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Original Paper

# Increasing Reasoning Awareness: Video Analysis of Students' Two-Party Virtual Patient Interactions

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## Abstract

**Background:** Collaborative reasoning occurs in clinical practice but is rarely developed during education. The computerized virtual patient (VP) cases allow for a stepwise exploration of cases and thus stimulate active learning. Peer settings during VP sessions are believed to have benefits in terms of reasoning but have received scant attention in the literature.

**Objective:** The objective of this study was to thoroughly investigate interactions during medical students' clinical reasoning in two-party VP settings.

**Methods:** An in-depth exploration of students' interactions in dyad settings of VP sessions was performed. For this purpose, two prerecorded VP sessions lasting 1 hour each were observed, transcribed in full, and analyzed. The transcriptions were analyzed using thematic analysis, and short clips from the videos were selected for subsequent analysis in relation to clinical reasoning and clinical aspects.

**Results:** Four categories of interactions were identified: (1) *task-related dialogue*, in which students negotiated a shared understanding of the task and strategies for information gathering; (2) *case-related insights and perspectives* were gained, and the students consolidated and applied preexisting biomedical knowledge into a clinical setting; (3) *clinical reasoning interactions* were made explicit. In these, hypotheses were followed up and clinical examples were used. The researchers observed interactions not only between students and the VP but also (4) *interactions with other resources*, such as textbooks. The interactions are discussed in relation to theories of clinical reasoning and peer learning.

**Conclusions:** The dyad VP setting is conducive to activities that promote analytic clinical reasoning. In this setting, components such as peer interaction, access to different resources, and reduced time constraints provided a productive situation in which the students pursued different lines of reasoning.

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## KEYWORDS

medical education; clinical decision making; problem solving; computer-assisted instruction

## Introduction

In professional education, students need to apply facts and concepts into relevant work-life situations. For medical students, it can be challenging to apply biomedical knowledge when

entering into clinical practice; this application has previously been described as “slow, awkward, or absent” [1]. It is therefore important that students are assigned activities that guide the transition from comprehension to higher-level problem solving and management [2]. Educational researchers suggest that

reasoning skills can and should be taught in order to develop deeper understanding of facts and concepts [2]. In the context of medicine, clinical experiences and thorough biomedical knowledge are combined within clinical reasoning, thus facilitating diagnostic and management processes in relation to patients [3]. The nature of clinical reasoning has been thoroughly researched; yet, in our experience, it is still rare for medical educators to arrange learning activities that enable any insight into, or guidance of, students' reasoning processes.

Two models are commonly used to describe the nature of clinical reasoning processes. The hypothetico-deductive model describes reasoning as starting with the generation of hypotheses, followed by analytic evaluation of these hypotheses [4]. This model is firmly rooted in laboratory and experimental empirical settings. However, research based on more naturalistic, real-life professional situations has challenged the hypothetico-deductive model and proposed more intuitive and experience-based nonanalytic models, often termed pattern recognition models [5]. In clinical professional practice, the nonanalytic pattern recognition model is emphasized because of the multidimensional characteristics of real-life practice [3]. This type of reasoning requires experience from clinical examples that generates an array of analogies as students develop their expertise [6]. However, in undergraduate education, students do not have large repertoires of patient encounters and need to rely on analytic use of their biomedical knowledge. The two reasoning approaches are not mutually exclusive; either one can be used or both in tandem, depending on the context and the educational goal [7,8].

An interactive virtual patient (VP) allows students to gather information in a stepwise manner and suggest diagnosis and management. Relevant VP cases have been shown to engage students in active thinking and decision making [9-11]. The engagement and perceived relevance are important to support meaningful learning [12]. VP activities are often designed with flexible, individual self-study in mind. However, one could assume that peer settings, in which students need to verbalize and argue their standpoints, would make reasoning processes more discernable to students and thus support their learning of reasoning strategies. In complex clinical settings, decisions are often based on collaborative reasoning [13]. Collaborative-thinking processes have been emphasized in complex processes such as managing a large military vessel [14], and the philosopher Dewey considered dialogue fundamental to logical thought [15]. Collaborative reasoning is therefore both a means to gaining professional competence and an educational goal for students in terms of gaining awareness of their own critical thinking [16].

The use of computer applications in small group settings has generally been shown to be beneficial for learning [17]. The dyad, which is a two-party peer collaboration setting, has been shown to generate learning outcomes at more abstract levels in problem solving than if the same task had been performed individually [18]. The dyad reasoning setting may also grant educators access to reasoning processes, thereby making it possible to refine and design engaging and challenging situations. Increasingly complex patient scenarios and challenges in health care have intensified the need for shared reasoning

and collaboration in professional practice [13,19]. The aim of this study was to explore characteristics of medical students' two-party reasoning on clinical cases presented as computerized VPs.

## Methods

An exploratory observation was conducted to identify interactions and delineate their characteristics during VP case sessions performed by students in dyads. The students were third-year medical students during their clinical rotation at the Rheumatology Unit at the Karolinska University Hospital in 2011. Four VP cases constituted a mandatory task, which was recommended to be conducted in pairs. The VP assignment was not scheduled at a specific time or graded, but it served as a basis for discussion with a clinical supervisor at the end of the rotation. The VPs were based on authentic patients and authored in a derivative platform of the NUDOV system described in Wahlgren et al [20]. The main researcher (SE) recruited a convenience sample of 2 student pairs (all female) and obtained written informed consent to video-record their VP sessions. They were free to select one of the 4 VPs. Two different cases were selected, one by each of the two pairs. Each session lasted for approximately 1 hour.

The construction of themes was data-driven, that is, not directed by a priori categories. The first session (session #1) was transcribed in full and a preliminary thematic analysis was performed [21]. This analysis was initiated by the first author, followed by iterative analysis in collaboration with the coauthors. In the first phase, instances of interaction pertaining to learning and clinical reasoning were identified as themes. These themes were then used to identify corresponding instances in the second session (session #2). Emerging themes along with illustrative instances from the videos were analyzed collaboratively in two collaborative data analysis sessions [22]. The research group brought specialty-specific (rheumatology) and educational perspectives into the analysis based on their expertise. Different views and perspectives on the themes were resolved by consensus. Clinical information of the VPs is provided in [Multimedia Appendix 1](#).

Ethical approval was granted by the regional Ethics Review Board in Stockholm, Sweden (#2009/609-32/5).

## Results

### Overview

Four categories of interactions related to learning were identified: (1) task-related dialogue, (2) case-related insights and perspectives, (3) clinical reasoning interactions, and (4) interactions with other resources. Each category is presented below, and interactions from the different categories are illustrated using quotes from the two sessions, indicated by the session number and point in time of the respective session.

### Task-Related Dialogue

Part of the dialogue was dedicated to understanding how to approach the task and navigate in the software. Interactions in this category were related to, for example, the students'

perceptions on how the assignment would be followed up by their supervisors, and, more directly, how the interface worked, in particular where they had to click to navigate in the VP software:

*Yes, exactly. May I just ask: what are we going to report on Friday? It was going to be about the diagnosis we identified and then about the management, right?*

*Exactly.*

*OK, I just wanted to be sure. [#1, 09:25]*

*But, by the way, did we have any...It says 3 questions, but we could ask many questions, couldn't we?*

*Yes, it...*

*Whether he is on any medication, perhaps?*

*Yes, but the question is...do you think it will register it?*

*No, but if we just imagined.*

*Yes, we can make up questions. [#2, 05:50]*

*I was just thinking...should we click through step by step? Or we can just adopt a specific approach.*

*Yes, perhaps we should just choose what's relevant and then look at things again later.*

*But for now we'll follow these ones, anyway.*

*Yes... [#1, 17:49]*

Since only one person could select and write text into the software, there were negotiations about control, for example, what to select and what questions to put to the patient. Sometimes, the pairs divided tasks between themselves. For example, one could read on the screen while the other one looked up facts in a textbook:

*It might be far-fetched, but...should I read all blood test results?*

*Here: it should be below, or between 60 and 400, but go ahead and read. Keep reading.*

*I'll read quietly, so that you can check there.*

*OK. [#1, 56:33]*

*What more do we want to know? For the purposes of our own learning...We want to know more...about how the pain varies?*

*Yes, and when. Whether he suffers from morning stiffness, whether motion relieves it and whether rest worsens the pain.*

*I want to know if he is affected in any other way, if he has any other symptoms, any other... [#2, 19:16]*

### Case-Related Insights and Perspectives

Through interaction with the VP cases, the students obtained insights related to symptoms and diagnoses and identified new clinical perspectives. The process of identifying differential diagnoses and the progress toward the final diagnosis generated discussions and reflections, based on information obtained from the patient and clinical findings. The software and the way the VP cases were constructed allowed a free flow of ideas, several

of which were followed up at later stages. Students reflected upon differences between this setting and authentic patient encounters, which they perceived as more constrained because of time restraints. They referred to previous experiences of feeling pressured to appear as if they already had knowledge in front of patients and supervisors:

*See how much we are able to think about when sitting like this. When you are with a patient so ehh...*

*It's because you don't have a lot of time. You have to focus on behaving properly in front of the patient and so on. [#2, 33:10]*

There was plenty of time to elaborate on findings. Ideas and hunches could be followed up. The clinical information in the VP case was presented in a variety of ways namely, in text, short video clips of the patient answering questions, or filmed examination procedures. In session #2, the students were inspired to try out a practice physical examination on themselves while watching the procedure, and they watched the procedure one more time after that:

*Well, let's check him over, okay?*

*Yes, I agree.*

[At this point, an examination of the patient's (Carl) chest flexibility is displayed in the software: "Carl, now I would like you to breathe deeply while looking at me. Please, breathe so that my hands move."]

*Then, it should normally move like this, right?*

[The student shows her hands moving.]

*May I try it on you?*

[The student performs the examination on her peer, who is breathing deeply in and out.]

*Somewhere here?*

*Yes. [#2, 36:48]*

*Schober's test. [Film clip showing the examination of the patient's back flexibility is displayed.]*

*So he is just bending the hip joints, not like that.*

*Yes, exactly.*

*Exactly, not like this when he also is bending the back.*

[The student illustrates different types of back flexion using her hands.]

*Can we look at it again? I would like to see it one more time. [#2, 39:47]*

In one case, the reference of nonsteroidal anti-inflammatory drugs (NSAIDs) led to a discussion about the mechanism of action of such drugs and their effects in relation to the assumed diagnosis:

*Yes, because it is an NSAID.*

*Yes, exactly.*

*But, oh my god, isn't this weird? Well, NSAIDs dampen the inflammation, but we want to prevent even more, don't we?*

*So you want to give corticosteroids, or something like that?*

*Yes, or wait, was he still on that? The white blood cell count was high as was the sedimentation rate... We don't want to just stop the symptoms, right? We want to stop the progression, don't we? If you understand what I mean...*

*Yes, I understand, but NSAIDs are anti-inflammatory drugs, this is what they do.*

*Well, yes, but it's only COX that is inhibited.*

*Yes, it's quite a weak inhibition of the inflammation one could say.*

*Then it's only leukotrienes and prostaglandins that are not being produced, which means that you don't see...*

*Leukotrienes are produced, it's the prostaglandins [that are not produced], and thromboxanes are not produced either.*

*Correct, it's only those that are not produced.*

*But still, it [the drug] inhibits quite a lot of the inflammation, one could say.*

*Yes, that's true.*

*But, yes, it's not the same thing as corticosteroids or methotrexate, or things like that.*

*It does not inhibit the lymphocytes per se, even if not as many of them stream out, maybe.*

*Yes, you are not supposed to see the same upsurge.*

*But again, we want to prevent something severe here so that it doesn't result in a bamboo spine, which is permanent.*

*Yes, I understand what you mean, but at the same time I think that there must be a reason why they treat it this way. But we could read more about it maybe. It is also stated here that continuous physical exercise prevents worsening of the functional status, so I note this recommendation: exercise! [#2, 1:07:34]*

The VP cases were based on authentic patients; they were therefore not textbook examples. Students identified inconsistencies in relation to classification criteria; yet, their suggestion of diagnosis at different stages during the session—rheumatoid arthritis (RA) in the following instance—was also based on references from real-life clinical complexity:

*I thought of RA.*

*I also thought of that.*

*But isn't it small joints that are affected first?*

*Yes, I also thought about that, and he mostly seems to have problems with large joints.*

*But we could note it down as an alternative diagnosis. Not everything has to be according to the textbooks.*

*Yes, true. [#2, 44:41]*

The students brought previous knowledge into the reasoning. However, in many instances, the level of knowledge varied between the 2 individuals, and on several occasions it was incomplete. They supported each other by filling knowledge gaps and looked up information when they were uncertain:

*This sounds pretty much like Bechterew to me.*

*I mean, I don't remember so much about that disease. Could you remind me?*

*Sacroiliitis, and some other things... [#2, 11:03]*

*I always confuse CRP and ESR, which is which... One is supposed to be below 100, and the other one below 3...I think.*

*Yes, but the one with 100 – it's only when you have a bacterial infection that it can be over 100.*

*That was it. CRP, right? [#1, 54:08]*

### Clinical Reasoning Interactions

The clinical reasoning interactions consisted of uncertainty, questioning, clarifying, and verifying dialogues. The dyad setting encouraged the students to generate explicit hypotheses, as well as to proceed with confirming or rejecting these hypotheses. In both sessions, there was often one and the same peer giving suggestions to further advance the reasoning:

*OK, then I think we can decide that he most probably has PMR, and so I think we initiate him with glucocorticoids to see whether he gets better. Because this way we can confirm the diagnosis, right?*

*Yes, sure. [#1, 52:57]*

The following quote provides another example of how the reasoning is verbalized and the thread of the reasoning is made explicit. The students updated themselves on diagnostic criteria, and this information guided both their focus when further interviewing the patient and their interpretation of the patient's answers and other findings. The reasoning revolved around symmetry and the patient's ways to express the location of pain.

*Should we consider polymyalgia rheumatica?*

[The student looks up the classification criteria in the textbook.]

*Yes, I am not sure what...*

*I will check what it is.*

*Okay. But here it is stated that chronic idiopathic myositis can be an isolated inflammatory systemic disease, or part of another rheumatic disease such as Sjögren's syndrome, systemic sclerosis, mixed connective tissue disease, systemic lupus erythematosus or rheumatoid arthritis.*

*Yes...*

*And then with regard to polymyositis in particular, it is stated that the predominant symptoms are decreased muscle strength, decreased stamina in the proximal muscles, shoulders, nape of the neck, thighs, and the pelvis. Symmetric distribution. So we need to know whether it is symmetric. Myalgia may occur, but it is not as common as the weakness.*

*Was there no question about the symmetry?*

[The student browses through the VP case in the software.]

*No, not really.*

*And then it is stated that acute myositis, which mostly is seen in conjunction with viral infections, is established quicker and is often followed by myalgia. So it could be this.*

*I'm sorry, what did you say?*

*Acute myositis, which is mostly seen in conjunction with viral infections, is established quicker and is often followed by myalgia. So it could definitely be this, too.*

*That's true. And this was that...poly- and dermatomyositis?*

*Yes, exactly.*

*And he responds quite inadequately to the question about symmetry: "It is located in the shoulders and hips." So it should be that...Because otherwise, he would say: "the right shoulder." [The student pats her shoulder] and...*

*Hm, yes, it should be that.*

*And here, for polymyalgia rheumatica it is stated that [the student reads from the textbook] "new onset of relatively acute established mechanic pain in the proximal parts of the arms, shoulders, nape of the neck, and/or hip areas and thighs is characteristic of PMR, as it is abbreviated. Patients describe intense morning stiffness, difficulties turning over in bed, getting up out of bed, and putting on clothes during the morning hours."*

*Okay.*

*In general, the symptoms are fully developed within several days to a couple of weeks. Constitutional symptoms, such as fatigue, subfebrility, loss of appetite, and weight loss...*

*Well...hehe.*

*It's crystal clear! [#1, 23:32]*

Furthermore, the students verbalized interpretations of radiographic images. In session #2, radiographic visualization of the spine evoked interest, and the peers helped each other to understand the findings and relate them to the patient's symptoms. The software displayed the images, but there were no indications of what to look for (eg, arrows), or how to interpret the findings. The students realized that they could not fully interpret one of the images:

*Yes. Here, we can see a little better. Let's see. Here, it is very uneven; and here, it feels like it starts to become more linear.*

*Hm, there they are evened out. They are evened out there.*

*These ones stick out like that...*

*And they are also evened out, I think.*

*Yes, exactly.*

*Here, however, you can see that it's fine. [#2, 59:00]*

*[Next radiographic image]*

*Still evened out, that is what I see.*

*Yes.*

*Yes, now we are up there.*

*Yes, the cervical spine.*

*This one is very difficult to interpret, I think.*

*I find it absurdly difficult, too. Yes.*

*Has it grown together here? And here, maybe? Here too. I don't think I am competent enough to interpret that one, actually.*

*No, that's true. I'm not competent enough for that one either. I mean, I'm not saying that you are not competent; I'm just saying that I'm not competent. [#2, 59:25]*

The students worked on the VP cases in conjunction with other clinical tasks during their clinical rotation. Several times, they referred to patients and procedures they had seen before. Examples from real-life experiences at the clinic were used to illustrate representative instances in the VP cases and facilitated clarifications during reasoning:

*Is it possible to have psoriatic arthritis without the typical skin lesions?*

*I think it is, but I think it most commonly affects the DIP [distal interphalangeal] joints.*

*The psoriatic arthritis?*

*Yes, or am I wrong?*

*Yes, they are the ones most commonly affected, but it can also be...I mean...the man I saw earlier today, he had...*

*Yes?*

*Well, I was not responsible for him on my own, but I talked to him for a while. Both of his wrists were swollen, here, and here, and he had pain in one shoulder, an elbow, and in both of his feet; so it was quite extensive.*

*Yes. Did he have any other symptoms?*

*No, those specific joints were swollen and tender. [#2, 47:04]*

## Interactions With Other Resources

Resources other than the VP platform were also used; mostly a textbook but also Web-based medical resources, lecture notes, and a list of laboratory tests. The students were allowed to use other resources, and they did so when they found it helpful in making the diagnosis, when they wanted to relate content in the VP case to classification criteria, guidelines, and common management routines, and when identifying knowledge gaps:

*They were like evened-up corners of the vertebrae, I think.*

*Yes, I remember that. But what is the source of the pain? I mean, what's happening? What's the reason for the patient experiencing pain? Well, I think I should read a little about it in the textbook. I'll look it up. [The student opens the textbook].*

*Well, yes, we can have a look; it's something we should know anyway. [#2, 11:32]*

*This is, in fact, an awesome way to learn!*  
*Yes, definitely.*  
*Especially when you have such a good textbook.*  
*Yes, it's actually a really good one.*  
*Imagine if we had such a good textbook during all rotations.*  
*It's actually extremely useful to work in a problem-based manner sometimes. [#1, 1:07:02]*  
*Hm, okay. But wait...should we look at...what's that?*  
*Is the ESR [erythrocyte sedimentation rate] elevated?*  
 55.  
*And it is supposed to be below 3, isn't it?*  
*Yes, normally yes...*  
*Well...we should look it up.*  
 [The student uses the Internet.]  
*Yes.*  
*Okay.*  
*I will just check.*  
*Ah...*  
*My goodness, that was very slow...*  
*My son had an ESR of 29"...Okay, it is supposed to be below 8. [#1, 53:25]*

## Discussion

### Principal Findings

In this study, we identified and described interactions within student dyads in VP-based learning sessions. Our observations revealed elaborate reasoning processes supporting the development of analytic clinical reasoning. Overall, the dyad peer setting contributed to fruitful interactions and promoted the development of analytic expertise.

