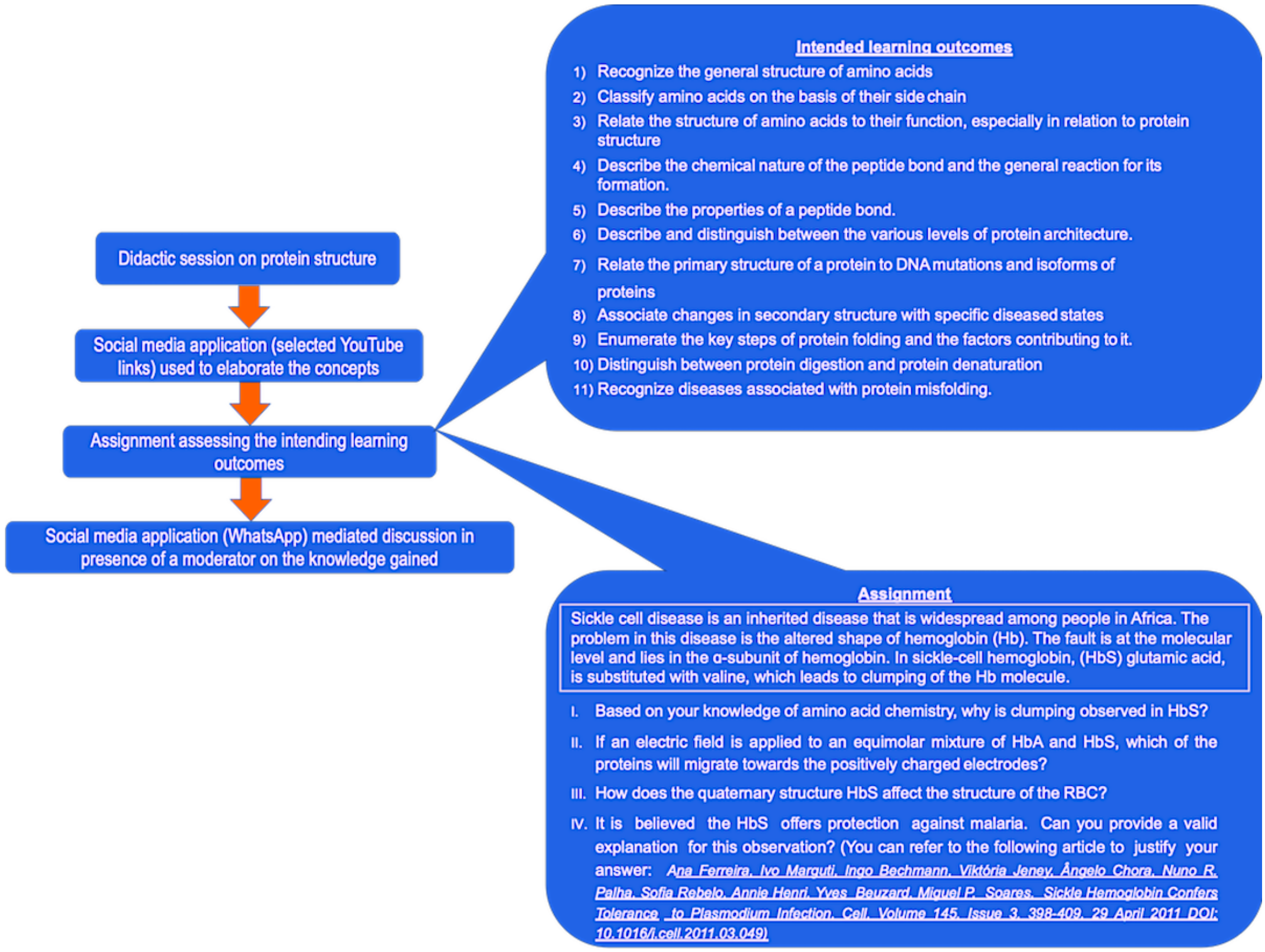
Table 8. Generation-Y medical students' perceptions of the use of social media app for intrauniversity communication.

Response	Female students, n (%)	Male students, n (%)
Positive (strongly agree and agree)	45 (94)	18 (95)
Neutral	1 (2)	1 (5)
Negative (strongly disagree and disagree)	2 (4)	0 (0)

Table 9. Generation-Y medical students' perceptions of the use of social media apps for interuniversity communication.

Response	Female students, n (%)	Male students, n (%)
Positive (strongly agree and agree)	40 (58)	14 (74)
Neutral	14 (21)	3 (16)
Negative (strongly disagree and disagree)	14 (21)	2 (10)

Figure 7. An example of social media application mediated delivery of a topic in biochemistry.(Note, the strategy for the delivery was designed using the social medial applications preferred by generation-Y medical students).



The number of female and male students effectively using social media apps to communicate with their colleagues in other universities was 58% and 73%, respectively. The primary reason for such a diverse response may be attributed to the fact that as MBRU is a new institution in the region, it still does not have an established digital footprint to initiate a focal point for establishing informal networks.

Moreover, the reason for a greater proportion of males using social media apps effectively for interuniversity networking (Table 9) may be that at MBRU, most of the male students are from countries outside the United Arab Emirates; hence, these students may be networking with their peers in medical schools from their countries of origin, to discuss various facets of medical education. Thus, dedicated research is required to provide more detailed insight into this aspect.

Simple Strategy to Employ Social Media Apps in Pedagogy

In this study, we also delineated a simple strategy to implement social media apps in a pedagogy of generation-Y medical students. We employed a social media app–integrated pedagogical strategy to deliver the intended learning outcomes with regard to the topic *Amino Acids and Protein Structure* in the course of Enzymes and Metabolism, which is a 3-credit Biochemistry course in the undergraduate medical curriculum at MBRU.