### Task-Related Dialogue

The assignment that framed the students' task was loosely regulated by the teachers, and the VP interface allowed for relatively free exploration of the patient cases, which made the task-related dialogue between the students necessary. During the task-related dialogue, a shared understanding was created on how one should approach the task to gather patient data in the case-related context.

### Case-Related Insights and Perspectives

Diagnosis-specific facts were elaborated upon, reference values from previous experience and other resources were used, and a variety of procedures were observed and discussed. The evaluation of key findings had positive consequences and resulted in structured gathering of further information and suggestions for managing the respective patient. To some extent, the knowledge was already present and readily available in the students' reasoning. However, in several cases, the students had to search for information or ask each other. The verbalization and application of knowledge seemed to add further value to preexisting knowledge, since it was put into a clinical context. Biomedical facts were thus interwoven with the clinical case

in a very active manner, connecting knowledge and procedures in a meaningful way.

### Clinical Reasoning Interactions

The verbal interaction between students made it possible to elicit reasoning processes that otherwise might have remained implicit or would not have occurred. Some of the findings pertain to a specific case while others are more general, for example, processes related to the development of reasoning strategies or decision making.

Previous literature on clinical reasoning is generally characterized by categorization into hypothetico-deductive analytic approaches and experiential-based nonanalytic approaches [7]. In our data, a slowed-down analytic reasoning was salient. The students made efforts to elaborate upon clinical findings in relation to classification criteria. Uncertainties were resolved by discussion, and the students filled knowledge gaps by using resources such as a textbook or the Internet. Even if an analytic approach was prioritized, real-life experiences from the clinic were also used during reasoning. The complexity of the clinical reality was thus introduced into the situation. According to our observations, the students alternated freely between the two approaches to reasoning and did not appear to make a distinction between them. These findings support previous suggestions that combining the two approaches to clinical reasoning is more beneficial compared with the use of only one style in educational settings, as they promote each other [6,8,23].

### Interactions With Other Resources

The setting in our study was based on VPs, using a structure that supported making a diagnosis and suggesting appropriate management of the patient before the real-life outcome of the respective patient was revealed. The students' interactions were clearly driven by the VP design, and the specific cases were always the central focus. Nevertheless, the students used several resources other than the VP software. A textbook, lecture notes, and the Internet were utilized to gather information that provided evidence needed for further reasoning and consolidation of knowledge. The actions within the learning activity were therefore not exclusively directed by the VP software. It is reasonable to assume that large variations in interactions were influenced by the possibility of accessing various other resources, as well as by the design of the VP scenario [24].

### The Dyad Setting

Our observations suggest that the peer setting in dyads was pivotal for the elaborate reasoning observed, as it provided constructive resistance while processing the VPs. It is reasonable to assume that part of this reasoning could have occurred internally within an individual in a nonpeer setting; however, the reasoning would not have been explicitly voiced; it would have occurred in silence, and it would certainly not have been critiqued or evaluated by a peer. Experimental designs have found that group cognition differs from individual cognition and that the dyad setting is productive for abstractions [18]. Peer learning settings have also been shown to have benefits in terms of increased awareness of the learning process, stimulation of reflections during problem solving, and strengthened



confidence [25-27]. In terms of group size in shared reasoning, the dyad setting worked very well in this VP arrangement. In a previous study comparing triads with individual settings using computer-based cases, no increased depth or elaborations were identified [28]. Nonetheless, the dyad constellation has been shown to be beneficial in clinical skills settings [29,30]. To our knowledge, no comparison has been conducted between dyad and triad peer settings in the context of VP-based learning. Such a comparison would shed more light on the influence of the size of the peer group on the reasoning process.

The constructive resistance that forms part of peer contribution may help to adjust topics to individuals' level of knowledge and experience. Still, a concern that has been raised is the risk of knowledge imbalance within the dyad, or incompatible pairs [31,32]. In the two sessions of this study, we could see variations of previous knowledge within different fields. It is worth noting that instances when one student took the lead and suggested how the pair should continue during the reasoning process were apparent. In our data, negotiations and arguments for specific decisions were observed in both sessions. From a learning perspective, this might lead to consolidation of knowledge for the leading person while the more reflective peer contributes with different perspectives and suggestions. In session #2, one student was repeatedly referring to clinical experiences as a basis for the reasoning, whereas her peer was more analytical. In both sessions, different perspectives contributed to a richer picture, and disagreements were resolved during reasoning. During this process, the peer with a higher level of knowledge within a specific field had to provide arguments for their reasoning. However, one could assume that if one peer repeatedly displays lack of knowledge and needs to rely on the other, the reasoning process and the learning experience may be hampered. A study of online dyad settings reported inconclusive results of learning outcomes when pairs were asymmetric in terms of their level of knowledge [32]. More research on knowledge symmetry within the pairs is needed to identify optimal ways to match learners according to their level of knowledge and thus best support their learning.

The arranged VP situation allowed the pair to take the time to reason broadly, ponder over certain issues, and even experiment with physical examination procedures. This slowed-down, broader reflection is rare during a time-constrained real-life patient encounter. The VP setting provides a less stressful milieu for reasoning and reduces the perceived demands on having to appear knowledgeable in front of patients and educators [33]. Throughout the task, the students adopted the role of a treating physician, navigating themselves toward the right diagnosis, and making decisions about future management. However, the educational setting prevailed and the observed emotional engagement was not at the same level as when, for example, enacting acute patient scenarios in full-scale manikin-based medical simulations [34]. In addition to acting professionally, student roles were also adopted during the sessions. For example, the students referred to lecture notes, negotiated how one should approach the task, and referred to their own previous learning processes. The clear benefit of the VP case approach is a less formal and less demanding climate, allowing the students to expand their reasoning and reflection beyond what

is possible in a full-scale simulation scenario or an authentic patient encounter, where decisions have to be made instantly.

## Methodological Considerations

A major strength of this study was the in-depth analysis of the sessions. However, the low number of sessions studied could be considered a limitation, as it limits the generalizability of our observations when applying them to other contexts. Thus, the identified themes are neither exhaustive nor expected to be replicated in all settings. Moreover, the characteristics of the specific cases and the VP interface may have influenced the reasoning process, and therefore the findings cannot be generalized to any VP dyad setting. The methods of observation provided not only an increased awareness of how students' reasoning processes function while exploring a VP case but also an insight into how peer interactions may relate to clinical reasoning. However, it is worth noting that the students were aware of the fact that they were being filmed during the sessions, and a social desirability effect may have impacted their interactions.

## Implications

By actively taking part in verbal reasoning and highlighting the process as well as the outcome, the students increase the meta-awareness of their reasoning [35]. Meta-awareness is related to diagnostic outcomes [36]. Such an awareness can be created in collaborative VP sessions and followed up further in seminars, during which the students reflect both on the reasoning process and clinical content. Even greater focus on reasoning strategies could possibly be achieved by taking notes or, for example, visualizing reasoning steps in a mind map and then discussing them in a follow-up seminar. A visual representation in adjunct to a VP system has recently been developed by other researchers [37].

The number of VPs in this setting was small. Therefore, they do not substantially contribute to the nonanalytic aspect of expert reasoning. However, the dyad setting contributes to an in-depth encounter with a few cases supporting the analytic thinking. This analytic thinking process, and the awareness thereof, requires cognitive efforts and time to be processed. VP scenarios and the surrounding educational framework should therefore be designed carefully, taking the benefits of reasoning into consideration [38].

VP activities can be organized in different ways; these different arrangements may influence both the learning process and learning outcomes [24]. When integrating VPs, it is logistically tempting to instruct the students to work with the VP scenarios individually and independently on their own accord. This type of integration design has the clear benefit of flexibility but relies on the students' own motivation and discipline. Edelbring et al found that fewer students (49% compared with 65%-96% of the students in a course) accessed the VPs, and these students also accessed fewer VP cases (an average of 1.27 out of 4 cases available) in an individual flexible integration compared with two different settings with scheduled follow-up seminars [39]. A link between VP course integration arrangements and student efforts to access and make use of VPs has been identified in various VP settings [40,41]. In this respect, arranged dyad

settings may contribute to improved learning outcomes as a result of shared reasoning and provide a means for students to delve deeper and more broadly into the VP cases. Shared reasoning is clearly a means to better educational outcomes and fosters the collaborative and reflective practice needed in health care [13,19].

## Conclusions

The dyad setting enabled a stepwise investigation of VP cases and elaborated reasoning. Both analytic and nonanalytic reasoning occurred during the interactions. The VP activity also triggered interactions with other sources, which served as tools for information gathering and contributed to consolidation of knowledge. The VP design and the dyad arrangement enabled reasoning and rigorous learning processes that are unlikely to occur in individual settings.

## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Supplementary methods information.

[[PDF File \(Adobe PDF File\), 20KB - mededu\\_v4i1e4\\_app1.pdf](#) ]

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## Abbreviations

- NSAID:** nonsteroidal anti-inflammatory drug  
**RA:** rheumatoid arthritis  
**VP:** virtual patient

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Original Paper

# A Web-Based Course on Public Health Principles in Disaster and Medical Humanitarian Response: Survey Among Students and Faculty

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## Abstract

**Background:** Web-based public health courses are becoming increasingly popular. “Public Health Principles in Disaster and Medical Humanitarian Response” is a unique Web-based course in Hong Kong. This course aimed to fill a public health training gap by reaching out to postgraduates who are unable to access face-to-face learning.

**Objective:** The aim of this paper was to use a structured framework to objectively evaluate the effectiveness of a Web-based course according to Greenhalgh et al’s quality framework and the Donabedian model to make recommendations for program improvement.

**Methods:** An interim evaluation of the first cohort of students in 2014 was conducted according to the Donabedian model and a quality framework by Greenhalgh et al using objective and self-reported data.

**Results:** Students who registered for the first cohort (n=1152) from June 16, 2014 to December 15, 2014 (6 months) were surveyed. Two tutors and the course director were interviewed. The Web-based course was effective in using technology to deliver suitable course materials and assessment and to enhance student communication, support, and learning. Of the total number of students registered, 59.00% (680/1152) were nonlocal, originating from 6 continents, and 72.50% (835/1152) possessed a bachelor’s or postgraduate degree. The completion rate was 20.00% (230/1152). The chi-square test comparing students who completed the course with dropouts showed no significant difference in gender ( $P=.40$ ), age ( $P=.98$ ), occupation ( $P=.43$ ), or qualification ( $P=.17$ ). The cost (HK \$272 per student) was lower than that of conducting a face-to-face course (HK \$4000 per student).

**Conclusions:** The Web-based course was effective in using technology to deliver a suitable course and reaching an intended audience. It had a higher completion rate than other Web-based courses. However, sustainable sources of funding may be needed to maintain the free Web-based course.

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**KEYWORDS**

disaster planning; online education; Donabedian model; public health

## Introduction

### Web-Based Public Health Courses

With the recent advances in Internet connectivity and increased mobile phone usage, Web-based public health courses have become increasingly convenient and popular. These vary from accredited courses such as Web-based master's and doctoral degrees to credit-free courses such as the massive open online courses (MOOC), which became popular in 2011 after Stanford University launched its first MOOC [1]. A single MOOC can have enrollment exceeding 100,000 students [2]. The majority of schools accredited by the Council on Education for Public Health offer Web-based courses [3].

Web-based courses offer opportunities for flexible learning, as students are not restricted to learn at fixed times and places. Cost of travel, living expenses, and tuition are reduced as compared with on-site courses. Students may also benefit from exposure to peers from a wider range of global backgrounds. These advantages may be especially appealing to those working in disaster settings, often with irregular schedules in developing countries. The University of South Florida College of Public Health offers numerous Web-based courses but reported that the course in global disaster management and humanitarian relief grew most quickly in popularity [1].

### “Public Health Principles in Disaster and Medical Humanitarian Response” Web-Based Course

This is a free 6-month program offered to anyone with interest in disaster and medical humanitarian response, although it is aimed at postgraduate level. All material is available on the Web and is completed independently at each participant's desired pace. Support from fellow students is available through online forums, and tutors answer queries via email. Program milestones consist of 4 formative quizzes and 1 final quiz, where a minimum score is required for course progression and certificate of course completion. [Table 1](#) describes the program schedule.

### Effectiveness of the Web-Based Course

A meta-analysis by the US Department of Education reported that purely Web-based learning is as effective as classroom instruction. Most studies surveyed students' demographics, knowledge, satisfaction, and completion rates [4,5]. Although these criteria are useful for comparing online learning with classroom instruction, they are insufficient for comprehensively evaluating online learning. Web-based courses encounter differing levels of participation and completion. Many students participate in MOOCs, but the completion rate is only 7.0% to 9.0% [6]. This may be due to potential barriers negatively affecting students' experience of online learning, such as technical problems, decreased instructor and peer presence, and difficulties in time management and self-directed learning [7]. These problems may be further exacerbated by the wide range of student backgrounds in education, culture, technical access, and time. There is lack of framework for standardized evaluation of Web-based courses. The Quality Assurance Agency for Higher Education does not assess MOOCs, as they are noncredit bearing and have no entry requirements [8]. The objective of this study was to use a structured framework to objectively evaluate the effectiveness of a Web-based course according to Greenhalgh et al's quality framework and the Donabedian model to make recommendations for program improvement.

### Source of Data for Evaluation of the Web-Based Course

The Web-based course will be evaluated using multiple sources of data such as course website content, assessment scores (quiz results), incoming student survey (1152 respondents; see [Multimedia Appendix 1](#)) and outgoing student survey (244 respondents; see [Multimedia Appendix 2](#)), dropout student survey (170 respondents; see [Multimedia Appendix 3](#)), semistructured staff interview (tutor and course director), and staff curricula vitae. [Table 2](#) summarizes sources of data used for evaluation and the information provided.

**Table 1.** Program structure of the “Public Health Principles in Disaster and Medical Humanitarian Response” Web-based course.

Lesson number and topic	Assessment	Program milestones
1 Public Health Approaches to Medical Disaster Response	Quiz 1	Progress to lesson 3 after achieving 80.0% score
2 Disaster Concepts and Trends		
3 The Impact of Disasters	Quiz 2	Progress to lesson 4 after achieving 80.0% score
4 The Human Health Impact of Disasters	Quiz 3	Progress to lesson 5 after achieving 80.0% score
5 Responding to Health Needs in Disasters (I)	Quiz 4	Progress to lesson 6 after achieving 80.0% score
6 Responding to Health Needs in Disasters (II)		
7 Public Health Emergency Preparedness		
Lessons 1-7	Final quiz	Course completion certificate after achieving 60.0% score

**Table 2.** Sources of data for evaluation.

Source of data	Existing data	Information provided		Missing information
		Strength	Weakness	
<b>Data on the Web-based course</b>				
Course website	Structure and format of the course	Enables benchmarking with criteria to describe what is sufficiently included and what is lacking in the course	No qualitative or quantitative data analysis	No data on students, staff, or outcomes
Course assessment scores	Formative and final quiz results	Enables comparison with other programs	Evaluation of knowledge gained during the course only	No data on staff and student perceptions only
<b>Data on students</b>				
Incoming student survey	Student demographics	Standardized set of questions; high response rate (100.00%, 1152/1152); quantitative data analysis; provides information on student background; enables comparison with other programs	Does not directly evaluate the course	No data on staff and student perceptions or outcomes
Outgoing student survey	Student perceptions	Standardized set of questions; quantitative and qualitative data analysis; enables comparison with other programs	Low response rate (21.00%, 244/1152); self-reported data; only students who completed the course participated; therefore, results are prone to bias	No data on staff perceptions
Dropout student survey	Student perceptions	Standardized set of questions; quantitative data analysis; enables comparison with other programs	Low response rate (19.0%, 170/908); self-reported data; prone to bias because of low response rate	
<b>Data on staff</b>				
Staff interview	Staff perceptions	Qualitative data analysis	Small sample size; cannot compare with other programs	No data on outcomes
Curricula vitae of staff	Staff qualifications	Provides information on staff background; enables comparison with other programs	No quantitative or qualitative data analysis	No data on outcomes and student and staff perceptions

## Methods

### Evaluation Framework

Evaluation was based on the Donabedian model [9] and Greenhalgh et al's quality framework for evaluating Web-based courses [10]. Table 3 summarizes the overlapping components of the frameworks.

### Six Criteria of Quality Framework by Greenhalgh and Colleagues

Following are the six criteria of Greenhalgh et al's quality framework:

1. Course materials: Course materials will support the overall program aims, provide clear learning objectives, and promote active learning.
2. Interactive learning environment: Formal online discussions on key topics (virtual seminars) will support the overall program goals through high-quality, focused, academic discourse, collaboration, and lateral support.
3. Tutor performance and development: Module tutors will be appropriately qualified, trained, and supported to deliver high-quality learner support in the online environment.
4. Assessment: Assessment will be valid, reliable, fair, appropriate, efficient, timely, formative, and summative.
5. Student communication and support: The program will be supported by accessible, accurate, and up-to-date documentation. Support and advice will be tailored to the needs of individual students. There will be an effective system of student representation.
6. Administrative and technical support: Administrative and technical systems will support the program goals through high-quality service delivery, multidisciplinary teamwork, effective communication, and robust technological infrastructure. Administrative and technical staff will have clear roles and responsibilities and will be adequately supported in their work.

The Donabedian model [9], was originally developed to evaluate health care service programs but has also been adapted to evaluate courses with a Web-based component, such as blended learning [11]. In addition, it addressed practical outcomes such as whether the course reached the intended audience and cost.

Greenhalgh et al's quality framework was developed to assess a Web-based MSc program [10].

### Study Period

Study period was defined as the course period for the first cohort of students, that is, June 16, 2014 to December 15, 2014 (6 months).

### Study Subjects

Students who registered for the first cohort (n=1152) were included in the study. Two tutors were interviewed for assessing tutor performance and development, as well as administrative

and technical support. The course director was interviewed when assessing the course cost. Verbal consent was obtained during interviews; all responses were anonymized; and permission was sought to review relevant documents such as course materials and surveys. This study fell under the auspices of learning and evaluation in the university and therefore did not need ethical approval.

### Data Source and Analysis

Table 4 summarizes the data source and analysis corresponding to the framework dimensions.

**Table 3.** Matrix of overlapping components of the evaluation frameworks.

Donabedian model	Greenhalgh et al's framework
Structure and process	<ul style="list-style-type: none"> <li>• Course materials</li> <li>• Interactive learning environment</li> <li>• Tutor performance and development</li> <li>• Student communication and support</li> <li>• Administrative and technical support</li> </ul>
Outcome	<ul style="list-style-type: none"> <li>• Assessment</li> </ul>
<ul style="list-style-type: none"> <li>• Whether the course reached the intended audience</li> <li>• Cost</li> </ul>	

**Table 4.** Framework dimensions, data source, and analysis.

Framework dimension	Data source and analysis
Course materials	<ul style="list-style-type: none"> <li>• Examine course materials from CCOUC<sup>a</sup> website</li> <li>• Quantitative analysis of outgoing student survey: all students completing the final quiz responded (n=244)</li> </ul>
Interactive learning environment	<ul style="list-style-type: none"> <li>• Examine interaction in the student discussion forum</li> <li>• Semistructured interview with the course tutor</li> <li>• Summarize relevant comments in the outgoing student survey</li> </ul>
Tutor performance and development	<ul style="list-style-type: none"> <li>• Examine curricula vitae of the tutor</li> <li>• Semistructured interview with the course tutor</li> </ul>
Student communication and support	<ul style="list-style-type: none"> <li>• Quantitative analysis of incoming and outgoing student survey</li> <li>• Examine course website for evidence of clarity, accuracy, and completeness of information on program content</li> <li>• Examine course website for individualized summary of progress</li> <li>• Semistructured interview with the course tutor</li> </ul>
Administrative and technical support	<ul style="list-style-type: none"> <li>• Examine job descriptions and curricula vitae of staff in administrative and technical roles</li> <li>• Examine funds allocated to administrative and technical support</li> <li>• Summarize relevant comments in the outgoing student survey</li> <li>• Semistructured interview with administrative and technical staff</li> </ul>
Assessment	<ul style="list-style-type: none"> <li>• Examine assessment materials and methods on course website</li> <li>• Quantitative analysis of assessment scores: assessment consisted of multiple-choice questions automatically graded by the computer</li> <li>• Quantitative analysis of the outgoing student survey</li> <li>• Semistructured interview with the course tutor</li> </ul>
Whether the course reached the intended audience	<ul style="list-style-type: none"> <li>• Quantitative analysis of incoming and outgoing student survey</li> <li>• Analysis of the dropout student survey</li> </ul>
Cost	<ul style="list-style-type: none"> <li>• Interview with the course director</li> </ul>

<sup>a</sup>CCOUC: Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response.



## Results

### Course Materials

Overall program aims were as follows:

- Understand and discuss public health needs and gaps in disaster preparedness and response, specifically in the context of the Asia Pacific region.
- Systematically formulate key guiding questions during pre- and postdisaster phases to drive evidence-based disaster mitigation actions.
- Select and consult relevant and credible databases, guidelines, and documents to address the above issues.

Course materials supported the overall program aims by providing accessible online reading and multimedia materials. Reading materials were classified by level of difficulty, with optional “A-Closer-Look” text boxes to give additional context. A glossary was provided and a “Take-home Message” at the end of each section. Occasionally, students were directed to watch relevant videos on external websites. Clear learning objectives were provided at the start of the course and each chapter. Active learning was promoted by “Stop-and-Think” activities that posed a question, with answers behind a reveal button. There were polls for students to vote on a question and compare opinions.

Figure 1 shows responses to the outgoing student survey, recorded on a Likert scale, from 1=strongly disagree to 6=strongly agree.

Most students answered positively regarding course content. In all 8 areas, over 90.0% (220/244) of students selected 4 or above (slightly agree, agree, or strongly agree). In the following 5

areas, over 80.0% (195/244) of students selected 5 or 6 (agree or strongly agree):

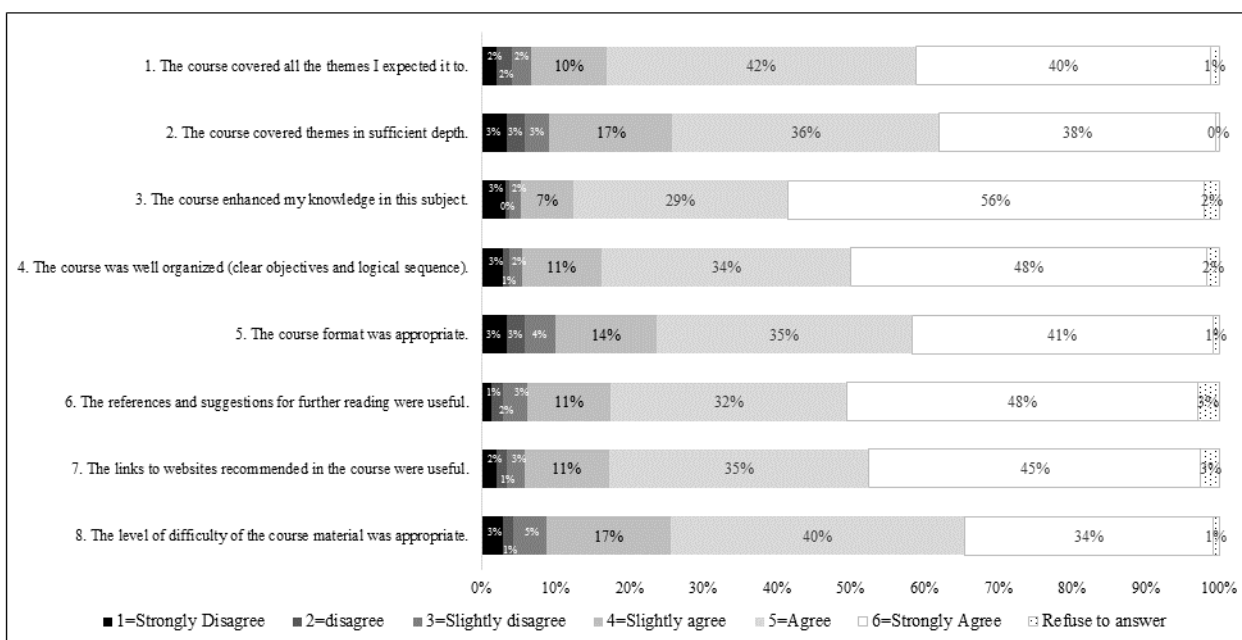
- The course covered all the themes I expected it to
- The course enhanced my knowledge (concepts and principles) in this subject
- The course was well organized (clear objectives and logical sequence)
- The references and suggestions for further reading were useful
- The links to websites or other parties/organizations recommended in the course were useful

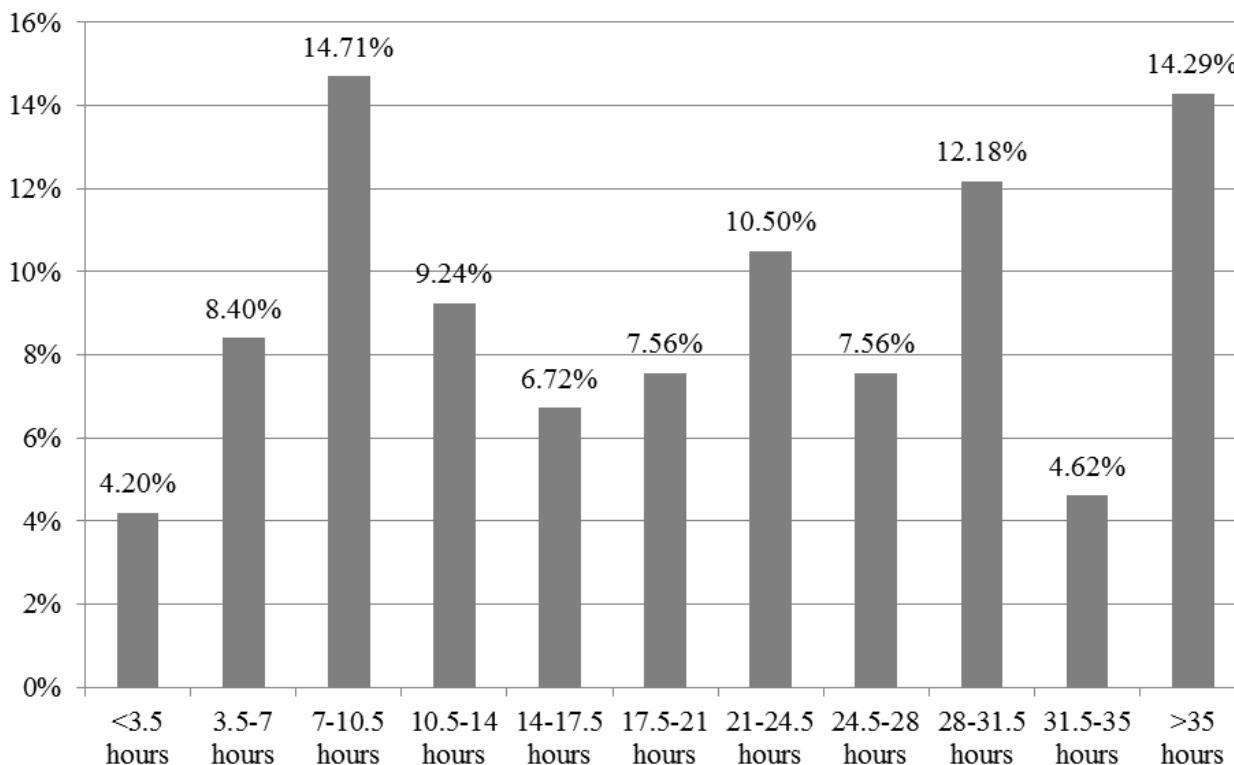
The course overview gave a clear estimation of workload, which was 1-3 hours per lesson, totaling 7-21 hours for 7 lessons. Figure 2 shows the total actual workload. Actual workload varied highly, from <3.5 hours to >35 hours. The most frequent responses were “7 hours to less than 10.5 hours” (14.7%, 36/244) and “35 hours or more” (14.3%, 35/244).

### Interactive Learning Environment

Content analysis of the online forum was conducted. There were no formal online discussions. However, each lesson had an informal discussion forum. Participation was voluntary and asynchronous. Students were free to create new threads on any topics. This was facilitated by the course tutor who occasionally read through threads and responded to questions. However, most of the content was grounded, drawing on students’ own experiences and course materials. For example, 1 student created a discussion thread on Ebola outbreak, which occurred during the course but was not covered in course materials. Others used the forum to reinforce learning of course materials by posting lesson summaries. Moreover, 6.60% of the students (76/1152) posted on the forum, generating 75 new threads and 216 posts.

Figure 1. Student responses to statements regarding course content.



**Figure 2.** Number of hours students spent studying.

Semistructured interview with the course tutor (who also served as the technical support officer) and subsequent content analysis revealed that there were no student complaints of difficulty in accessing the forum or problems with online etiquette. In the outgoing student survey, 1 question invited students to write any comments about the course or any specific suggestion as to how it could be improved: Several requested more online videos (eg, lectures) to supplement course materials, whereas only 1 student suggested the course could be improved by holding an online video conference.

### Tutor Performance and Development

Semistructured interviews were conducted with the program director and tutors. Questions were adapted from Greenhalgh et al's quality framework criteria, standards, evidence, and quality failures. Subsequent content analysis was done according to these themes. The program director chose 2 tutors who also functioned as technical support officers throughout the course. Both were originally research assistants with Master of Public Health degrees who helped develop the course content. As there was no compulsory interaction on the course, tutors were only responsible for answering student queries and occasionally facilitating online discussion. This was done in addition to other roles and responsibilities that tutors had as research assistants for other projects. The program director appraised the tutors' performance annually, although not specifically for the Web-based course. Tutor development was encouraged. One tutor is a PhD student and has been promoted to assistant lecturer, whereas the other has published in the *Lancet*.

Interview with the course tutor revealed that their workload was manageable and questions posed by students were within their capability. Students usually emailed the first tutor listed on the

website. There were a few queries, ranging from course logistics to technical support. Students preferred to discuss academic questions among themselves in the forum, rather than asking the tutors. In the outgoing student survey, there were no complaints about the tutors or their level of input.

### Student Communication and Support

The course website clearly stated learning objectives for each lesson, expected time commitment, and required assessments to progress and gain a certificate. A personal progress log was available to each student. The course tutor's contact details were listed for student queries. There were Web-based links to explore beyond course materials and an online forum for informal discussion. Student views were actively sought through a Web-based evaluation survey. In the outgoing student survey, 63.9% (156/244) had taken a similar course before, with 91.8% (224/244) rating the course as similar or better, and 93.9% (229/244) were satisfied with the course overall. Interview with the course tutor revealed that few students had queries regarding course navigation, material, or technical difficulties.

### Administrative and Technical Support

The program director selected course tutors to provide administrative and technical support, in addition to academic support. There was no dedicated training budget for tutors. In the outgoing student survey, there were no complaints regarding lack of administrative or technical support. Of 244 students, 181 (74.2%) preferred online learning over face-to-face learning. However, several students requested a PDF version to aid revision, as they lived in areas with suboptimal Internet access. Interview with course tutors revealed that there were few queries requesting administrative or technical support. All were within their capabilities.

## Assessment

Assessment consisted of Web-based multiple-choice questions completed anytime within the course. There were 4 short self-assessment quizzes and 1 final quiz for course completion. There were 10 questions in each short quiz. An 80.0% score was needed for students to proceed to the next lesson. Students were free to retake quizzes. As quizzes were drawn from a question bank, retake questions were not necessarily the same. The final quiz tested all course materials. A 60.0% score was required to achieve a certificate of completion. This method of assessment is reliable, as all questions are drawn from the same question bank and marked electronically. However, as there was no live monitoring during the quiz, it may not be a fair assessment, as it would be difficult to guard against cheating (eg, if someone else took the quiz in place of the student). This method has other advantages of being efficient, as minimal tutor time is required because of automatic computer marking. In addition, multiple formative quizzes allow students to have timely feedback on their progress.

The process of reviewing assessment questions was described in an interview with the course tutor. Course authors developed the assessment questions. These were reviewed by the program director, who is an international expert. Although course content was peer-reviewed by numerous academic colleagues, assessment questions were not reviewed by them, thereby decreasing content validity.

Figure 3 shows average and median grades of all quizzes. Average grades for first attempts of the first 4 formative quizzes were between 63.2% and 69.0%. The average student needed to reattempt each quiz at least once to achieve the required grade to progress to the next lesson. The average grade for the first attempt of the final quiz was 63.6%, which would have been high enough for the average student to obtain the completion certificate (issued for grades of 60.0% or above) on their first

attempt. Out of 1152 students registered in the cohort, 244 took the final quiz and 233 passed and gained a certificate of completion.

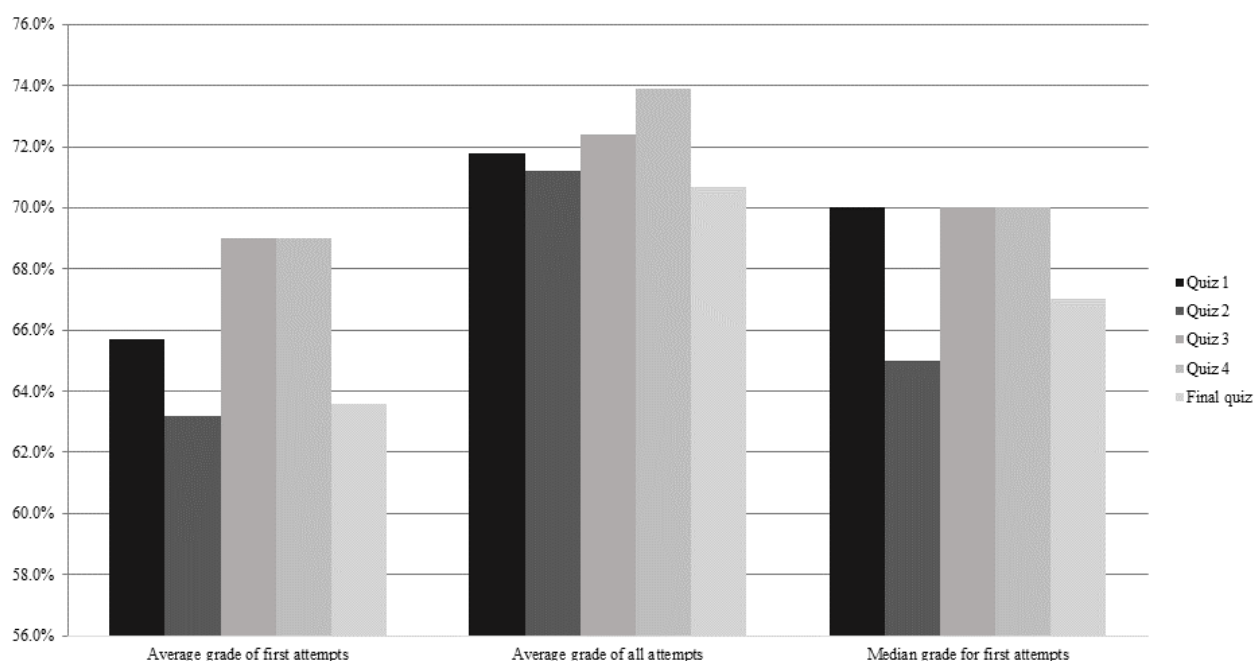
Figure 4 shows opinions on the assessment methods in the outgoing student survey. Most agreed that assessment methods of quizzes were appropriate. The scores and survey responses indicate an appropriate assessment, where course materials content is reasonably assessed in quizzes.