The entire cohort of 45 students registered for the course, which spanned over 15 weeks, in which the *Amino Acids and Protein Structure* topic was delivered over a period of 3 weeks. Figure 7 demonstrates the steps used to integrate social media apps in disseminating information on the topic. A didactic session of 20 min was used to deliver the intended learning outcomes pertaining to the *Amino Acids and Protein Structure* topic (Figure 7).

The students were then guided to online resources (YouTube videos) selected by the instructor to further expatiate on the topic and were provided with an assignment on sickle disease (Figure 7), for which relevant items were used to assess the intended learning outcomes.

The assignment was part of the formative assessment of the course and was graded using a defined grading rubric. As the students prepared the assignment, queries and doubts were addressed in a discussion group established on a social media app platform (WhatsApp). Students had the liberty of adding a participant to the group; however, the discussion threads were monitored by the instructor. Following the completion of the assignment, general feedback was provided to the entire cohort through the discussion group.

Although the strategy still needs to be formally evaluated, the Enzymes and Metabolism course received a positive feedback from the cohort, with approximately 93% of the students strongly supporting the teaching style. Furthermore, in informal interactions with the instructors, the students indicated that integration of social media apps in teaching Biochemistry facilitated a better understanding of the delivered concepts.

Discussion

Limitations and Future Directions

Our study has a few specific limitations that are discussed below:

We used a prevalidated questionnaire [25] with minor modifications. However, MBRU caters to students from 19 different nationalities from different high school curricula. Therefore, it would have been ideal to develop a questionnaire following a needs-assessment study. An educational needs assessment can be defined as the gap between “what is known” and “what should be known” [81]. We performed a general needs assessment using *gap analysis* [82] through a literature review of seminal articles. Our search identified five recent systematic reviews investigating the use and role of social media apps in undergraduate medical education (Table 1). Observations from these systematic reviews were used for modifying the prevalidated questionnaire (Multimedia Appendix 1). However, since our study was a proof-of-concept study, it lacked a needs assessment of targeted learners.

One of our future goals is to employ one of the consensus methods—nominal group technique or Delphi Technique—to develop a framework for needs assessment of targeted learners. Both these methods intend to attain a concourse of views surrounding a particular topic. *The definitive nominal group technique* has 4 phases—silent generation, round robin, clarification, and voting (ranking) [83]. The *Delphi technique*, on the other hand, employs a multistage self-completed survey with individual feedback, to define agreement from a bigger group of “experts” [84]. Through the concerted application of these techniques, one would be able to identify novel domains in generation-Y medical students’ education, where social media apps can be employed. Questions pertaining to these domains can be incorporated into the existing questionnaire to obtain more extensive responses. Development and validation of such a framework can form the basis of future studies.

Our study has identified social media apps that are preferred by generation-Y medical students. Furthermore, we employed these social media apps modules in disseminating specific intended learning outcomes, which received positive feedback from the learners. However, successful incorporation of these social media apps in the design of pedagogical strategies concomitantly with curriculum and course design still needs to be appraised, for which an elaborate study needs to be strategized. One of the ways to strategize this study is to design a lesson plan using social media apps employing conventional instructional design strategies, such as that of Gagne and Peyton [85], followed by incorporation of these lesson plans into courses founded on Kern’s 6-step approach [86]; these courses can then be evaluated by established models of evaluation such as the Stake’s Congruence-Contingency Model [87]. Thus, the quality of these social media app–incorporated courses can be perfected using innovative quality assurance and quality-enhancement frameworks strategized according to the Deming cycle, customized to the ISO 9001:2000 standards in medical education [88].

Our study targets generation-Y medical students who have transitioned from high school to the university, which happens mostly in middle schools located in the Middle East and North Africa. Although the observations in our study can be translated into the design of effective social media app–integrated pedagogical strategies for medical schools in the Middle East and North Africa region, they may be insufficient for translation to medical schools where generation-Y medical students often attend junior college before transiting to the university, because the learning styles and cognitive and metacognitive abilities of both these group of students are significantly different [89].

Our study focuses on generation-Y medical students who are in the preclinical phase in the medical curriculum, where the emphasis is on dissemination of knowledge and provision of a basic know-how of this knowledge through this app, addressing basic clinical problems in the form of simple vignettes/cases. Therefore, if social media apps are to be employed in the design of pedagogical strategies implemented in the clinical phase of the undergraduate medical curriculum, a separate study needs to be strategized, as the goal of the clinical phase is to apply the knowledge acquired in the preclinical phase to diagnose and manage complex clinical problems as well as to grow into a safe and competent health practitioner.

Although, in designing the questionnaire, we attempted to include all the popular social media app modules, we omitted a few such as Tumblr and Reddit. This is because these social media app modules are either restricted for use in the region or are not popular among end users in the region.

Conclusions

This proof-of-concept study identifies social media app platforms preferred by generation-Y medical students in medical education, specifically in a spiral curriculum. In addition, this study identifies the differences between female and male generation-Y medical students in terms of the use of social media apps in medical education, which we believe will assist instructors in designing pedagogical strategies to integrate social media apps. Furthermore, we have determined the perception of generation-Y medical students on the implementation of social media apps in medical education, which we believe will facilitate the design of more student-centered pedagogical approaches. A simple strategy to implement social media apps in teaching generation-Y medical students is also presented, which can be translated to any course in the preclinical phase of the medical curriculum. Furthermore, the identified limitations of this study provide an understanding of the gaps in research on integration of social media apps in a medical curriculum catering to generation-Y medical students. In other words, 21st century medical education requires effective use of social media app platforms to augment competency-based medical education: *Augmentation of Flexnerism in the current scenario is possible only by the adaptation of Twitterism.*

Conflicts of Interest

None declared.

Multimedia Appendix 1

Questionnaire.

[PDF File (Adobe PDF File), 365KB - mededu_v5i1e12403_app1.pdf]

Multimedia Appendix 2

Reviewer comments.

[PDF File (Adobe PDF File), 177KB - mededu_v5i1e12403_app2.pdf]

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Abbreviations

MBRU: Mohammed Bin Rashid University

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Original Paper

Use of Smartphone-Based Head-Mounted Display Devices to View a Three-Dimensional Dissection Model in a Virtual Reality Environment: Pilot Questionnaire Study

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Abstract

Background: Virtual reality (VR) technology has started to gain attention as a form of surgical support in medical settings. Likewise, the widespread use of smartphones has resulted in the development of various medical applications; for example, Google Cardboard, which can be used to build simple head-mounted displays (HMDs). However, because of the absence of observed and reported outcomes of the use of three-dimensional (3D) organ models in relevant environments, we have yet to determine the effects of or issues with the use of such VR technology.

Objective: The aim of this paper was to study the issues that arise while observing a 3D model of an organ that is created based on an actual surgical case through the use of a smartphone-based simple HMD. Upon completion, we evaluated and gathered feedback on the performance and usability of the simple observation environment we had created.

Methods: We downloaded our data to a smartphone (Galaxy S6; Samsung, Seoul, Korea) and created a simple HMD system using Google Cardboard (Google). A total of 17 medical students performed 2 experiments: an observation conducted by a single observer and another one carried out by multiple observers using a simple HMD. Afterward, they assessed the results by responding to a questionnaire survey.

Results: We received a largely favorable response in the evaluation of the dissection model, but also a low score because of visually induced motion sickness and eye fatigue. In an introspective report on simultaneous observations made by multiple observers, positive opinions indicated clear image quality and shared understanding, but displeasure caused by visually induced motion sickness, eye fatigue, and hardware problems was also expressed.

Conclusions: We established a simple system that enables multiple persons to observe a 3D model. Although the observation conducted by multiple observers was successful, problems likely arose because of poor smartphone performance. Therefore, smartphone performance improvement may be a key factor in establishing a low-cost and user-friendly 3D observation environment.

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KEYWORDS

medical education; smartphone; virtual reality

Introduction

A Virtual Reality and Three-Dimensional Model

In light of its recent growth and development, virtual reality (VR) technology has been gaining attention as a new system for potential introduction in education and training environments and as a form of surgical support in medical settings [1-5]. An increasing number of three-dimensional (3D) textbooks, such as the *3D Dissection Atlas* series, are being studied and read to test their usefulness [6,7].

Owing to tools such as the OsiriX DICOM Viewer (Pixmeo) and the SYNAPSE VINCENT volume analyzer (Fujifilm), it is now easy to build 3D models based on image data taken from patients' actual cases [8,9]. Thus, expectations that 3D constructed models will become a form of surgical support are growing [10,11]. Furthermore, 3D models are useful for surgical teams in terms of image sharing. Presenting cases preoperatively using 3D models and visualizing actual previous surgeries provide immense positive outcomes as well as major educational benefits [12]. There are also numerous reports showing attempts at using VR technology in the process of surgery planning and/or navigation in the area of hepato-biliary-pancreatic surgery [2,13].

There are currently many types of 3D-modeling software tools, each equipped with distinctive features. How users employ the models differs depending on the needs of each user; whether or not users find the performance of these models satisfactory also differs accordingly.

Smartphone

Older cell phone types have been replaced by the now ubiquitous smartphones, and we have recently entered an era in which everyone owns at least one of these extremely useful and convenient devices. Many advanced functions of these smartphones are being considered for their potential and/or availability for use in actual medical settings [14,15]. Smartphone and tablet apps for educational use have been developed and are becoming more available. Smartphone apps concerned with health care and medicine include digital books (eg, textbooks and guidelines) as well as sensors and video functions. Development of such medical apps that handle symptom evaluation, education, and rehabilitation has also been reported [16,17]. Reports on using smartphone video functions have recently increased [18,19], showing that high-definition smartphone cameras have also improved. Smartphones and their linked apps have enabled the use of VR and/or augmented reality (AR) environments through lenses using simple activation.

Head-Mounted Display

Various head-mounted display (HMD) devices, such as Oculus (Facebook), VIVE (HTC), and Hololens (Microsoft), have been developed and are available in the market today. Moreover, wearable devices such as Google Glass (Google) and Hololens [10,20-23], the usefulness and feasibility of which are being studied, are used for medical purposes. 3D model presentation methods include both monitors and HMDs; nowadays, 3D printers are also employed [24,25]. We believe that when 3D models are used in medicine or medical science, the method or environment in which the models are observed will differ according to the costs in terms of time and economics, considering the extra time and cost it would require to prepare several numbers of the same HMD devices and/or install them so that they link and make the same movements.

In harnessing HMD for multiple persons to observe the same model, the number of HMD devices to be used will be the same as the number of observers. For this reason, it is costlier to teach and provide operating instructions to observers. On the contrary, as smartphones are now widespread, using them to share data and observe models could provide a simple, low-cost observation environment, which we consider highly feasible. However, we have yet to determine which system is the most practical to observe 3D models and identify problems that could arise when a new system of employing smartphone-based simple HMD devices is in practical use.

Aim of This Study

This is the first study conducted for medical education purposes by using a smartphone-based HMD. It aimed to analyze potential issues of observing a 3D model of an organ that was produced based on an actual surgical case with a simple HMD using a smartphone. In addition, we evaluated and gathered feedback on the performance and usability of the simple observation environment that we created.