## Whether the Course Reached the Intended Audience

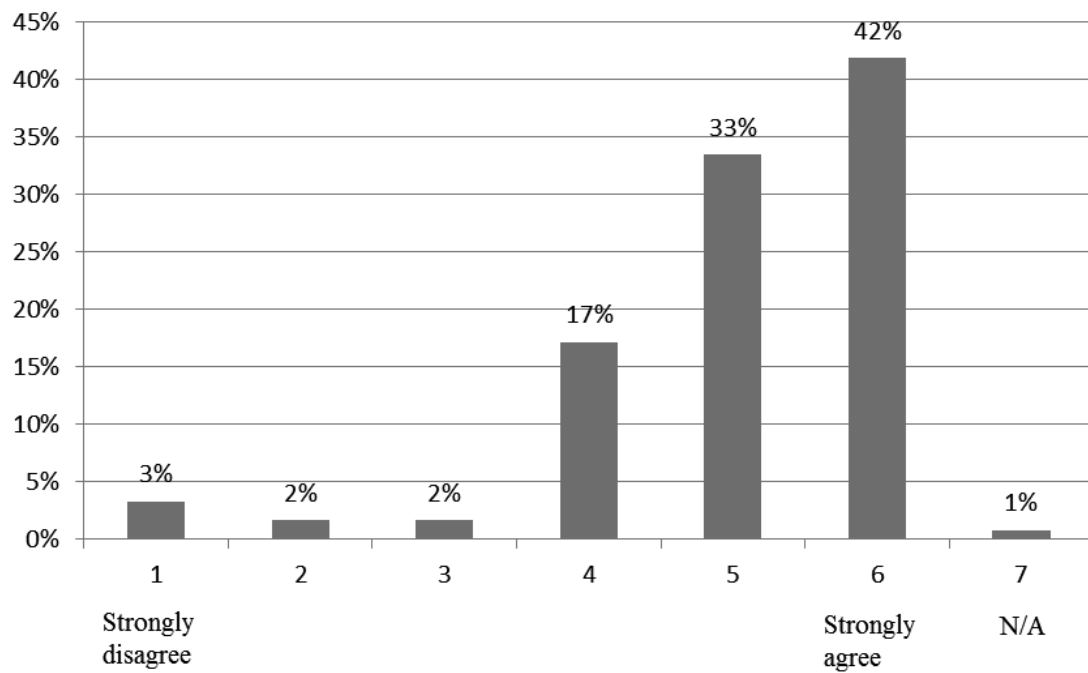
The course was intended for postgraduates who are unable to access face-to-face learning. In a survey of all students ( $n=1152$ ), the gender balance was roughly equal: 49.30% (568/1152) female, 50.50% (582/1152) male, and 0.00% (2/1152) who answered "others"). Figure 5 depicts student age. Most students were aged between 18 and 39 years. Figure 6 depicts students' occupations. Most worked in nongovernmental organizations, health care sector, or were students. Figure 7 depicts highest academic qualifications obtained by students. Students' highest academic qualifications were mostly a bachelor's or a master's degree. Figure 8 depicts students by continent. The majority of students came from Asia, with 41.00% being (472/1152) from Hong Kong.

The chi-square test comparing students who completed the course with dropouts showed no significant difference in gender ( $P=.40$ ), age ( $P=.98$ ), occupation ( $P=.43$ ), or qualification ( $P=.17$ ). Among those who completed the course, 48.7% (119/244) were local. A survey of 170 dropout students revealed that the main reasons for dropping out were change in schedule 71.2% (121/170) and lack of Internet access 25.9% (44/170). Moreover, 85.3% (145/170) would recommend the course to other people. As most students had at least a bachelor's degree and were nonlocal (and therefore would have difficulties attending face-to-face learning), the course managed to reach the intended audience.

Figure 3. Average and median quiz grades.



**Figure 4.** Students' responses to statement that assessment methods (quizzes) were appropriate. N/A: not applicable.



**Figure 5.** Student age (years).

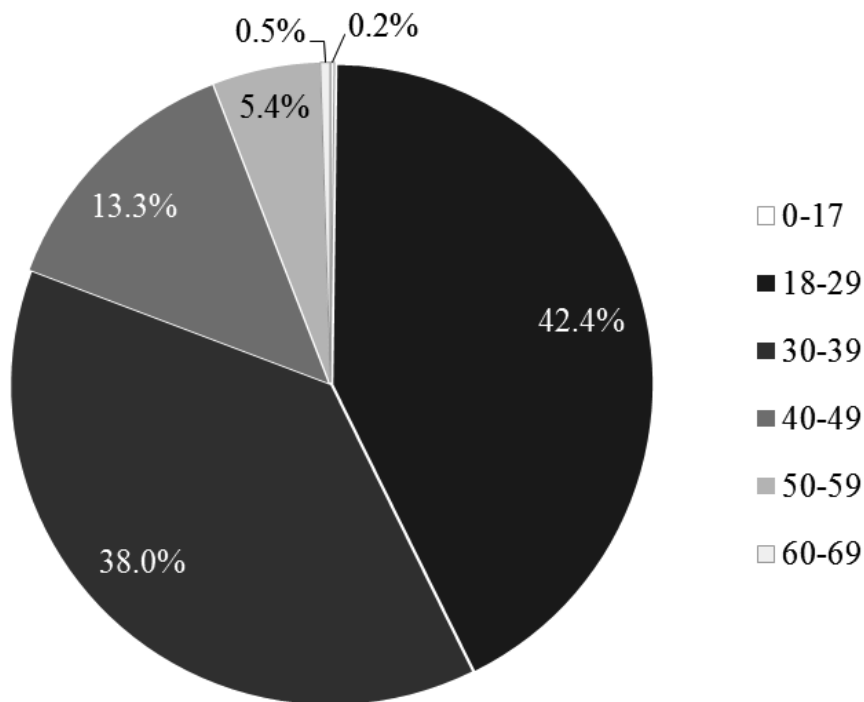


Figure 6. Student occupation.

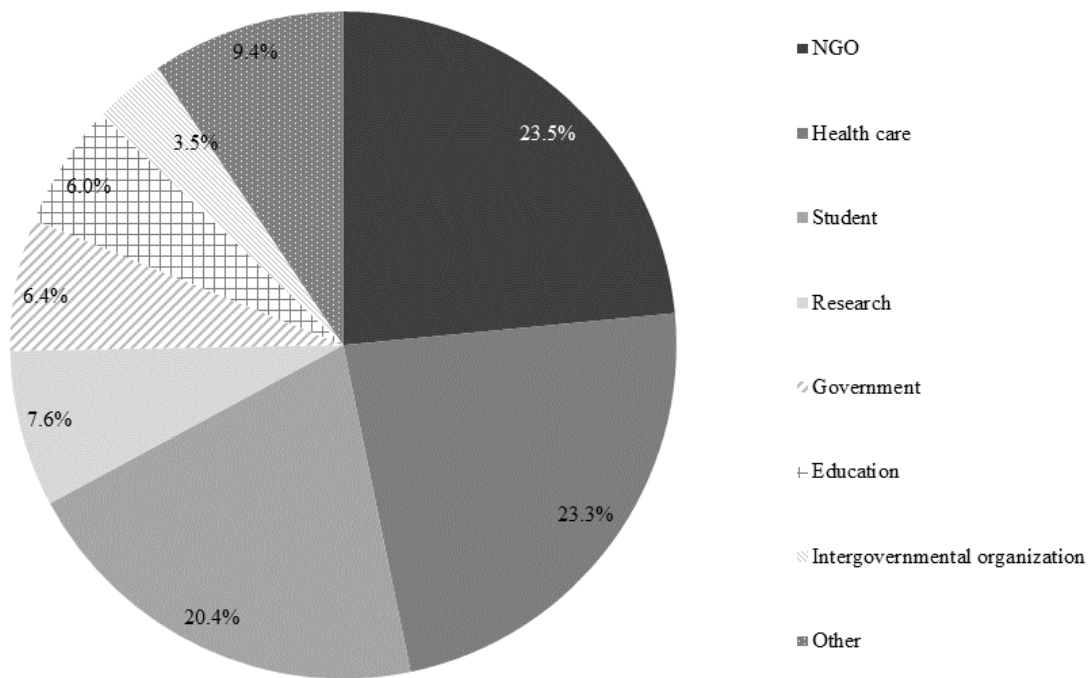
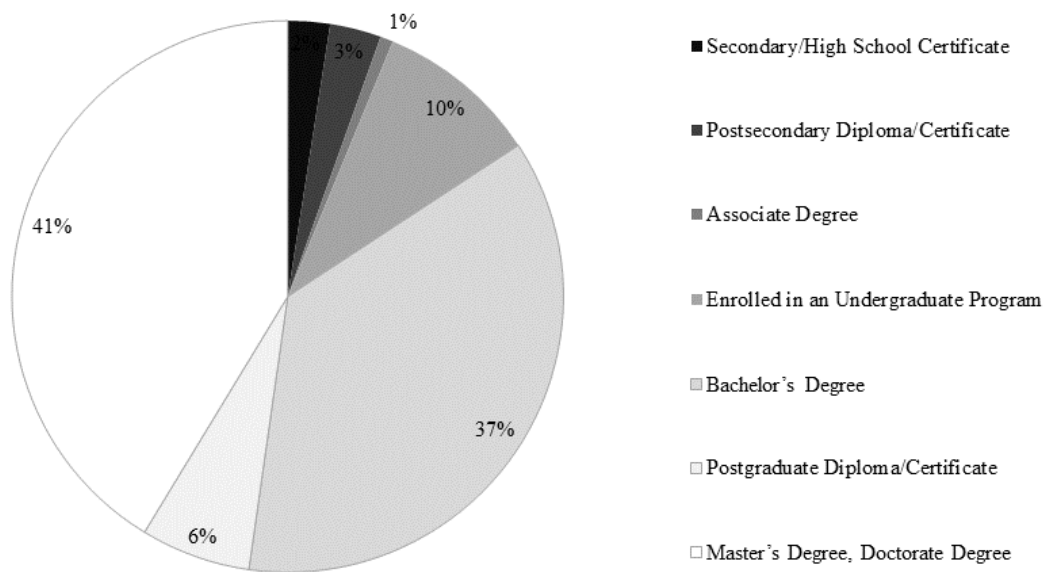
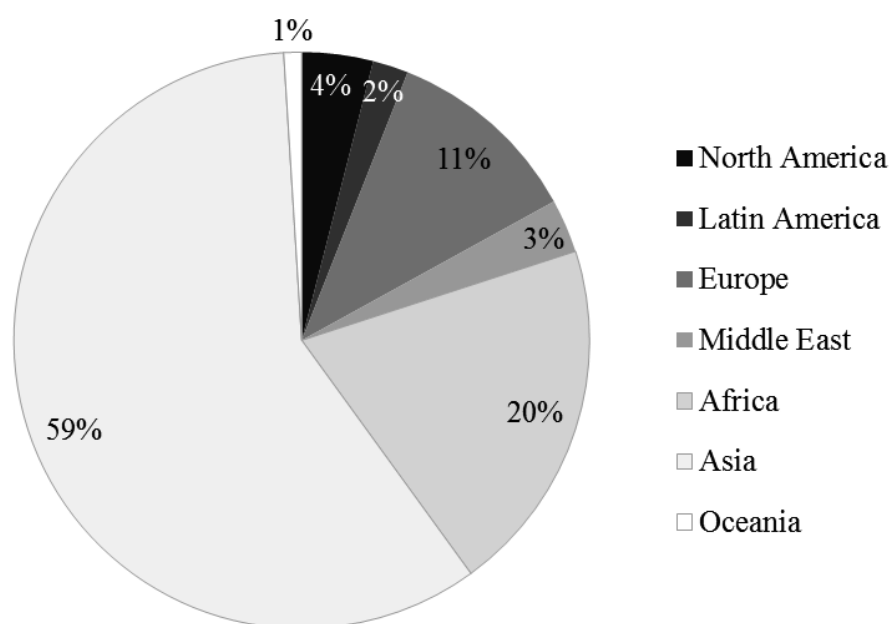


Figure 7. Students' highest academic qualifications.



**Figure 8.** Students by continent.

### Cost

Interview with the course director revealed that a grant of HK \$109,000 was given to enroll 4000 students across 6 cohorts. This resulted in an average cost of HK \$35 per enrolled student. In contrast, a face-to-face course with the same content at CUHK (The Chinese University of Hong Kong) charged a HK \$513 enrollment fee.

## Discussion

### Principal Findings

Our study used Greenhalgh et al's quality framework and the Donabedian model to assess the effectiveness of a Web-based course. This was done through content analysis of the course website, quantitative analysis of assessment scores and students' surveys, semistructured interview with staff, and examining related administrative documents. Overall, the Web-based course was effective in using technology to deliver suitable course materials and assessment and to enhance student communication, support, and learning. It reached its intended audience of postgraduates who would have difficulties attending face-to-face learning, and the cost per student was much less compared with an equivalent face-to-face course.

The course materials supported the program aims by providing high-quality accessible reading and multimedia materials. These enabled students to "understand public health needs and gaps in disaster preparedness and response," but not necessarily to "discuss" them; as there were no interactive tutorials or formal discussions, the interactive learning environment was dependent on informal interaction on the discussion board. Although this was used throughout the course, only 6.60% of students posted comments. In addition, to "formulate key guiding questions" and "select and consult relevant and credible databases, guidelines and documents to address the above issues" were

part of the program aims. However, it would be difficult to develop these skills in depth during the course, as additional assignments (eg, exercises for group interaction or essay writing) would be needed to achieve these aims. Learning objectives were clearly stated and course materials promoted active learning, although not to the extent of fulfilling all program aims. Students were generally satisfied with the content and format of the course materials, suggesting that their personal aims might be less ambitious than the program aims. Additional assignments would require more tutor resources. Peer grading has been advocated in MOOCs, but suffers from difficulty in quality control [12]. In addition, the funnel of participation might further narrow, resulting in less students participating and completing the course [13]. Modifying the program aims to align with student aims might be more realistic than increasing active learning to achieve the current program aims.

One of the quality failures listed in the quality framework [10] noted that "poor performance by a majority of students on a course should raise questions about course design or tutor competence, whereas poor performance by a minority of students is usually attributable to other factors." As average performance in assessments was reasonably satisfactory, it could be concluded that course design and tutor competence were adequate. Course tutors were familiar with the course materials, as their research was in similar areas. However, tutors played a passive role in the course: students sought out tutors infrequently, and tutors monitored and occasionally participated in organic discussions. This approach to teaching has also been used in other MOOCs [14]. In a face-to-face setting, tutors could identify struggling students by inattention or lack of attendance, with early intervention to improve learning. However, identifying these students in a Web-based environment is difficult, especially with large enrollment numbers. This may account for the low completion rate of MOOCs [7]. Current research aims at using student engagement on the Web to

identify those who are struggling [15], which may improve completion rates while posing less additional burden on the tutor.

Assessment questions would have improved content validity if peer-reviewed by experts. Assessment using Web-based quiz was reliable, although not necessarily as fair as face-to-face assessment. The Web-based quizzes were appropriate, efficient, and timely and included both formative and summative assessment. The assessment format may have been conducive to the relatively high course completion rate (20.00%, 230/1152) as compared with MOOCs with completion rates of 7.0% to 9.0% [6]: the quizzes had flexible quiz deadlines and did not combine other assessment methods. One study comparing multiple MOOCs showed that courses with flexible deadlines had higher course completion rates (15.5%) compared with those with firm deadlines (4.6%). In addition, courses with solely Web-based quizzes as assessment methods had a higher course completion rate (14.9%) compared with those combining quizzes with other assessment methods such as peer assessment (7.9%) [14]. Another study reported that the result of multiple Web-based quizzes throughout the course was the strongest explanatory variable in final exam scores when compared with other assessment methods (eg, self- and peer assessment) [16].

Participants had similar backgrounds to those in other MOOCs; they were mostly young, well educated, and employed. However, they differed in gender and location. One study reported 56.9% of male participants across 32 MOOCs, whereas the Web-based course had 49.30%. In addition, most students at the University of Pennsylvania's MOOCs came from the United States or non-US OECD (Organisation for Economic Co-operation and Development) countries [17]. In contrast, students in the Web-based course mostly came from Asia, with 41.00% (472/1152) from Hong Kong. This reflects the tendency of Web-based courses to attract participants locally as well as internationally. As most students were international (59.00%, 680/1152), the Web-based course effectively reached a diverse population who did not have easy access to a face-to-face course in Hong Kong.

Participant demographics point to a cohort who would likely be more self-motivated and technology literate than the general population. Most students in the Web-based course had at least a bachelor's degree, which coincided with the course's target audience, who were postgraduate-level public health practitioners working in the field of disaster management. Adequate learning infrastructure might provide sufficient support to these students. The Web-based course provided this infrastructure through resources on the Web, forums, and a "check your progress" tool. Most outgoing students reported satisfaction with the course, and there were no complaints regarding the level of communication and support provided. In addition, students dropped out mainly because of personal reasons. A higher level of student support could be provided by using the "check your progress tool" to alert the staff about students who are progressing poorly through the course.

Despite the lack of specific staff training budget, students who completed the course were generally satisfied with the administrative and technical support. This may be related to the

choice of online platform. Moodle was used, with the advantage of being free and widely used globally [18]. In addition, the bulk of course material was in written format, enabling easier access to those with lack of high-speed Internet. Although some students suggested including video lectures, using this format would have increased access difficulty, which increased technical support may be unable to solve. On the other hand, some students requested a PDF version so as to increase access to the course material when the Internet was not available. Studies analyzing video use in MOOCs reported that only half of participants and certificate earners watched the majority of course videos [19,20]. Despite participants from developing countries such as India earning the most certificates compared with other countries, use of video lectures was conversely lower. One explanation was that poor Internet access was an obstacle to downloading videos [21]. Another study conducted in fragile contexts, which the Web-based course aims to reach, noted that video lectures were an insurmountable obstacle and that downloaded materials were widely shared locally, enabling a wider reach of learners than those who initially accessed the material on the Web [22]. The conflicting student comments from the Web-based course reflect a range in preferred learning styles and ease of technological access. Including video lectures would require more financial resources, yet appeal to more people. However, changing the format from written course material to video lectures might result in excluding those with limited Internet access. The lack of request for online video conference or live tutorial discussions could be because of the required technology, extra time commitment, and difference in student time zones, which may discourage participants.

The cost of the course was reasonable, with the Web-based course costing significantly less than a comparable face-to-face course.

### Implication of Findings

Using the Donabedian model [9] and Greenhalgh et al's [10] structured quality framework enabled this evaluation to identify strengths and weaknesses that would be omitted in a conventional evaluation that assessed outcomes only. The resulting comprehensive approach to evaluation will be useful for providing recommendations to improve the program.