Methods

Flow of Experiment

A pilot study was conducted in the Department of Gastroenterological Surgery at Tokai University, where 17 medical students performed 2 experiments to observe 3D dissection models through a simple HMD. The targeted participants conducted the 3D model observations in 2 experiments: one by a single observer and another by multiple observers. Upon completion, they assessed the results by responding to a postexperimental questionnaire survey. To maintain consistency, we explained the details and flow of the experiment process to the participants before the experiments began. The following subsections describe the experiments.

Participants

The participants consisted of 17 medical students at Tokai University who were in their fifth year of medical school and had studied anatomy. Tokai University's clinical study ethical review board (17R112) reviewed and approved the study, and each participant provided written consent.

Apparatus and Setting

We performed a simple automatic extraction using 3D surface rendering by OsiriX (Pixmeo) and modeled arteries and portal vein branches (Figure 1). We used a smartphone (Galaxy S6; Samsung, Seoul, Korea) and downloaded the resulting data into it. We also used Unity (Unity Technologies) for displaying 3D models on smartphones.

Next, we used Google Cardboard to create a simple HMD system (Figure 2). The Google Cardboard was created in compliance with the Google VR specifications [26]. The diameter of the lens was 34 mm, and the distance between the centers of both lenses was 64 mm. The actual measurement of the camera's angle of view was 55 degrees and that of the HMD was 59 degrees. The distance between the lens and the virtual monitor was 667 mm, but the actual visual distance was 685 mm, as the length between the lens and the eye was 18 mm. In addition, the smartphone weighed 136 g and the cardboard 79 g, and the total weight of the HMD was 215 g.

The system we built was capable of sharing a model between 2 HMD devices by applying AR markers (through the Vuforia platform; PTC). AR markers triggered the display of the virtual information. When we view AR markers through digital cameras based on image recognition technology, content that matches the digital camera image is displayed, appearing as if it is actually right in front of us. In this experiment, the AR markers consisted of 1 sheet and 1 box. When the device recognized them simultaneously, the 3D model from the sheet and the indicating bar from the box appeared on the display, which the participants were able to view (Figure 3). The size of the AR marker used on the sheet was 270 × 190 mm, whereas the AR marker used as an indicator bar was made from a cube (70 mm sides) and a paper drawing glued together. The indicator bar was designed to pop out from one corner. The length of the sharp bar was 100 mm. We chose natural images for the drawings (paper) used on each marker to make them recognizable.

This specification enables the observer to view the dissection model at a distance of 685 mm from the screen. At a magnification of 16.8 times, together with the smartphone screen width of 47 mm, the visual field of the virtual monitor will expand accordingly, with a 59.9-degree field of view. According to an actual observation, the 3D model and indicator bar were displayed on the screen without delay.

Experimental Design and Data Collection

We asked the participants to observe the 3D model through the simple HMD system (Figure 4) and evaluate the results by responding to a questionnaire survey.

Experiment 1: Observation by a Single Observer

Participants observed 3D models using an HMD device while reading a text on anatomy. Even if they had the HMD attached, they were able to see the text through the smartphone's camera. They performed an observation exercise using this HMD to carry out the second experiment (Textbox 1). Afterward, they made an assessment using a 5-level Likert scale, ranging from *invisible* to *visible* (1-5, respectively).

Experiment 2: Multiperson Observation

In this experiment, participants paired up and took turns. One participant with the *box* marker indicated an artery or vein, whereas the other answered our questions, as shown below (Table 1). After the experiment, they assessed the results on a 5-level Likert scale, ranging from *strongly disagree* to *strongly agree* (1-5, respectively). We then gathered their opinions and impressions and prepared an introspective report. The participants filled out a usability questionnaire on the system. We calculated the overall scores attained by all participants.

Statistical Analysis

The items of the scored questionnaire were analyzed through Pearson correlation analysis using SPSS for Windows, version 18.0 (IBM Japan).

Figure 1. Three-dimensional (3D) dissection model. We performed a simple automatic extraction using 3D surface rendering of OsiriX and the modeled arteries (in red) and portal vein branches (in purple).