### Limitations

Ideally, the Web-based course should have multiple independent reviewers to evaluate the program. However, in this report, there is only 1 reviewer (the author). As it was difficult to find frameworks to adequately evaluate free Web-based courses, the quality framework used was originally developed from evaluation of a Web-based MSc course. These Web-based MSc courses are accredited, fee paying, and last up to 5 years [23]. In contrast, the course is nonaccredited, free, and lasts for 6 months. Thus, some of the criteria were difficult to apply to the course, as the course would have less resources and educational time when compared with the Web-based MSc course.

As the Web-based course attracted students globally, it was not possible to evaluate the effectiveness of the program using a randomized controlled design, which would have compared the Web-based course to face-to-face learning. In addition, students

came from a range of backgrounds, and each individual's learning experience varied. Although all incoming students answered a questionnaire concerning demographics, other aspects of evaluation dealt with students' experience on the course. Therefore, only those who completed the course answered the outgoing questionnaire. This may have resulted in possible overestimation of course satisfaction, as those who were dissatisfied may have dropped out early. In addition, the dropout student survey had a low response rate of 19.0% (170/908).

### Recommendations

The program aims could be modified to align with student expectations and to reflect what could be achieved realistically with limited time and resources in a free, 6-month Web-based course. Moreover, to increase accessibility to course materials, a PDF version of the course material could be made available for download. Accompanying material such as books, CD-ROM (Compact Disc Read-Only Memory), and video lectures of the course material could supplement the existing course. These could potentially be available at a price, to subsidize the staff and technological infrastructure needed to run the course. Additional options for students who completed the course would enable them to continue their education. Students who completed the course could be invited to attend a fee-paying, face-to-face, short course to facilitate active learning, such as discussions and essay assignments. Completion of the face-to-face course could lead to university credit. Using the Web-based course as part of requirements to gain credit would motivate students who

desire advanced learning and accreditation. Struggling students could be identified by tracking their progress and engagement on the Web. These students could be automatically emailed to ask what problems they may be encountering. This would proactively identify which students may need a tutor's help. Finally, assessment questions would have higher content validity if peer-reviewed by experts.

### Barriers to Implementation of Recommendations

Producing supplementary material would require additional resources. However, students may be unwilling to pay for the supplementary material or additional face-to-face courses. Necessary software would also be needed to track student progress and send automatic alerts. However, this may not be widely available yet and may pose additional costs to the course.

### Conclusions

The "Public Health Principles in Disaster and Medical Humanitarian Response" Web-based course is effective in using technology to deliver suitable course materials and assessment and to enhance student communication (via discussion boards), support (via access to staff), and learning (using interactive Web-based tools). It is also effective in reaching the intended audience. However, there are a few areas for improvement. Program aims could be modified to align with student aims, while supplementing with increased active learning (eg, video lectures, essay writing, live tutorials, and discussions) for those who desire further learning. Assessment questions could be reviewed by experts. In addition, active efforts could be made to identify struggling students and to provide better support.

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### Acknowledgments

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### Conflicts of Interest

None declared.

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### Multimedia Appendix 1

Incoming student survey.

[[PDF File \(Adobe PDF File\), 41KB - mededu\\_v4i1e2\\_app1.pdf](#) ]

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### Multimedia Appendix 2

Outgoing student survey.

[[PDF File \(Adobe PDF File\), 32KB - mededu\\_v4i1e2\\_app2.pdf](#) ]

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### Multimedia Appendix 3

Dropout student survey.

[[PDF File \(Adobe PDF File\), 31KB - mededu\\_v4i1e2\\_app3.pdf](#) ]

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## Abbreviations

**CD-ROM:** Compact Disc Read-Only Memory

**MOOC:** massive open online courses

**OECD:** Organisation for Economic Co-operation and Development

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Viewpoint

# Jordan Field Epidemiology Training Program: Critical Role in National and Regional Capacity Building

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## Abstract

Field Epidemiology Training Programs (FETPs) are 2-year training programs in applied epidemiology, established with the purpose of increasing a country's capacity within the public health workforce to detect and respond to health threats and develop internal expertise in field epidemiology. The Jordan Ministry of Health, in partnership with the US Centers for Disease Control and Prevention, started the Jordan FETP (J-FETP) in 1998. Since then, it has achieved a high standard of success and has been established as a model for FETPs in the Eastern Mediterranean Region. Here we describe the J-FETP, its role in building the epidemiologic capacity of Jordan's public health workforce, and its activities and achievements, which have grown the program to be self-sustaining within the Jordan Ministry of Health. Since its inception, the program's residents and graduates have assisted the country to improve its surveillance systems, including revising the mortality surveillance policy, implementing the use of electronic data reporting, investigating outbreaks at national and regional levels, contributing to noncommunicable disease research and surveillance, and responding to regional emergencies and disasters. J-FETP's structure and systems of support from the Jordan Ministry of Health and local, regional, and international partners have contributed to the success and sustainability of the J-FETP. The J-FETP has contributed significantly to improvements in surveillance systems, control of infectious diseases, outbreak investigations, and availability of reliable morbidity and mortality data in Jordan. Moreover, the program has supported public health and epidemiology in the Eastern Mediterranean Region. Best practices of the J-FETP can be applied to FETPs throughout the world.

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**KEYWORDS**

field epidemiology; training program; education; capacity building; disease outbreaks; public health surveillance; epidemiological monitoring; Jordan

## Introduction

The Field Epidemiology Training Program (FETP) is a 2-year training program in applied epidemiology, modeled after the US Centers for Disease Control and Prevention's (CDC) Epidemic Intelligence Service [1]. The purpose of the FETP is to increase the epidemiologic capacity of a country's public health workforce to detect and respond to health threats and develop internal expertise in field epidemiology [2]. FETPs' curricula aim at improving public health systems and developing professional skills to ensure the country meets surveillance and

response requirements. The programs are established within national ministries of health and may access technical assistance from the CDC.

The model of the FETP is "learning by doing," through which a selected group of Ministry of Health public health professionals, called residents, participate in a combination of classroom instruction (25%) and fieldwork (75%) [3]. FETP curricula can be individualized to fit the needs of the country, but the common goal of each program is to improve surveillance systems, outbreak investigations, disease response, and data reporting. A large part of the program is the field component,

which exposes the residents to real-time experiences where they learn to detect and respond to diverse public health events. On graduation from the program, the residents are skilled in applied epidemiology and are highly qualified for government-level public health positions; globally, more than 80% of FETP graduates work in government and many obtain leadership positions within national health systems [1].

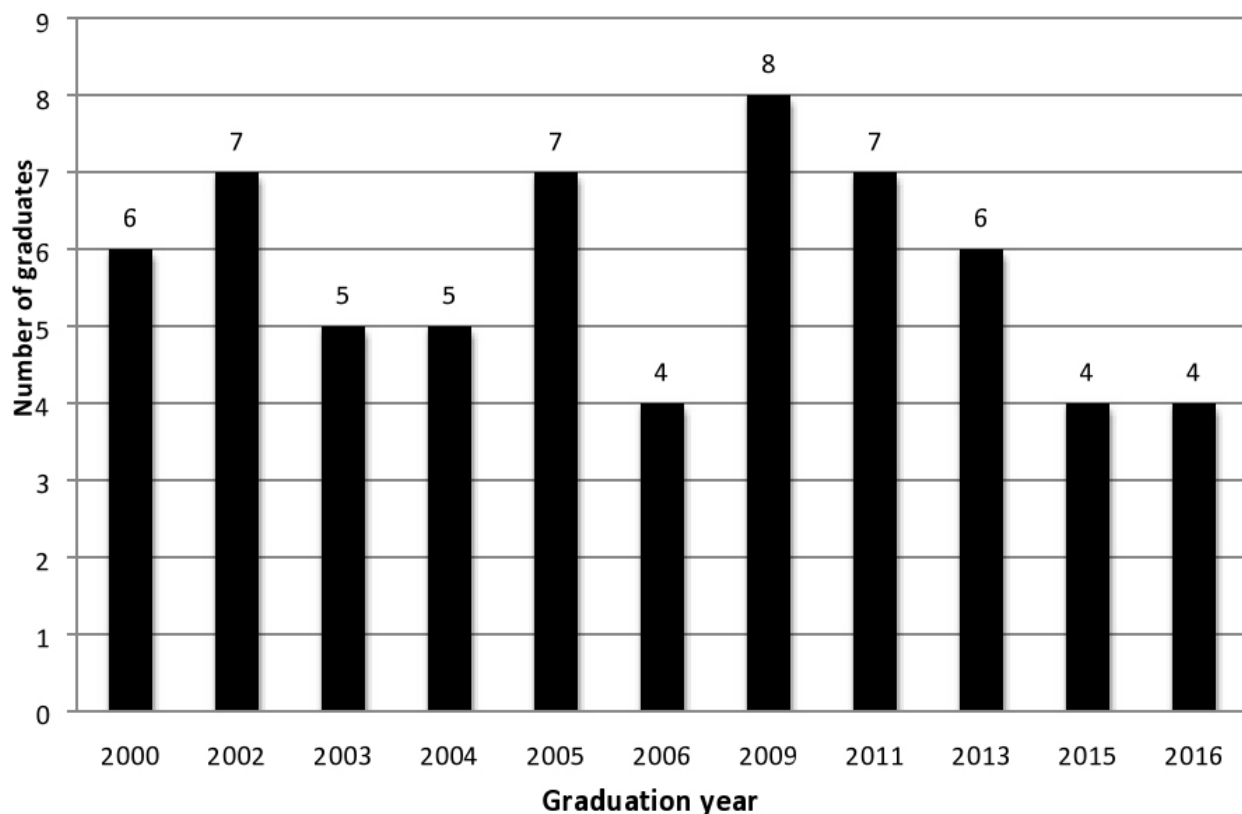
The Jordan FETP (J-FETP) was established in 1998 with funding from the US Agency for International Development's Jordan mission and with technical assistance from the CDC. The first cohort graduated 6 residents at the completion of the 2-year training. The J-FETP was supported by a CDC-assigned Resident Advisor from 1998 until 2007.

Since its inception in 1998, the J-FETP has been significantly transformed and expanded through 4 distinct phases. The initial phase, Jordan Data for Decision Making (J-DDM) Project (phase I), which ran from 1998 to 2001, comprised 2 separate programs: the J-FETP and the J-DDM program. The focus at that time was to improve the use of data at all levels of the Jordan Ministry of Health. From 2001 to 2004, the FETP was in its second phase as the Jordan Surveillance Project (phase II) and expanded its scope to include communicable and noncommunicable disease surveillance. Two major systems, the Mortality Surveillance System and the Behavioral Risk Factors Surveillance System, were put in place. In 2004 (phase III), the program was renamed the Jordan Applied Epidemiology Project, with an enhanced focus on surveillance systems. The current phase (phase IV) of the FETP is marked by the departure of the CDC-assigned

Resident Advisor, demonstrating a sustainable and institutionalized J-FETP. As of 2007, the program became fully sustained and is being run by the Jordan Ministry of Health.

Today, the J-FETP is housed within the Ministry of Health in the Primary Health Care Administration. The program is led by the J-FETP Coordinator, a Ministry of Health official. The program uses the standard CDC FETP curriculum with modifications and case studies based on needs assessments of Jordan's public health status. By 2017, the program had graduated a total of 63 physicians (Figure 1), with 17 residents in training. All residents who have enrolled in the program so far have been physicians, with the exception of 2 veterinarians, who enrolled during the height of the influenza epidemic in 2007. Of the graduates, 62% (39/63) work as epidemiologists at the central or governorate level of the Jordan Ministry of Health. Jordan is one of the few countries in the region that meets the international public health standard of 1 field epidemiologist per 200,000 people, with at least one FETP graduate working in 8 of the 12 governorates. All of the remaining graduates work in the region: 16% (10/63) at the government level, 13% (8/63) as regional epidemiologic experts, and 10% (6/63) with international nongovernmental organizations. The J-FETP is currently training its 13th cohort, with 14 physicians enrolled. The Ministry of Health recently incorporated the FETP into the Community Medicine Residency Program as part of the Jordan Medical Council. As a result, the J-FETP program is now accredited as a training program for the Jordanian Board Certificate in community medicine.

**Figure 1.** Number of graduates in the Jordan Field Epidemiology Training Program by year.



Graduates of FETP will have completed 2 years toward the community medicine certificate, creating an additional financial and career benefit for FETP residents. Integration of FETP and the Jordanian Board Certificate in community medicine has made the program an appealing option for young and motivated physicians.

Up to the end of 2017, a total 63 persons had graduated from the FETP program and 17 persons are currently enrolled in the residency program. Of the total graduates, 54 were from Jordan, 2 from Palestinian territories, 2 from Iraq, 3 from Yemen, and 2 from Syria. All were physicians except for 2, who were veterinarians. Of all graduates, 62% (39/63) are working at the central or governorate level of the national health system. All graduates who are at the Ministry of Health have management positions. A total of 6 graduates are working with international organizations.

Here we describe the J-FETP, its role in building the epidemiologic capacity of Jordan's public health workforce, and its activities and achievements.

## ***The Jordan Field Epidemiology Training Program***

The major function of the J-FETP is to improve reporting and surveillance systems, and prepare the country for outbreak investigations.

### **Outbreak Investigations**

J-FETP graduates and residents are critical contributors to outbreak investigation in Jordan and the region. J-FETP residents are trained in proper outbreak investigation practices as part of the FETP curriculum, and residents as well as graduates are called upon regularly to investigate and respond to public health issues related to crises and emergencies.

The J-FETP residents and graduates are able to quickly detect outbreaks, collect and interpret data, then communicate with the Primary Health Care Administration on the proper response to disease outbreaks. With assistance from CDC's Outbreak Response and Prevention Branch and the World Health Organization, the J-FETP and the Ministry of Health established 5 sentinel sites in Jordan to detect and respond to foodborne illness.

The J-FETP has been a major resource in the investigation of the regional outbreak of Middle East respiratory syndrome coronavirus (MERS-CoV). In collaboration with the CDC, Jordan Ministry of Health, and the Eastern Mediterranean Public Health Network (EMPHNET), J-FETP has formed a Jordan MERS-CoV team. The J-FETP has conducted retrospective serologic and epidemiologic studies of the virus, resulting in an improved understanding of the etiology and mode of transmission of MERS-CoV, nationally and globally. J-FETP contributed to 2 investigative reports on MERS-CoV, published by the Oxford University Press. The first, "Hospital-associated outbreak of Middle East respiratory syndrome coronavirus: a serologic epidemiologic, and clinical description," found that 9 cases of a hospital-associated respiratory illness outbreak in Jordan in 2012 were positive for MERS-CoV [4]. A second

report, "Stillbirth during infection with Middle East respiratory syndrome coronavirus," investigated the first recorded occurrence of stillbirth during infection with MERS-CoV [5]. J-FETP coleads the MERS-CoV outbreak investigation in the country.

### **The Syrian Refugee Crisis**

As of a July 2014, there are over 600,000 Syrian refugees in Jordan, with the majority living in host communities throughout Jordan. The Jordan Ministry of Health provides free health care to Syrian refugees in Jordan to support the health needs of the displaced population. The Ministry of Health facilities experience the burden of addressing the unique health profile of Syrian refugees and require support in optimizing their capacity. The J-FETP established a system for collecting and reporting data regarding Syrian refugee care at Ministry of Health facilities. An FETP focal point in local governorates reports data regarding refugee health care at Ministry of Health facilities to the Primary Health Care Administration. The data inform the Jordan Ministry of Health of health trends among the Syrian population such as potential disease outbreaks, access to Ministry of Health facilities by the refugee population, and the type of care provided. With this information, the Jordan Ministry of Health is able to respond to the needs of the Syrian refugee population, prevent major population health issues, and identify needs for increased health facility capacity. The Ministry of Health is also able to communicate monthly data reports to international nongovernmental organizations to enable a collaborative humanitarian response.

### **Improvements in Surveillance Systems**

The J-FETP has made advancements in health data surveillance that are well recognized in the Eastern Mediterranean Region. From the start of the J-FETP program in 1998, residents began to evaluate and plan for improvements in Jordan's health surveillance systems as part of their fieldwork and training. Efforts were made to improve the collection and analysis of, and response to, surveillance data.

Mortality and morbidity data are an essential component of health information systems and are essential in identifying national and local health needs [6]. It has been estimated that noncommunicable diseases, including cardiovascular disease, cancer, diabetes, and chronic respiratory diseases, account for 60% of total deaths in Jordan [7]. J-FETP has recognized the burden of noncommunicable diseases, assessed the trend of major diseases, and addressed the concern at the national and local government levels [8]. J-FETP has led the implementation of 3 Behavioral Risk Factors Surveillance System surveys to identify the population behaviors causing noncommunicable diseases and to assess the changes in the pattern of noncommunicable diseases. The survey was designed and conducted by J-FETP residents in 2002, 2004, and 2007. Major findings of the 2002 and 2004 surveys were published in the CDC's *Morbidity and Mortality Weekly Report* [9,10], and the 2007 survey findings were published in the CDC's *Preventing Chronic Disease* journal [11]. The survey results were accessed by public health officers to provide government and policy decision makers with evidence-based information used in the context of determining national health priorities, as well as

planning, evaluating, and monitoring country health programs. In response to the survey findings, the Non-Communicable Disease Directorate was established in the Ministry of Health in 2005. The Directorate is responsible for monitoring noncommunicable disease surveillance and implementing noncommunicable disease reduction programs. The Directorate is led by a J-FETP graduate, and J-FETP residents spend a portion of their training working within the Directorate.

Moreover, improvement in the surveillance systems resulted in appropriate data to study the trends of diseases and assess their burden. Such data have been used by many investigators who studied the disease trends and published their research in reputable journals. Recently, in 2017, 2 papers were published on the trends of cancer using the surveillance data [12,13].

The J-FETP has played a vital role in improving mortality data in Jordan [6]. J-FETP residents have examined and analyzed mortality data systems and death certificates in Jordan. The findings of the J-FETP projects led to a major review of mortality surveillance and a national effort to establish a modified system. In 2001, the Jordanian parliament passed a civil registration law that regulated death reporting, burial permits, and death certificates based on the recommendations of the J-FETP, demonstrating the feasibility of updating a national mortality statistics system. The death notification form was revised to comply with international standards, and the Jordan mortality surveillance system has been presented at a number of international conferences [8]. The updated procedures required better accuracy and completeness of reporting. Today, the Mortality Surveillance Unit is headed by a J-FETP graduate.