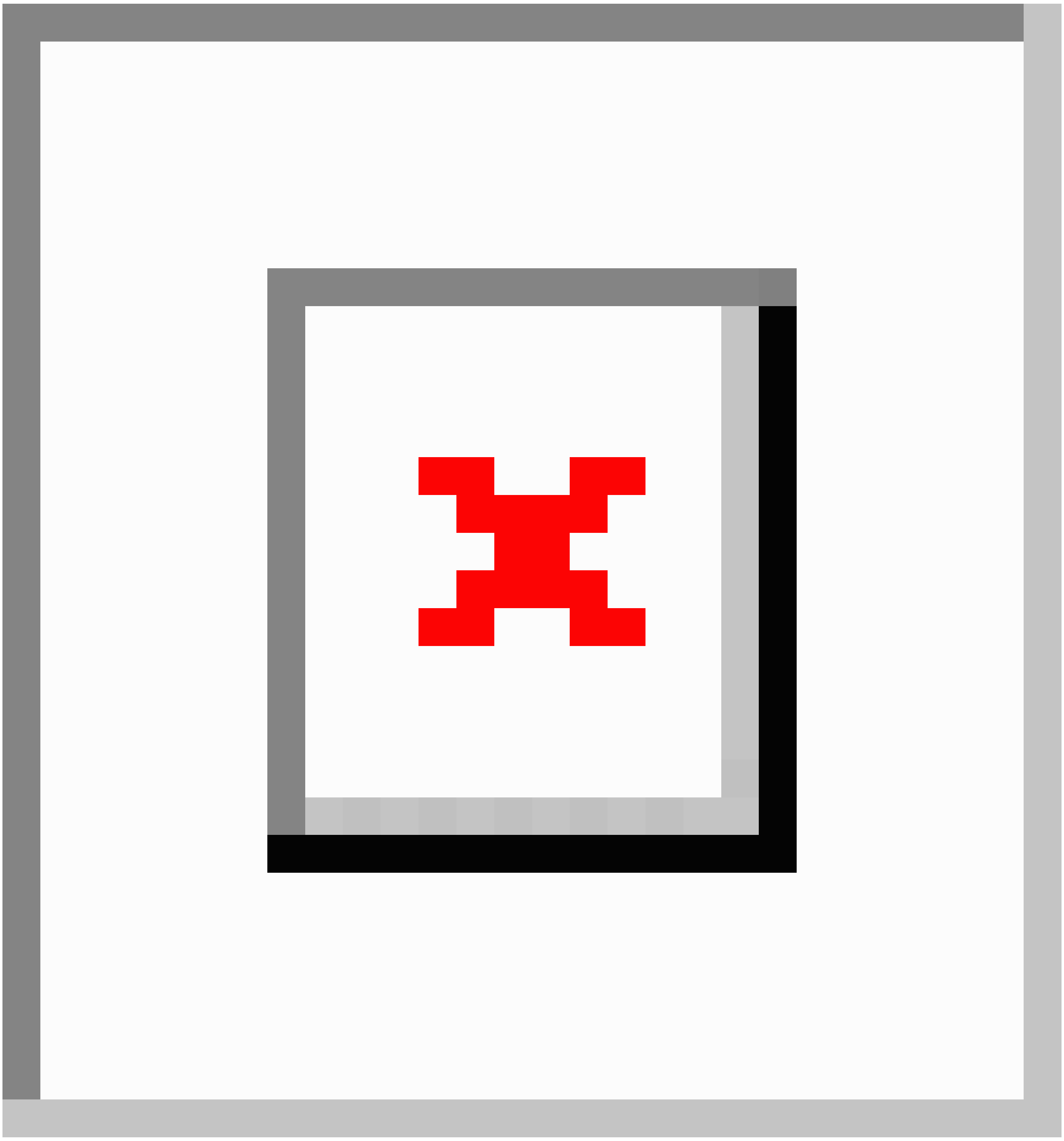


Figure 2. A simple head-mounted display (HMD) system. We built a simple HMD system using a smartphone (Galaxy S6 by Samsung) and Google Cardboard.

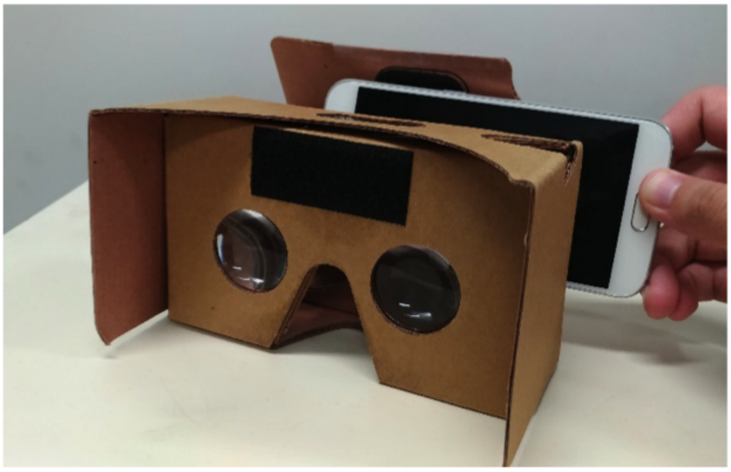


Figure 3. The participant's perspective. When the smartphone's camera recognized 2 augmented reality markers simultaneously, the three-dimensional organ from the sheet and indicator bar from the box appeared in front.

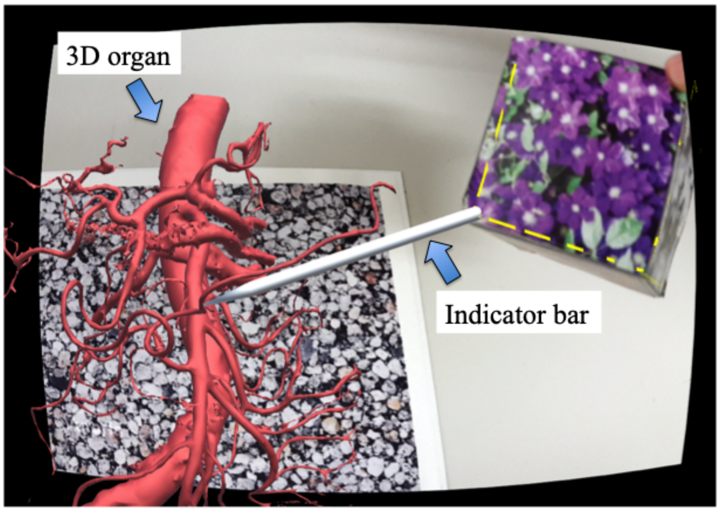
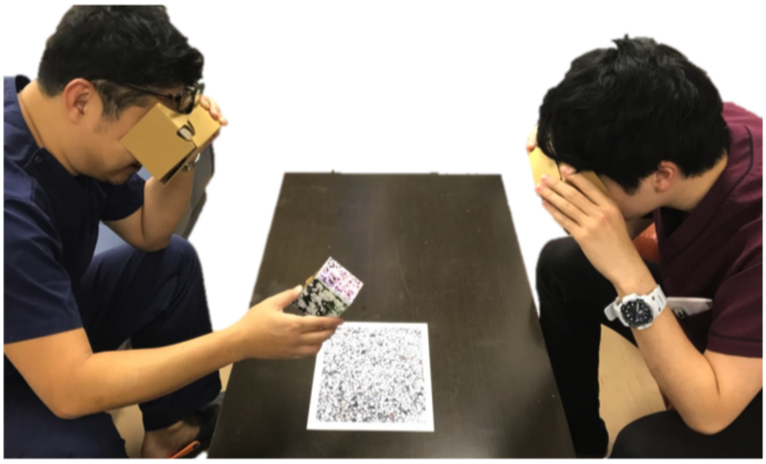


Figure 4. Participants' observation of the three-dimensional (3D) model using the head-mounted display (HMD) system. In Experiment 2, participants faced each other and were asked to observe the 3D model through the simple HMD system.