As a result, residents and graduates have been recognized for their applied epidemiology projects in surveillance systems in a number of international conferences, including events hosted by Training Programs in Epidemiology and Public Health Interventions Network, EMPHNET, the International Epidemiological Association, and the CDC Behavioral Risk Factors Surveillance System. Notable applied epidemiology projects include outbreak investigations, and evaluation of surveillance systems, mortality, noncommunicable diseases, and injuries.

### **The Jordan Infectious Disease Information System**

The J-FETP recognized the need for surveillance and reporting at the local levels, as well as strong communication to the central government. For this reason, the Jordan Infectious Disease Information System (JIDIS) was created. The electronic database was installed at the local and central directorates to track cases of infectious disease. All cases of infectious disease are recorded by Ministry of Health facility staff in the JIDIS.

Each week, the FETP residents collect, examine, and organize the data from the JIDIS into a presentation for the Directorate of Communicable Diseases at the Ministry of Health. The weekly presentation communicates all cases of infectious disease throughout the country, by governorate. During each meeting, Ministry of Health officials analyze the data and discuss action or follow-up needed on any issues of concern. The central national laboratory attends the meetings as well, in order to enhance coordination between the epidemiologists and

laboratory staff. Based on the information from the JIDIS, J-FETP residents produce communicable disease reports, which are published on the Ministry of Health website.

### **The Jordan Data for Decision Making Program**

Established at the same time as the J-FETP, the J-DDM program was put in place to increase the effective use of data in setting health priorities and policies in Jordan. The program, which is supported by the CDC, encourages making cost-effective decisions on the allocation of resources to optimize the capacity of Jordan's health system. While the FETP program is a 2-year program primarily for physicians who will transition into leadership positions in the government, the J-DDM program is a 12-month on-the-job training program with 5 to 6 weeks of classroom instruction, catered to midcareer health officers at the governorate and district level. These health professionals are trained in basic epidemiology, surveillance, data collection, and analysis.

The J-DDM program and J-FETP function cohesively with one another, as joint classroom sessions are conducted when appropriate. Additionally, the J-FETP residents act as facilitators and trainers throughout the J-DDM program instruction, in addition to acting as mentors to the J-DDM participants.

The J-DDM program has graduated 53 midlevel professionals through 3 cohorts since its establishment in 1998. In recent years, the J-DDM program has contributed to progressive policy changes with regard to national health. The program has trained Ministry of Health hospital personnel and established a hospital infection control surveillance system at the local levels. Notable examples of J-DDM research are a project in Balqa, Jordan, that led to increased reporting of modifiable disease from the private sector, and a report on rubella among government school teachers that resulted in revision to the national policy on teachers' sick leave.

### **Regional Contributions**

The J-FETP is a major source of support in public health and epidemiology in the Eastern Mediterranean Region. The J-FETP has supported regional investigations, response, and surveillance through resident and graduate expertise, and has hosted a number of residents from neighboring FETP programs.

In 2002, the J-FETP hosted 2 residents from the Palestinian territories, 1 resident from Gaza and 1 from the West Bank. The residents completed their first year of training with the J-FETP and then returned to their homes, where they completed their second year while conducting fieldwork on surveillance. After the program, each graduate went on to lead surveillance units in Gaza and the West Bank. J-FETP supported Iraq in increasing its public health capacity through enrolling 3 Iraqi physicians into the program. The 3 residents completed the program alongside their Jordanian counterparts, during which time they conducted and published investigations in Iraq on thallium poisoning (in 2008) [14] and a cholera outbreak in 2008 (F Al-lami, written communication, December 2017). J-FETP continued to offer assistance and guidance to Iraq as it established its own FETP in 2010, led by one of the Iraqi graduates of the J-FETP. Moreover, the J-FETP hosted 3 Yemeni residents. During their stay in Jordan at the Ministry

of Health, Yemeni residents in turn participated in outbreak investigations in Jordan, diversifying their skills and obtaining exposure to a range of public health concerns. The Yemeni residents completed their second year in their home country, bringing their new skills and experience back to their national Ministry of Health. The residents went on to lead a major investigation of a dengue fever outbreak and presented a comprehensive report of dengue fever along the Red and Arabian seas at the EMPHNET regional conference in 2011 [15]. In addition, J-FETP also enrolled 2 Syrians as residents in the program in 2011 with a long-term plan of starting an FETP in Syria. Though the current Syrian crisis has halted efforts to establish an FETP, Jordan remains supportive of public health professionals in neighboring countries.

Beyond training residents from countries in the region, the J-FETP has extended its support to regional outbreak investigations. The J-FETP sends graduates and residents to countries throughout the region to participate in multinational investigations in coordination with the World Health Organization and international nongovernmental organizations. EMPHNET, the network that supports the strengthening of FETPs in the Eastern Mediterranean Region, is headquartered in Amman, Jordan, and therefore the J-FETP has access to additional resources to support its capacity and impact.

## Conclusion

The J-FETP has developed immensely since its inception in 1998; today the program is regarded as a model for FETPs in the region. The success of the program is a result of many factors. First, the health system in Jordan is considered to be one of the strongest in the region. The health system is widely accessed by the population, and the Ministry of Health provides 61% of all health care [16]. The health system is comparatively well funded by the national government; with 7.72% of its gross domestic product spent on health care, Jordan has among the highest public health spending levels in the Eastern Mediterranean Region. With a relatively strong Ministry of Health, the J-FETP is well supported at the central government level and can expect attention and action in response to FETP

studies and findings. Second, the J-FETP has accessed a strong pool of qualified physicians to enroll and graduate from the program. A strong system of support and technical assistance from the CDC and regional organizations such as EMPHNET has provided J-FETP with resources for growth and development.

Despite the success of the J-FETP and the accomplishments of the Jordan Ministry of Health, there remains a shortage of skilled epidemiologists in Jordan. Political unrest and humanitarian crises in the region add complexity to the public health needs in Jordan and the Eastern Mediterranean Region. The prolonged existence of these regional issues will further increase the demand for an enhanced public health response, requiring experts with field experience who are trained in outbreak investigation, surveillance, and emergency response. Additionally, as Jordan witnesses an increase in the burden of noncommunicable diseases and morbidity due to injury, J-FETP must support the Ministry of Health in addressing these health issues at the national and local levels.

As J-FETP looked to enroll a new cohort in 2017, the program intensified eligibility requirements to recruit and assess the most qualified physicians in the country. The program's primary challenge moving forward will be to ensure the sustainability of the J-FETP through appropriate internal and external funding, and ongoing improvements to the curriculum and program function.

Although this report describes the activities and achievements of J-FETP, no evaluation study has been conducted to assess and document the performance and impact of the J-FETP. Therefore, we recommended conducting a comprehensive evaluation of the J-FETP's impact on human resources and health services in Jordan.

In conclusion, the J-FETP has contributed significantly to improvements in surveillance systems, control of infectious diseases, outbreak investigations, and the availability of reliable morbidity and mortality data in Jordan. Moreover, the program has supported public health and epidemiology in the Eastern Mediterranean Region.

## Conflicts of Interest

None declared.

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## Abbreviations

**CDC:** Centers for Disease Control and Prevention  
**EMPHNET:** Eastern Mediterranean Public Health Network  
**FETP:** Field Epidemiology Training Program  
**J-DDM:** Jordan Data for Decision Making  
**J-FETP:** Jordan Field Epidemiology Training Program  
**JIDIS:** Jordan Infectious Disease Information System  
**MERS-CoV:** Middle East respiratory syndrome coronavirus

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Original Paper

# Resident and Attending Physicians' Perceptions of Patient Access to Provider Notes: Comparison of Perceptions Prior to Pilot Implementation

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## Abstract

**Background:** As electronic health records have become a more integral part of a physician's daily life, new electronic health record tools will continue to be rolled out to trainees. Patient access to provider notes is becoming a more widespread practice because this has been shown to increase patient empowerment.

**Objective:** In this analysis, we compared differences between resident and attending physicians' perceptions prior to implementation of patient access to provider notes to facilitate optimal use of electronic health record features and as a potential for patient empowerment.

**Methods:** This was a single-site study within an academic internal medicine program. Prior to implementation of patient access to provider notes, we surveyed resident and attending physicians to assess differences in perceptions of this new electronic health record tool using an open access survey provided by OpenNotes.

**Results:** We surveyed 37% (20/54 total) of resident physicians and obtained a 100% response rate and 72% (31/44 total) of attending physicians. Similarities between the groups included concerns about documenting sensitive topics and anticipation of improved patient engagement. Compared with attending physicians, resident physicians were more concerned about litigation, discussing weight, offending patients, and communicated less overall with patients through electronic health record.

**Conclusions:** Patient access to provider notes has the potential to empower patients but concerns of the resident physicians need to be validated and addressed prior to its utilization.

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## KEYWORDS

access to information; electronic health records; physicians; internal medicine; surveys and questionnaires

## Introduction

Electronic health records (EHRs) have become a part of daily life for physicians practicing in today's technological era. EHRs are used for documentation and billing but can also increase patient engagement through portals that allow patients to contact

physicians, review lab work, and perform other tasks. Recent studies have shown that patients with access to their notes feel more engaged to work as a team with their health care providers. In 2012, the OpenNotes study gave nearly 20,000 patients access to their clinical notes through a patient portal. Overall, the study showed that patients were empowered by access to their notes

and were more likely to follow their respective care plans. Provider concerns regarding increased time burden, patient concerns about note content, and documentation challenges were less significant than anticipated. In fact, most providers opted to continue offering their patients access to their notes after the study period concluded [1,2,3,4].

The initial OpenNotes evaluations did not evaluate perceptions of the resident physicians. As use of open clinical notes becomes more prevalent in both community and academic centers, it is imperative to evaluate perceptions of providers at all levels of training to identify barriers for comfort using OpenNotes and opportunities for education. Few studies till date have assessed internal medicine residents' perceptions of open clinical notes and compared their perceptions with those of attending physicians [5].

In this study, we evaluated differences in the perceptions of resident and attending physicians prior to implementation of patient access to provider notes to identify potential targets for curricular interventions and facilitate optimal use of EHR features while increasing patient empowerment.

## Methods

### Study Design

Since November 2014, office notes in our primary academic general internal medicine clinic were made available to patients through our secure patient portal. The faculty practice clinic had 54 resident and 44 attending physicians when the pilot began. Attending physicians had 3 faculty meetings set up in the months prior to roll-out of the pilot to provide feedback and address concerns related to implementation of OpenNotes. A tip sheet derived from the OpenNotes Frequently Asked Questions resources was provided and reviewed prior to roll-out. Residents had a 20-min introduction session immediately before pilot roll-out and were also provided a tip sheet. The session and tip sheets for both groups of doctors informed them how they could document sensitive topics in a special section of the chart that would remain inaccessible to patients. A standardized survey which is publically available was provided to all physicians to assess their perceptions of current practices, benefits, patient impact, and barriers to the use of open clinical notes prior to roll-out. There were 3 free response comment sections within the survey. The OpenNotes provider survey covered many possible perceived barriers such as time, addressing sensitive issues in notes, and liability. Live surveys were distributed to the attending physicians during their regularly scheduled faculty meetings and were given to the resident physicians at the start of the 20-min introduction session. This study was reviewed by the University of Pittsburgh Quality Improvement (QI) Review Board and was deemed a QI project; therefore, it was exempt from review by the Institutional Review Board. Participation in the survey was optional.

### Statistical Analysis

Descriptive statistics were generated evaluating the frequency of each response. Fisher's exact and Chi-square tests were used

to determine significant differences between the responses of the attending and resident physicians. We collapsed categories of responses on survey items so that "Disagree" included disagree and somewhat disagree and "Agree" included agree and somewhat agree. Concern responses were divided so that "Not Concerned" included "not concerned" and "minimally concerned" whereas "Concerned" included "moderately," "very," and "so concerned I do not want OpenNotes." Data analysis was performed using SAS version 9.4.

## Results

A convenience sample of residents who were on their ambulatory block pre-implementation reached 37% (20/54) of resident physicians within our academic practice, with a 100% resident response rate. We obtained an overall response rate of 72% (31/44) for all our attending physicians. Of the combined group, 86% (44/51) agreed that they anticipated that OpenNotes could empower patients and help them better understand their respective care plans; 63% (44/51) expected that access to notes would make their patients worry more; 82% (42/51) were concerned that their patients would contact them with questions about the notes postimplementation. Both groups stated they anticipated changing their documentation about sensitive topics including cancer (31/51, 61%), mental health (36/51, 70%), and substance abuse (36/51, 70%).

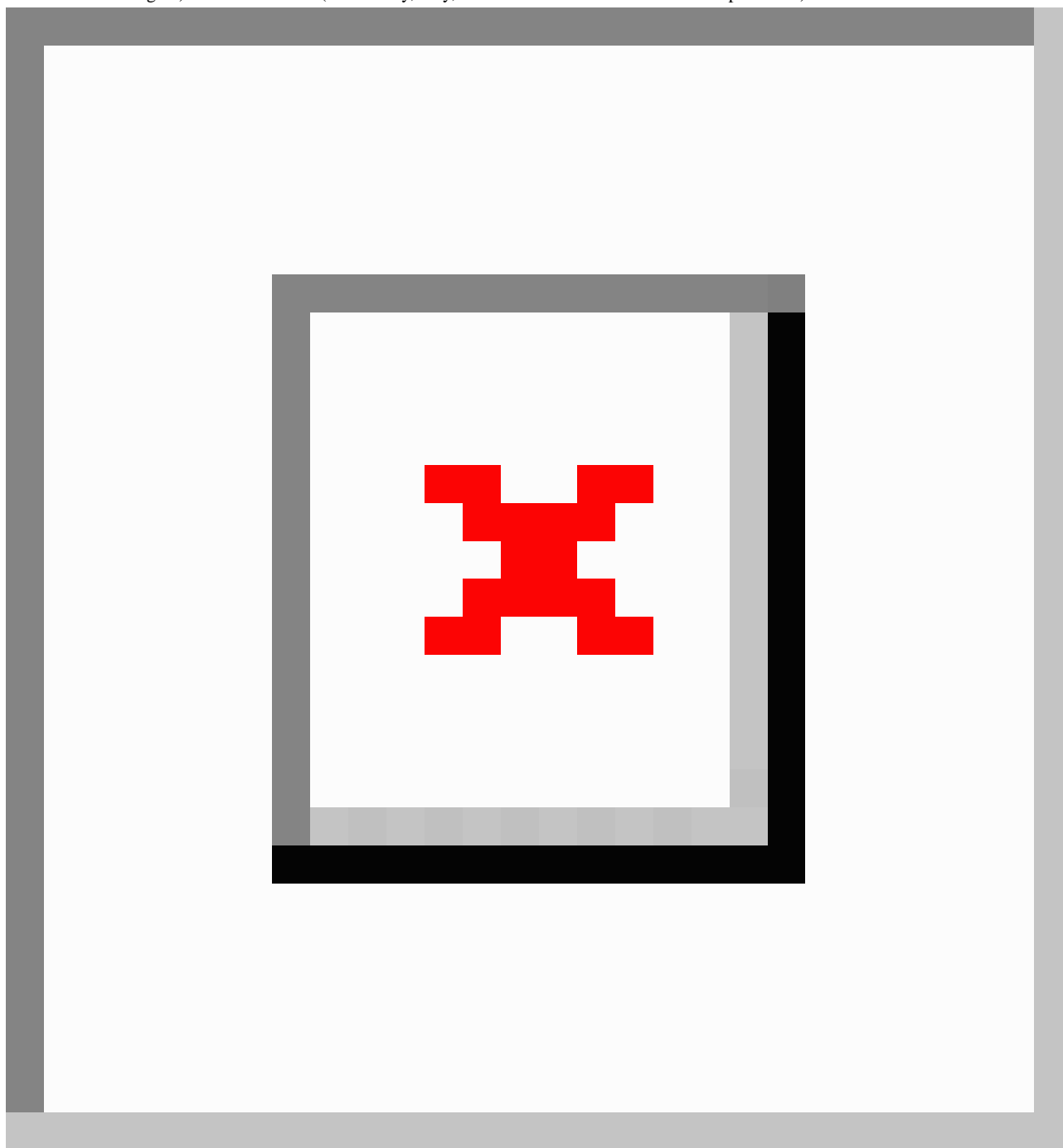
Between resident and attending physicians, there were some significant differences in survey responses. Resident physicians were more concerned than attending physicians about patients being offended by the contents of notes (50% [10/20] vs 23% [7/31];  $P=.005$ ). Resident physicians also perceived an increased risk of litigation (50% [10/20] vs 13% [4/31];  $P=.01$ ). Overall, 53% (16/31) of the attending physicians reported that they communicated almost daily with patients electronically compared with 0% (0/20) of the resident physicians ( $P<.0001$ ). Regarding sensitive topics, the resident physicians felt more likely to change documentation about weight than the attending physicians (65% [13/20] vs 34% [10/30];  $P=.03$ ; [Figure 1](#)).

We analyzed a total of 30 separate entries for the 3 free response questions (questions 14, 31, 42). Two reviewers (DRN, MC) reviewed the comments and placed them within broad response categories. A major response category was concerns about more work with little yield or impact on patient outcomes but with an anticipation of increased patient empowerment. One provider stated that "notes will be longer, less helpful for reference later, as [I] may leave out things to make [the patient] happy."

Another provider noted a personal experience stating, "Midwife let me look at my chart—allowed me to ask better questions."

Another category increased patient confusion or concerns with note interpretation such as how to approach sensitive topics and medical terminology use. Comments included, "same issues as bedside rounds of mixing doctor speak and lay terms," and "[I will be] less honest about feelings on sensitive topics."

**Figure 1.** OpenNotes domains in which resident physicians report greater concerns than attending physicians. Results show those who either agree (agree and somewhat agree) or are concerned (moderately, very, and so concerned I do not want to open notes).



During the introduction session, resident physicians expressed significant concerns about how much additional work OpenNotes would create for them and how they would have to change major portions of their documentation. Many questions came up during the debriefing, primarily related to legal concerns and patient misinterpretation of their notes, which correlated with survey responses.

## *Discussion*

Although resident and attending physicians shared some of the same perceptions about OpenNotes, we found some significant differences. Both groups felt that OpenNotes had the potential to empower patients but were concerned about discussing

sensitive topics in the notes. Our results corroborate with a recent qualitative analysis that showed that both attending and resident physicians were concerned about offending patients and potential litigation but felt that OpenNotes could be empowering [5]. However, our results showed that resident physicians expressed significantly more discomfort than attending physicians regarding litigation, discussing obesity, and offending their patients. Overall, our results are similar to those by Walker et al [1] that further validated our representative sample and revealed anticipation of improved patient communication and education, along with concerns about increased patient questions and litigation.