Textbox 1. Dissection name (abbreviation shown in brackets) used for blood vessels confirmation (Experiment 1). We chose the blood vessel titles shown in the model. The participants confirmed each blood vessel while reading a textbook. Afterward, the participants performed an assessment using a 5-level Likert scale, ranging from invisible to visible (1-5, respectively).

- Common hepatic artery (CHA)
- Left gastric artery (LGA)
- Splenic artery (SpA)
- Portal vein (PV)
- Superior mesenteric vein (SMV)
- Inferior mesenteric vein (IMV)
- Splenic vein (SpV)
- Gastroduodenal artery (GDA)
- Right gastric artery (RGA)
- Proper hepatic artery (PHA)
- Right and left hepatic artery (Right/left HA)
- Anterior superior pancreaticoduodenal artery (ASPDA)
- Inferior pancreaticoduodenal artery (IPDA)
- Superior mesenteric artery (SMA)

Table 1. Experiment 2: usability of the head-mounted display (HMD) system. We assessed the usability of the HMD system. After the experiment, the participants marked the results on a 5-level Likert scale, ranging from *strongly disagree* to *strongly agree* (1-5, respectively).

Evaluation	Statement
Visual image	
Image quality	The image quality was good enough
Reality of the object	The reality of the object was good enough
Device	
Size perception	The size perception was acceptable enough
Distance perception	The distance perception was acceptable enough
Usability of the wearable device	
Comfort	It was comfortable to use
Heaviness	It was light to the touch
Motion sickness	I did not feel sick from using it
Eye fatigue	I did not experience eye fatigue from using it
Total usability	This HMD had acceptable usability

Results

Experimental Results

The assessment of the direction model yielded a largely favorable outcome (Figure 5). In terms of clear image quality, reality of object, size perception, and overall usability, the evaluation of the observation was high. In an introspective report on the observation experiment conducted by a single observer, more than half of the respondents responded that their spatial understanding improved compared with when reading a textbook. As for simultaneous observation by multiple observers, positive comments referenced the clear image quality and shared understanding. On the contrary, we received a low rating because of visually induced motion sickness and eye fatigue caused during the process (Figure 6).

Introspective Report on Simultaneous Observation

Negative comments were also received because of hardware failure (specifically slow smartphone performance caused by heating issues and problems with AR markers; Figure 7). As a result of visually induced motion sickness during the experiment process, some respondents suggested that observation through a monitor would be a better choice.

Figure 5. Dissection model assessment. The vertical axis indicates dissection names and the horizontal axis shows assessment scores. The results are as shown on a 5-level Likert scale, 5 points for "greatly understood" and 1 point for "did not understand." Points for each organ are shown in the box plot. ASPDA: anterior superior pancreaticoduodenal artery; CHA: common hepatic artery; GDA: gastroduodenal artery; HA: hepatic artery; IMV: inferior mesenteric vein; IPDA: inferior pancreaticoduodenal artery; LGA: left gastric artery; PHA: proper hepatic artery; PV: portal vein; RGA: right gastric artery; SMA: superior mesenteric artery; SMV: superior mesenteric vein; SpA: splenic artery; SpV: splenic vein.

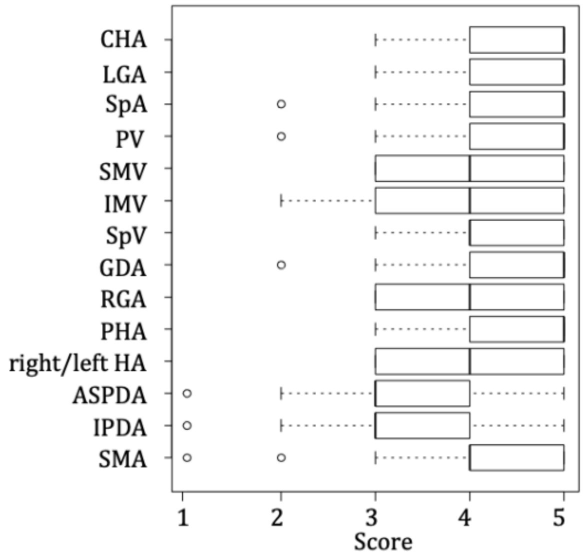
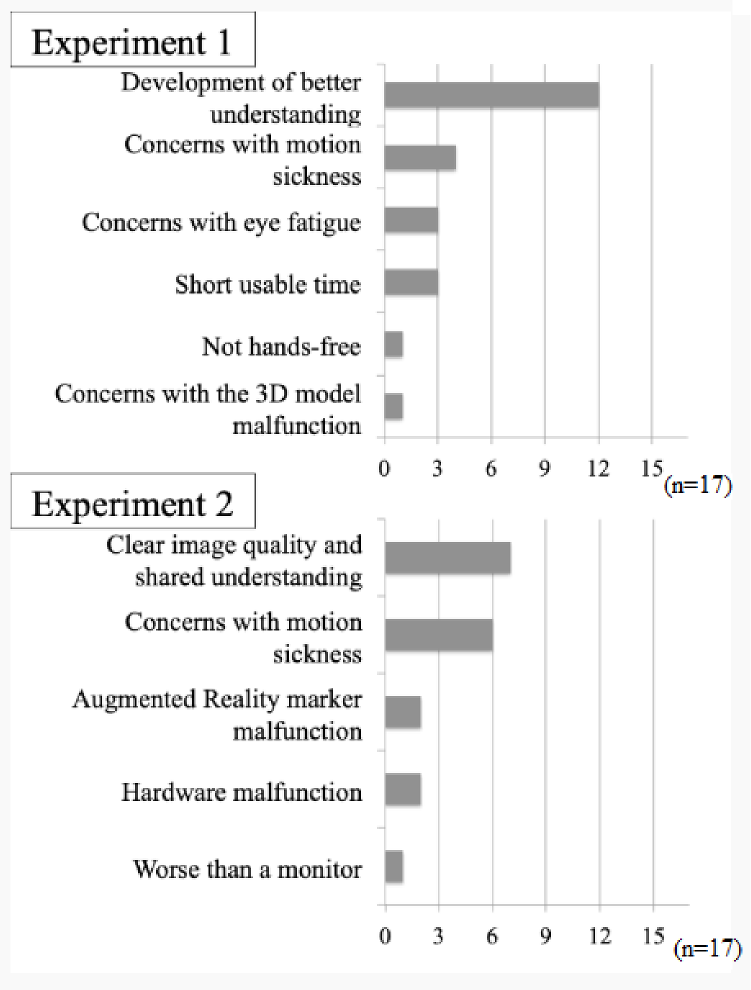


Figure 6. Usability assessment. The vertical axis shows assessment items. The horizontal axis indicates evaluation scores. The results are as shown on a 5-level Likert scale, 5 points for "very good" and 1 point for "very bad." With respect to heaviness, motion sickness, and eye fatigue, the points are in inverse proportion to the burden. Each assessment item is shown in the box plot.

Figure 7. Introspective report on simultaneous observation. There were a total of 17 participants. The vertical axis indicates the comments received in the descending order of their frequency. The number of participants who provided the comments is shown on the horizontal axis (bar chart). 3D: three-dimensional.



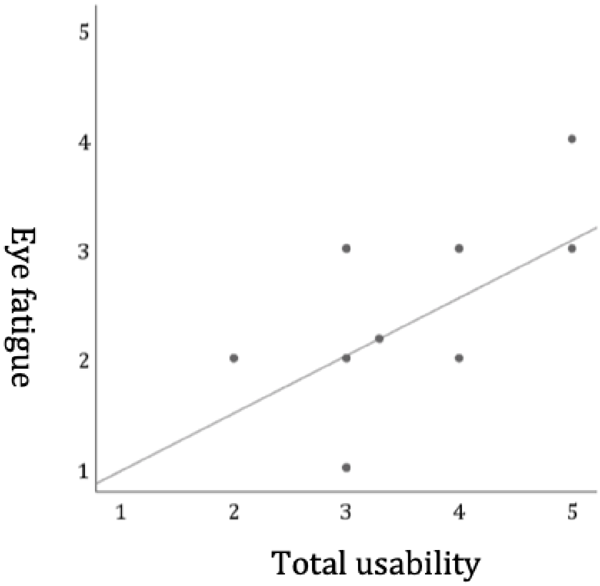
Discussion

Simultaneous Observation

In this research, we were able to observe a 3D dissection model that had been extracted from patient data using a simple HMD. Smartphones, which are now widespread, are capable of observing a 3D model of a surgical patient by downloading the 3D model data. The moment such data are downloaded, this system becomes available to anyone with access to a smartphone, Google Cardboard, and the patient's computed tomography (CT) data. This enables the user to hold a 3D surgical case conference anywhere. The 3D model here is a simple one created with the OsiriX viewer, and although issues remain in terms of smartphone performance, a detailed model is implementable. In addition, we believe that the most meaningful part of this experiment was that we were able to share the same model information with multiple observers in this observation environment, in which we used smartphone-based HMD devices.

We used Google Cardboard (created in compliance with the Google VR specifications) in the system. As the settings (eg, distance between both eyes and focal length) are fixed and there is no room for even a minor adjustment, it may help address the negative effects of VR sickness and/or eye fatigue by, for example, adjusting the lenses based on each individual. In sharing the 3D model information, we used AR markers instead of fingers to display the indicating bar. Thus, we were able to direct the dissection of the 3D model. Our use of the smartphone's narrow angle of view may have also contributed to the restricted work space, making the recognition of the AR markers more difficult. Presumably, this can be avoided by using wide lenses. However, as the viewing angle is extremely narrow when compared with the Oculus Rift or HTC VIVE, a further comparative study is required. The total weight of the HMD is 215 g. It is relatively light as it is made of cardboard, but we need to keep holding it in our hands during its use. According to the introspection report, its light and user-friendly features received positive comments. On the contrary, negative comments were received regarding the burden of having to hold it every time. During the experiment, some participants had to hold down the smartphone with their hands to stop it from moving within the cardboard. Therefore, something that could keep the smartphone fixed on one's head may be needed. Observation was the only task performed at this time, and participants' feedback was rather favorable as the experiment did not require large movements, such as head adjustments. We look forward to the comments that we will receive when we add tasks other than observation in our future experiments.

Figure 8. Correlation between eye fatigue and total usability. The vertical axis shows eye fatigue scores. The higher is the score, the less is the burden. The horizontal axis indicates the total usability scores. Eye fatigue showed close correlation with total usability (r=0.526, P=0.02).