Differences in how OpenNotes was introduced to attending and resident physicians may have influenced the perception of OpenNotes. Our attending physicians were given several months to discuss potential opportunities and challenges surrounding the program, and their feedback was incorporated into logistical planning for the OpenNotes roll-out. Resident physicians, on the other hand, were introduced to OpenNotes as an initiative, regardless of their inputs. In the introduction session with the resident physicians, the overall response was of shock and concern about how much perceived additional work this would create for them and how they would have to significantly change their documentation style. To continue addressing these issues, we recommend open forums post-implementation to discuss the impact of OpenNotes on resident documentation or how patient feedback from the OpenNotes initiative could be helpful in alleviating many of these concerns. As seen in many post-implementation studies, most providers found that they made few, if any, changes to their notes post-implementation [4]. This also brings to light the need to include a more foundational curriculum addressing EHR and health portal use as patient engagement tools, medical-legal aspects of

documentation, and setting of expectations for what changes, if any, this should make on their current documentation practices. It is possible that some of these differences are related to the fact that compared with the attending physicians, the resident physicians in this study communicated with their patients significantly less outside of the clinic. This could have led to more discomfort with granting patients electronic access to their own notes. Overall, as initiatives like OpenNotes become more common, it is important to find better ways to address concerns of the resident physicians surrounding patient access portals so that providers will use these portals as tools for patient empowerment. This study has several limitations: single-center study; small sample size; and consisted of only resident physicians.

In order to prepare trainees to be comfortable with EHR features such as patient access to provider notes, concerns about documentation, litigation, and increased electronic communication need to be addressed and additional curricula need to be developed, highlighting how to use these features to empower patients prior to implementation.

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### Authors' Contributions

Each of the authors have contributed equally to this work from conception to manuscript development and editing.

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### Conflicts of Interest

None declared.

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### Abbreviations

**EHR:** electronic health record

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Original Paper

# Taking Constructivism One Step Further: Post Hoc Analysis of a Student-Created Wiki

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## Abstract

**Background:** Wiki platform use has potential to improve student learning by improving engagement with course material. A student-created wiki was established to serve as a repository of study tools for students in a medical school curriculum. There is a scarcity of information describing student-led creation of wikis in medical education.

**Objective:** The aim is to characterize website traffic of a student-created wiki and evaluate student perceptions of usage via a short anonymous online survey.

**Methods:** Website analytics were used to track visitation statistics to the wiki and a survey was distributed to assess ease of use, interest in contributing to the wiki, and suggestions for improvement.

**Results:** Site traffic data indicated high usage, with a mean of 315 (SD 241) pageviews per day from July 2011 to March 2013 and 74,317 total user sessions. The mean session duration was 1.94 (SD 1.39) minutes. Comparing Fall 2011 to Fall 2012 sessions revealed a large increase in returning visitors (from 12,397 to 20,544, 65.7%) and sessions via mobile devices (831 to 1560, 87.7%). The survey received 164 responses; 88.0% (162/184) were aware of the wiki at the time of the survey. On average, respondents felt that the wiki was more useful in the preclinical years (mean 2.73, SD 1.25) than in the clinical years (mean 1.88, SD 1.12;  $P < .001$ ). Perceived usefulness correlated with the percent of studying for which the respondent used electronic resources (Spearman  $\rho = .414$ ,  $P < .001$ ).

**Conclusions:** Overall, the wiki was a highly utilized, although informal, part of the curriculum with much room for improvement and future exploration.

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**KEYWORDS**

wiki; constructivist learning; medical education; analytics

## Introduction

### Wiki Use and Underlying Educational Theory

Wikis belong to a broader class of “Web 2.0” online tools, which draw from social engagement of users to directly create and modify content, rather than the traditional model of publisher to consumer. Wikipedia (Wikimedia Foundation Inc, San Francisco, CA, USA) is the best-known wiki website. Web 2.0 tools and wikis have become very common not only among medical students, but also among physicians. One UK survey found that more than 80% of junior physicians used Web 2.0 tools for professional purposes, with wikis being the most common [1].

Wikis are supported by the constructivist model of learning, which states that students learn best by actively creating their own knowledge structures, in contrast to traditional behaviorism models in which education is a unidirectional flow of information from teacher to learner [2,3]. Wikis can take constructivism one step further by allowing students to collaboratively create and organize structures of knowledge. In constructivism, the entire learning process is self-directed by the learner. Wikis are a valuable supplement to classroom

learning because they allow students to reformulate knowledge, integrate concepts across multiple lectures, and assure their understanding [4]. The potential for students to interact with one another through the wiki serves both a social and educational role. Students can create a “Folksonomy” (folk taxonomy) of information by tagging useful websites and resources for their peers, as opposed to a typical taxonomy of information bestowed in a top-down fashion from a lecturer or textbook [5]. Wikis can serve as part of a hybrid model between the traditional and constructivist learning environments by enabling students to self-organize and augment knowledge they receive from top-down teaching methods (Figure 1). Because teachers are also free to interact with a wiki, they too can participate by guiding the structure and content. Wikis can be powerful in the context of a course because they allow students to build on work by previous learners, creating a robust and refined document. In addition, wikis can provide task-specific benefits: when wikis were utilized for group work in a nursing program, students felt that it helped build knowledge, monitor progress, and avoid redundant work [6]. Because any user can edit any content, the wiki model allows those with the passion and knowledge to contribute to their colleagues’ education. In addition, work is instantly subjected to an informal and perpetual peer-review process.

**Figure 1.** Models of learning in medical education. A wiki can serve as a hybrid model (C) between the traditional (A) and constructivist (B) learning environments by enabling learners to self-organize knowledge they receive from the teacher. The broken line in the hybrid model (C) represents the ability of the teacher to contribute and review information in the knowledge base.

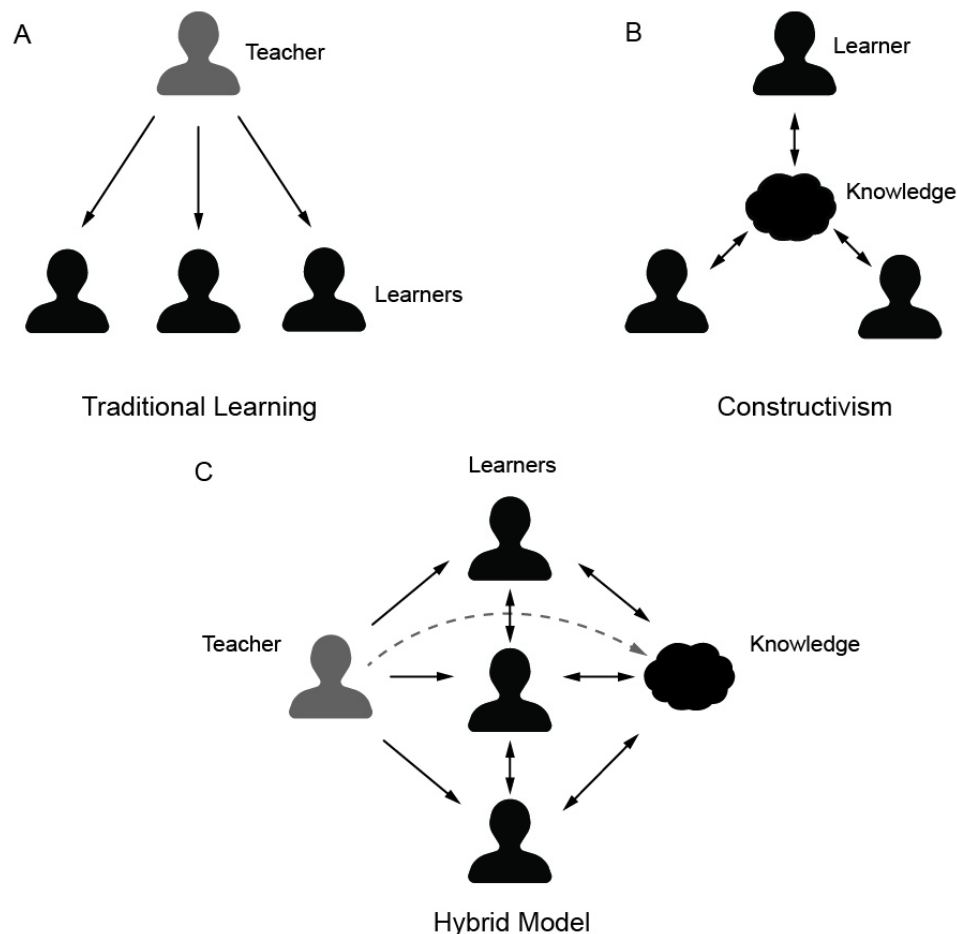
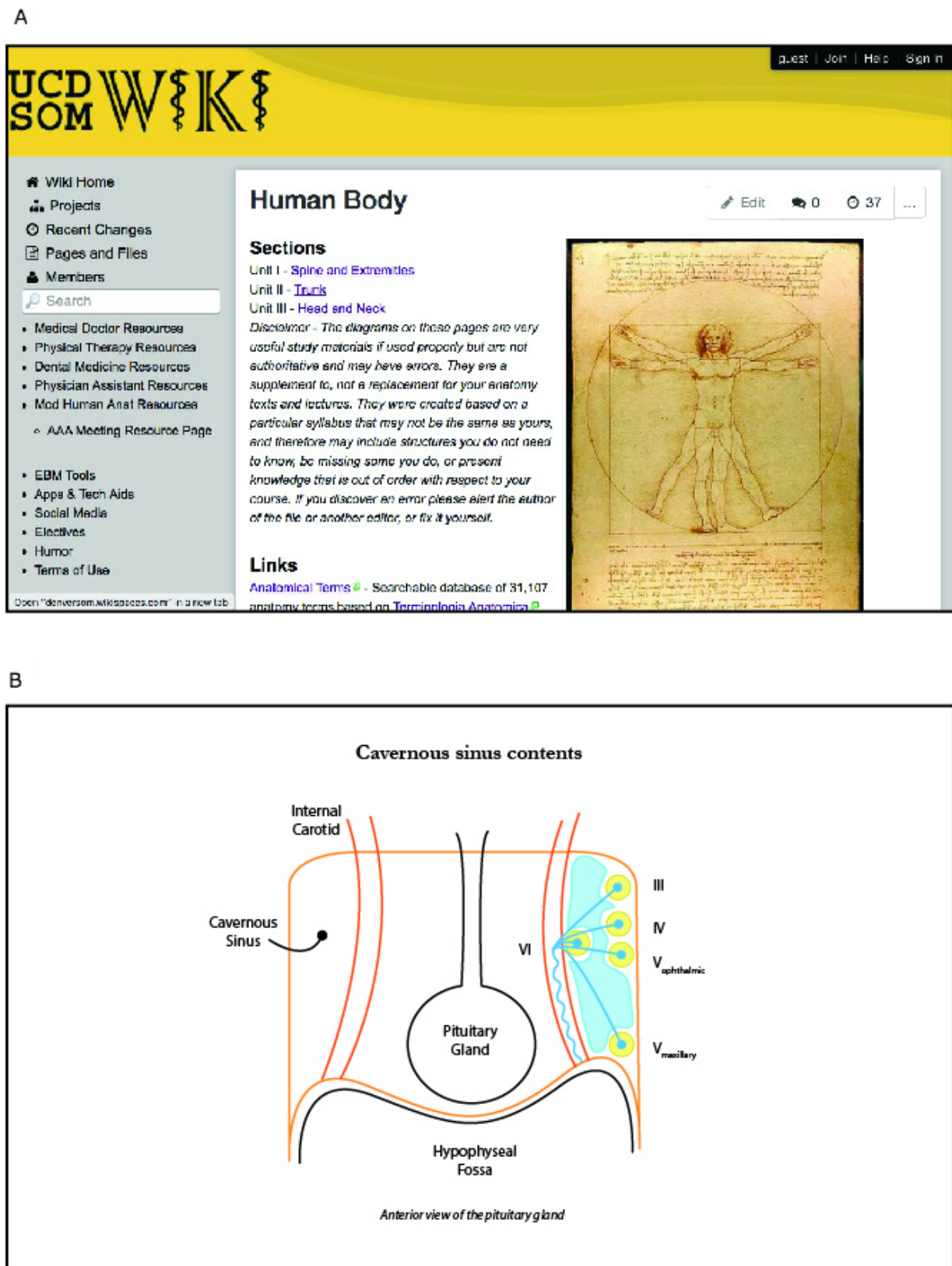


Figure 2. Screenshots showing an example page of a curricular block (A) and content (B).



**Wikis in Medical Education**

Smaller and more focused wikis are becoming popular in many educational settings due to the collaboration and knowledge sharing they support. A wide variety of uses for wikis in

education have been documented in the literature, including collectively annotating class reading, publishing syllabi and other class documents, concept mapping, resource sharing, and group authoring of documents [7]. Many researchers have published specifically within medical education and concluded



they have significant potential and require further study [8,9]. In addition, several medical school and graduate medical education residency program wikis are documented to contain large quantities of content with a large volume of Web traffic. For example, a medical student-initiated wiki had nearly 1600 pages and 1.2 million page views covering most aspects of their curriculum [10]. Other medical schools have utilized wikis in a more focused form. An elective at one medical school had students write brief appraisals of evidence that they then placed on Wikipedia; course reviews were favorable [11]. A pathology residency program incorporated a wiki into a course for second- and third-year residents by asking participants to write online review articles based on assigned lectures. Pretest and posttest data indicated a greater increase in test scores compared to previous years (25% versus 16%) [12]. A large internal medicine residency program incorporated a wiki to share frequently accessed links such as forms and contact information as well as brief summaries and links to curated websites with more authoritative information [13]. Their survey showed that 100% of house staff felt the wiki improved their ability to complete tasks, 89% reported it improved their efficiency, and 57% reported it improved their education. In another example, an anesthesiology department utilized a wiki for guiding residents to educational materials such as podcasts and lectures [14]. Wikis also have the potential to promote collaboration more broadly within a specialty. For example, OpenAnesthesia.org is a large and growing wiki that covers many anesthesia topics, and received more than 10,000 visitors in its first month of operation [15]. The results of these studies demonstrate the primary strengths of wikis: to hold useful, well-organized information in an easily updated format.

### Wiki Establishment and Growth

The preclinical curriculum of the University of Colorado (first two years; MS1 and MS2) is composed of organ system-based blocks, except for the first block, Human Body block (gross anatomy). Early in the 2009-2010 academic year, students of the Class of 2013 began using Google Groups (Google Inc, Mountain View, CA, USA) to share files and Web links such as electronic flashcard sets and useful websites. However, the files were stored in a single list that quickly grew to hundreds of entries and included irrelevant or outdated items. In addition, the files were part of the Class of 2013 Google Group, which were not accessible to other classes. A wiki website was chosen because it offered an easy way for all classes to contribute in a format that most students would be familiar with due to the popularity of Wikipedia.

The block structure of the medical school curriculum served as the template for organizing wiki content, with pages for each block and subpages within each block section (eg, Human Body, Figure 2A). The wiki platform Wikispaces (Tangient LLC, San Francisco, CA, USA) was selected as the host of the wiki and a URL was established [16]. A handful of students from each successive class began posting additional material. This level of engagement is typical of wikis in which participation is not required, as suggested by a study of Wikipedia that found 1% of users make half of the page edits [17]. The wiki received an additional boost in content from an anatomy instructor (MAP),

who contributed many diagrams (eg, the cavernous sinus, Figure 2B).

Although the benefits of wiki use in medical education have been documented, there is a paucity of information on the utilization and perceived value of a student-led wiki. Therefore, the aims of this study were to (1) quantify the utilization of a student-led wiki through website traffic analysis and (2) evaluate the perceptions of usage through individual survey of medical students at our institution. We hypothesized that the wiki would be highly utilized by medical students and perceived as useful in their studies.

## Methods

### Study Participants

The University of Colorado Anschutz Medical Campus (Aurora, CO, USA) is a large academic medical center that includes programs in medicine, dentistry, pharmacy, nursing, physical therapy, and physician assistant studies. At the time of the study, the medical school enrolled approximately 160 students per class year.

### Wiki Traffic Analysis

The utilization of the University of Colorado School of Medicine (CUSOM) wiki was quantified using Google Analytics (Google Inc, Mountain View, CA, USA), an open-source tool for collecting detailed website traffic information, which was added to the wiki in July 2011. Google Analytics defines a session as a group of interactions within a given time frame. A session was considered terminated once there was 30 minutes of inactivity. New visitors were logged specific to the browser and device that was used. A pageview was an instance of a page being loaded (or reloaded) in a browser. To gain a sense of how long users were engaging with a page of the wiki, average session duration was calculated by dividing the total duration of all sessions (in seconds) by the number of sessions. To determine degree of engagement with content, bounce rate was calculated as the percentage of single-page sessions (ie, sessions a user left the wiki from the entrance page without interacting with the page). To assess changes over time, a comparison of website traffic was performed between the Fall 2011 and Fall 2012 semesters. It is important to acknowledge the potential influence of fake visits on Web traffic for any website employing Google Analytics (ie, ghost spam). To quantify the size of this effect, we counted and subsequently filtered out the sessions originating from hostnames outside of the wikispaces subdomain [16].

To gain insight into device usage patterns, sessions were categorized by type (desktop/laptop, tablet, or mobile). The pages with the most pageviews were also determined in order to understand what resources were most utilized.