Virtual Reality Sickness

The presence of motion sickness, cyber sickness, and VR sickness along with various physiological symptoms was observed during the experiments; these are thought to be caused by parasympathetic activities and/or visual flow [27,28]. This seems to be related to various complex factors. Issues concerning the technical aspects of the VR environment (eg, HMD settings) are also observed. In previous studies where the Oculus Rift was used [29], motion sickness resulted in a VR environment and varied by gender. However, no gender difference was observed in this study. Although stereo vision is crucial in 3D depth perception and is considered advantageous [30] in terms of hand-eye coordination or driving technique, the prevalence rate of stereo blindness among the participants who lacked this vision was 1% to 30% [31]. It is thus possible that stereo blindness affected motion sickness or eye fatigue. In the case of observation conducted by multiple observers, displaying AR markers simultaneously resulted in smartphone heating, which eventually led to slow performance of the phone. Furthermore, adjusting head positions to display AR markers is likely to have caused motion sickness and eye fatigue. In fact, eye fatigue showed close correlation with total usability (r=.526, P=.02; Figure 8). Keeping score of VR sickness is suggested, and this suggestion is undergoing review [32]. To assess the issues of motion sickness, we need to keep a log of certain items (eg, general discomfort, fatigue, eyestrain, difficulty in focusing, headache, blurred vision, dizziness, and vertigo) to have further discussions.

Simple System

In this research, we focused on how we can establish a simple system with ease, as well as on the prevalence of an environment in which medical students can learn or study preoperatively. The observers were not allowed to control the device except for moving (adjusting) viewpoints. The extent to which our HMD (using smartphones) can achieve this is still under discussion; however, we have started working on our model observation. Although this system, which can be created by using just a smartphone and a cardboard, is enough to perform a 3D model observation, it is not adequate for performing more complicated activities.

Our goal this time was to observe a simple HMD. Previous research that used the HMD reported that their aims included establishing a remote education system of surgical methods [23] and a system using the Oculus Rift to create a simulation or medical VR environment [33]. These studies are considered useful in clinical practice and/or surgery settings. Thus, from now on, we need to not only observe but also implement an interaction that could help perform tests (anatomy comprehensive exams) on training grounds with the use of our system as well as assess complex interactions, such as by implementing models (to be excised, etc), which appear exactly as they would in an actual surgery. Moreover, participants' responses included requests for new functions such as a dissection title display feature for learners as well as on and off buttons to switch between each blood vessel model. However, in such a case, adding complex tasks (eg, transformation of 3D models in proportion to the surgery progress) may alter said evaluation. Furthermore, although it seems crucial to solve issues such as motion sickness, these problems may be solved naturally with the development of simple systems supported by the technological advancement of smartphones and AR markers.

In this study, we were not able to implement this system in an operating room or observe it in clinical practices because of ethical approval conditions. As we need to work in coordination with the hospital's system to conduct a 3D observation on all patient data, it would be necessary to design an elaborate system. Currently, our simple system may be suited for case studies that present images of unique cases. As reflected by the results of Experiment 1, the evaluation of the 3D model quality was "agreeable." As for the dissected parts with low evaluation, although the visual image may have been inadequate, it was enough to obtain and comprehend a rough image of the dissection. This point may also require assessment from a surgeon. Taking into account requirements from educational or clinical practices, we need to consider where this system will be needed or how we can develop this system in the future.

Limitations

We currently face limitations such as hardware constraints (ie, system failures due to heating and/or recognition precision limits of the AR markers). To address this, we asked 5 surgeons from a hepato-biliary-pancreatic surgery group (Department of Gastroenterology, Tokai University) to conduct an observation and provide feedback by responding to some survey questions. The results were as follows: all 5 surgeons agreed on the clear image quality, and 3 of them had favorable reactions to the user-friendly device owing to its simplicity and compact size. Their positive comments reflected how the system enables intuitive observation from different angles as opposed to observation via monitors, making it easier to create a distinct image of the surgery (simulation), as the operator and his or her assistants usually stand face-to-face during the operation. However, nobody chose to use the 3D device over the two-dimensional (2D) CT test for preoperative checking. This is because of the limited information 3D models can provide compared with CT graphics (original data). To be specific, in addition to the vascular system's graphics, images (such as those of tumors and other organs) are considered necessary as well. Thus, for detailed information, there is nothing more preferable to original data. We assume this to be the reason that the surgeons tend to choose 2D images over 3D models (shown on this system) for preoperative planning. Nevertheless, letting medical students or interns perform observations using 3D models should have positive educational effects. Some comments referred to the following possibility: if we install a function into the system that enables us to draw images onto the 3D space, it will enable us to conduct conferences with detailed information with surgeons who could draw additions or alterations onto rough 3D models while explaining and discussing them. Thus, we now need to bring the system to clinical sites and gather various types of requests. Future work in the field of surgery (eg, surgical conferences and education) will most definitely involve smartphone usability, which continues to evolve. In other words, the more our system develops, the more its quality (user-friendliness) would improve as regards handling complex 3D models and/or assisting surgeons.

An environment in which medical images can be easily processed and observed by linking wearable devices and sensors to smartphones or tablet computers is becoming more common these days, but we must not forget to keep abreast of related laws and guidelines. OsiriX MD has been licensed by the US Food and Drug Administration but has not been approved in Japan. It is critical that we solve these issues first to realize the clinical application of visualized images of individual patients (3D models) in surgery simulation and/or navigation.

Conclusions

Using a smartphone, we built a simple system in which multiple people are able to observe a 3D model created by OsiriX. Although observation by multiple persons was possible, we found problems presumably caused by poor smartphone performance. Improving smartphone performance may be the key factor in establishing an inexpensive and user-friendly 3D observation environment.

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Conflicts of Interest

None declared.

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Abbreviations

2D: two-dimensional
3D: three-dimensional
AR: augmented reality
CT: computed tomography
HMD: head-mounted display
VR: virtual reality

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