### Usage Survey

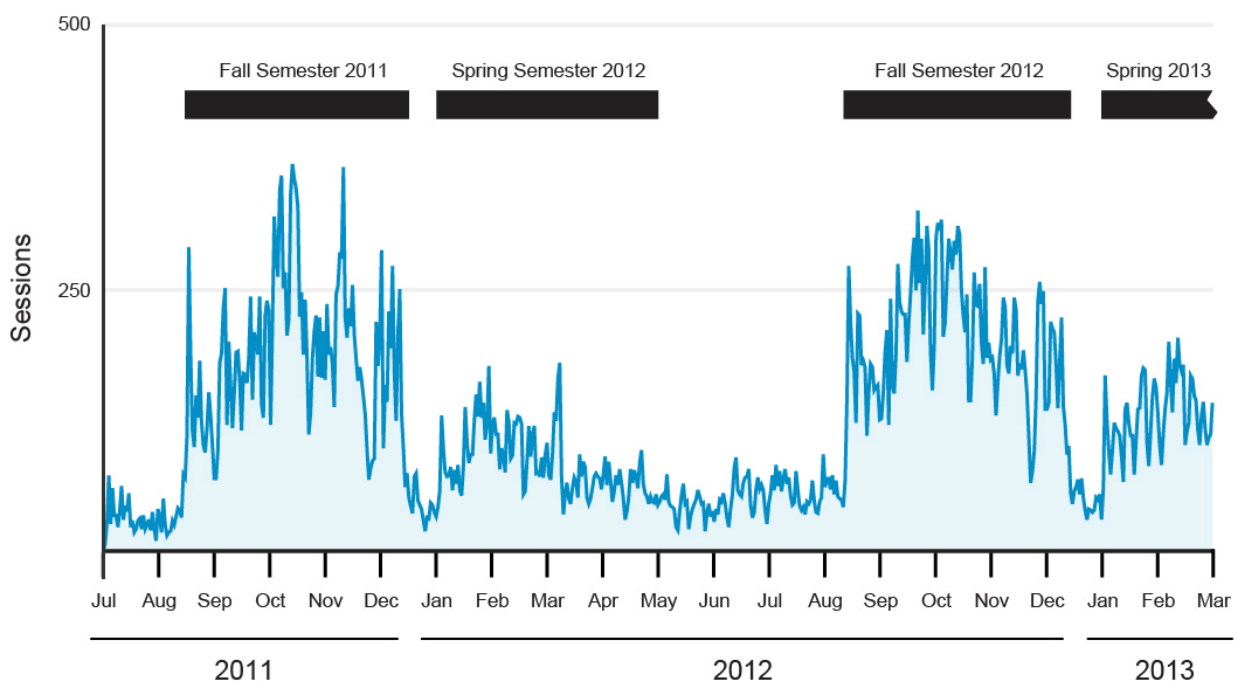
To obtain individual-level data about medical student use of the wiki, a survey was developed online using Google Forms (Google, Inc). After technical functionality of the survey was tested, the survey URL was distributed by email to a convenience sample of all four current classes in the School of

Medicine (N=640; classes of 2013-2016), with one follow-up email sent as a reminder. The survey was open for 2 weeks (January 2-16, 2013). The survey ([Multimedia Appendix 1](#)) consisted of 20 questions, nine of which all respondents were presented with and an additional 11 that were presented only if the student indicated past wiki use. The survey assessed students' user experience with the wiki, including ease of navigation, satisfaction with content, and importance as part of their education. Students were also asked about self-perceived willingness and ability to edit or make contributions to the wiki. Items on the survey were formatted as choose from a list, 5-point Likert evaluation scale, or open field response. Individual student submissions were collated in a Google Spreadsheet and later downloaded to a Microsoft Excel spreadsheet (Microsoft Corp, Redmond, WA) for in-depth analysis and data cleaning. Only completed questionnaires were analyzed.

Descriptive summary statistics were calculated for close-ended usage survey questions. The Kruskal-Wallis test (nonparametric) was used to analyze differences in the six Likert scale questions of the survey (see [Multimedia Appendix 1](#)) across the groups (ie, student class year). The degree of linear association between two survey items was examined using Spearman rho rank correlation coefficient. Positive rho values between zero and .2 indicated no correlation. Values between .2 and .5 represented a weak correlation; between .5 and .8, a moderate correlation; and greater than .8, a strong to perfect correlation [18].

An alpha level of  $P < .05$  was used to identify significant differences and statistical analyses were performed using SPSS version 25 (IBM, Armonk, NY, USA). Data are presented in the text and tables as mean and standard deviation and in figures as mean and standard error. These experimental procedures were reviewed and approved by the Colorado Multiple Institutional Review Board.

**Figure 3.** Trend in user sessions compared with timing of academic semesters.



## Results

### Wiki Traffic

Quantitative data from Google Analytics were collected from July 1, 2011 to March 1, 2013 (20 months; 610 days). During this time, there were a total of 74,317 sessions (daily range: 7-368; mean 122, SD 80 sessions per day), of which 66.93% (49,741) were logged by returning visitors. During these sessions, a total of 192,545 pageviews were generated (mean 315, SD 241 pageviews per day), yielding mean 2.59 pages per session. Most sessions consisted of visiting one page of the wiki (ie, bounce rate; 46,125/74,317 sessions, 62.07%) with 6902 (9.29%) visiting two and 6582 (8.86%) three pages, respectively. The mean session duration was 1.94 (SD 1.39) minutes. There was a noticeable elevation in sessions corresponding to the occurrence of semesters ([Figure 3](#)). The number of sessions identified as ghost spam and removed from analysis was very small (8/74,317 sessions, 0.01%).

The type of device used to access the wiki most frequently was a desktop/laptop computer (69,968/74,317 sessions, 94.15%). Tablet and mobile devices accounted for 2355 (3.17%) and 1994 (2.68%) sessions, respectively. The page of the wiki site with the most pageviews was the home page (32,532/192,545, 16.90%), followed by the Head & Neck section of Human Body block (21,106/192,545, 10.96%) and the main page of the Human Body block content (10,076/192,545, 5.23%).

Key website traffic measures were compared between Fall 2011 (August 15 to December 14; 122 days) and Fall 2012 (August 14 to December 15; 124 days) semesters. These data are summarized in [Table 1](#).

**Table 1.** Comparison of website traffic measures between Fall 2011 and Fall 2012 semesters.

Variable	Fall semester 2011	Fall semester 2012	Percent change <sup>a</sup> , %
Sessions, n	22,992	24,861	8.13
Sessions per day, mean (SD)	188.46 (71.24)	200.49 (60.85)	6.38
Returning visitors, n (%)	12,397 (53.92)	20,544 (82.64)	65.72
New visitors, n (%)	10,595 (46.08)	4317 (17.36)	-59.25
Pageviews, n	57,926	70,009	20.86
Pageviews per day, mean (SD)	474.80 (240.54)	564.59 (213.92)	18.91
Pages per session, mean (SD)	2.43 (0.53)	2.79 (0.51)	14.81
Session duration (minutes), mean (SD)	2.20 (1.58)	2.60 (1.21)	18.18
Bounce rate, %	65.04	56.22	-13.6
Sessions via desktop/laptop, n	22,161	23,301	5.1
Sessions via smartphone/tablet, n	831	1560	87.7

<sup>a</sup>Percentage change calculated using (Fall 2012–Fall 2011)/Fall 2011 \* 100.

**Table 2.** Summary of medical student responses to the survey.

Variable	Class of 2013	Class of 2014	Class of 2015	Class of 2016	Total	P value
Number of responses, n	73	57	19	15	164	—
Response rate, %	46	36	12	9	26	—
Aware of wiki before survey, n (%)	62 (85)	49 (86)	19 (100)	15 (100)	145 (88)	—
Have edited wiki in the past, n (%)	16 (22)	14 (25)	6 (32)	0 (0)	36 (22)	—
Importance in preclinical years <sup>a</sup> , mean (SD)	2.11 (1.08)	2.77 (1.13)	3.74 (0.99)	3.80 (0.94)	2.73 (1.25)	<.001
Importance in clinical years <sup>a</sup> , mean (SD)	1.63 (0.90)	1.75 (1.06)	3.71 (0.76)	3.40 (1.14)	1.88 (1.12)	<.001
Ease of finding content <sup>a</sup> , mean (SD)	3.55 (1.03)	3.51 (0.94)	4.16 (0.77)	4.07 (0.88)	3.68 (0.98)	.0173
Willingness to contribute content <sup>a</sup> , mean (SD)	2.82 (1.22)	2.84 (1.18)	3.00 (1.11)	3.80 (0.94)	2.94 (1.19)	.0292
Ease of making changes <sup>a</sup> , mean (SD)	3.60 (1.27)	3.50 (1.38)	2.67 (0.58)	2.00 (1.41)	3.29 (1.27)	.322
Confidence of adding content <sup>a</sup> , mean (SD)	2.86 (1.41)	2.88 (1.21)	2.89 (1.29)	3.33 (1.45)	2.91 (1.33)	.705

<sup>a</sup>For this survey item, a five-point Likert scale was used with 1=not important at all and 5=essential.

## Usage Survey

Surveys were completed by 164 of 640 students in the four medical school classes (25.6% response rate; [Table 2](#)). Overall, 145 of 164 respondents (88.4%) were aware of the CUSOM wiki prior to taking the survey. Among these students, 108 of 145 (74.5%) had heard about it from a classmate, 23 (15.9%) from someone in another class year, and 3 (2.1%) from a professor or administrator. Eleven (7.6%) did not remember how they learned about the wiki. A relatively small number of students had edited the wiki in the past (36/164, 22.0%). The Likert ratings significantly differed between groups for the importance of the wiki in preclinical and clinical years, ease of finding content, and for willingness to contribute. No significant differences were observed for ease of making changes and confidence of adding content.

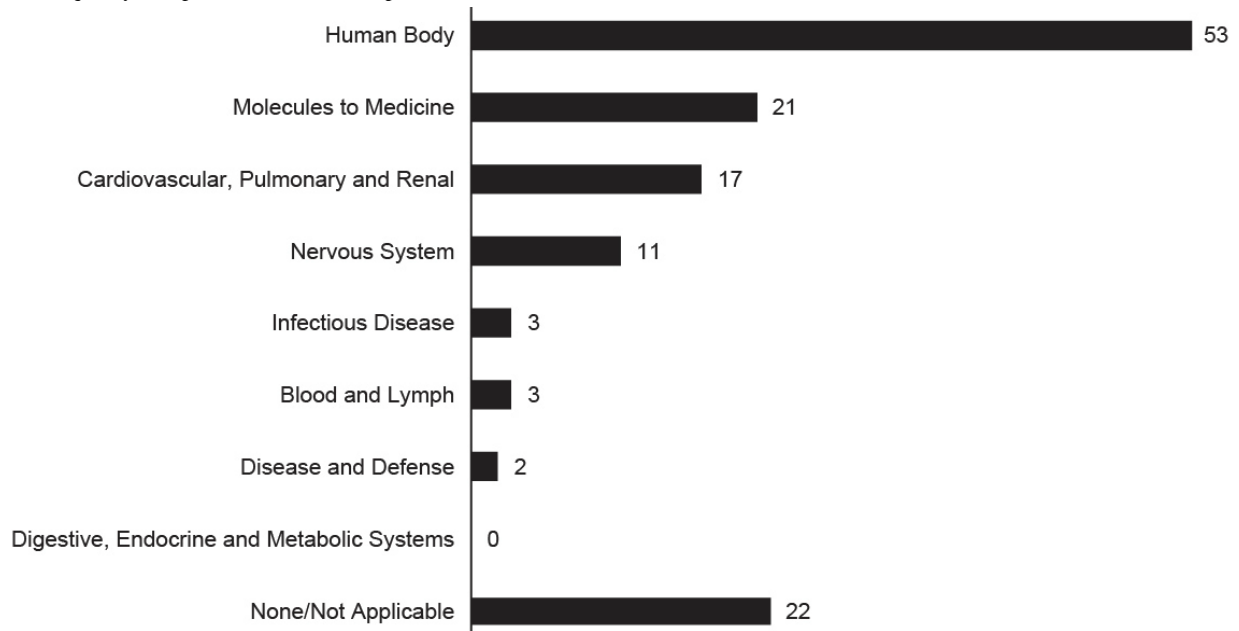
Students reported using the wiki the most during the Human Body block of the preclinical years of the curriculum (58/164, 35.4%), whereas 21 and 17 respondents, respectively, used it

most for the Molecules to Medicine and the Cardiovascular, Pulmonary, and Renal blocks ([Figure 4](#)). Twenty-two students selected none/not applicable for this item.

Students reported content was easy to find on the wiki (mean 3.68, SD 0.98 out of 5.00; N=132). Relatively few students accessed the wiki daily in the block in which they used it most (11/145, 7.6%; [Figure 5](#)). A much greater number of students indicated that they accessed the wiki at least once a week (81/145, 55.8%).

On average, respondents felt the wiki was more useful in the preclinical years of MS1 and MS2 (mean 2.73, SD 1.25, N=143) than in the clinical years of MS3 and MS4 (mean 1.88, SD 1.12, N=120;  $P<.001$ ) on a 5-point scale in which 1 indicated not important at all and 5 indicated essential. Usefulness of the wiki in the preclinical years demonstrated a positive, but weak, correlation with the percent of studying time in the preclinical years using electronic study resources (Spearman  $\rho=.414$ ,  $P<.001$ ; [Figure 6](#)).

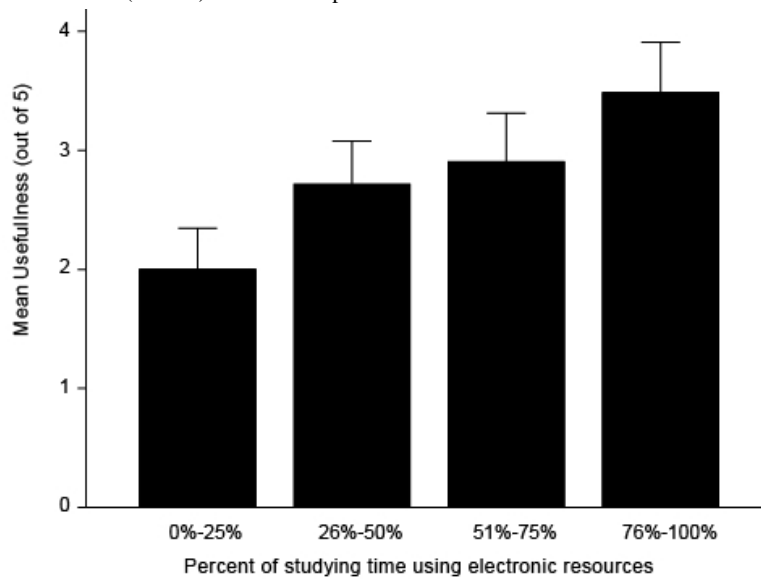
**Figure 4.** Frequency of reported use of the wiki per block of the medical school curriculum.



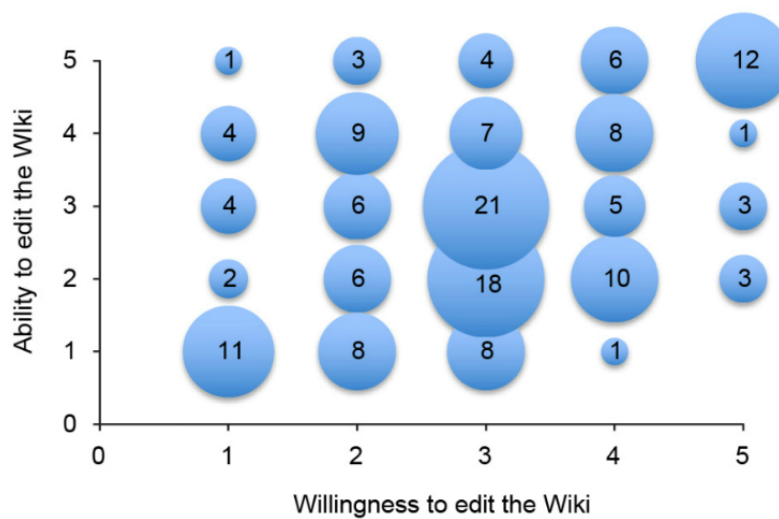
**Figure 5.** Reported frequency of usage of the wiki.



**Figure 6.** Student-perceived usefulness as a function of percent of studying time using electronic resources. The respondents that used the wiki for a high percentage of time found it more useful ( $P < .001$ ). Error bars represent standard error.



**Figure 7.** Ability to edit the wiki as a function of willingness to edit the wiki. The numbers in each circle represent the number of respondents.



Level of engagement with editing the wiki was assessed numerically along two dimensions with two Likert scale questions: “How willing will you be to contribute content to the wiki in the future?” and “How confident are you that you could add content if you wanted to?” Average willingness and average confidence were mean 2.94 (SD 1.19) and mean 2.91 (SD 1.33) out of 5, respectively. The most common answer was 3 to both questions (N=162). The answers were weakly correlated (Spearman  $\rho=.346$ ,  $P<.001$ ). All possible answer pairs were observed except a willingness of 5 and ability of 1 (Figure 7).

## Discussion

### Principal Findings

A collaborative wiki containing valuable study resources for a medical school curriculum was established by students in a relatively short time frame. These results address a gap in the literature on a student-created wiki representing a hybrid model between traditional and constructivist learning theories. The wiki received a large volume of traffic year-round, with the most dramatic peak in visitation corresponding to timing of the fall semester. Popularity of the wiki grew with time as evidenced in the increase in many key website traffic variables from the Fall 2011 semester to the Fall 2012 semester. In a usage survey, most medical students reported awareness of the wiki as a resource (88%) and used it most often during the Human Body block (gross anatomy) of the preclinical years of the curriculum. A weak positive correlation was observed between willingness to edit the wiki and ability to edit the wiki.

The development and usage of the wiki underscores many principles of the constructivist theory of learning. Students chose to organize information in a format most meaningful to them by constructing pages that mirrored the curricular structure (year and blocks of body systems). Students also developed a rich folksonomy of useful websites and resources by providing website names, URLs, and descriptions. In one particular aspect, the CUSOM wiki served as a hybrid between traditional and constructivist models (Figure 1). An anatomy teacher in the medical curriculum added several websites and drawings (Figure

2B) to the Human Body block of the curriculum (Figure 2A). The ability of students to self-organize content enhanced the ability to find information efficiently. This was a major improvement over the previous Google Groups platform, in which older content was buried in the timeline and very difficult to retrieve.

Experiences documented in the literature from both successful and failed wikis have provided several key factors for establishing a successful and self-sustaining wiki. It is necessary to have an initial set of content and a user-friendly explanation of how to get started on adding content, a method of reassuring users that their content will be valued, and thorough testing and rapid response to technical difficulties: Cole [19] documented a failed attempt to incorporate a wiki into an undergraduate course on information systems, in which students frequently cited technical difficulty, lack of time, lack of interest, and hesitancy to be the first to post content as reasons for not editing the course wiki, which received zero contributions. Jalali et al [20] attempted to incorporate a student-created wiki into an undergraduate medical curriculum, but were not successful due to similar reasons as the aforementioned attempt-focus group. Comments included difficulty accessing the wiki, lack of content the users were looking for, and participant lack of confidence in their own knowledge to contribute. Although the CUSOM wiki has been reasonably successful, many of the same comments were echoed in this survey. Frequent reasons for not editing the wiki included unfamiliarity with the site, a difficult interface, or uncertainty about the value of their contributions. These barriers overlap with those reported in a study of emergency room residents’ beliefs about contributing to an online collaborative slideshow [18].

When asked to rate certain aspects of the wiki, some group differences emerged between the classes of medical students. Substantial differences were noted between upper-year (MS3 and MS4) and lower-year (MS1 and MS2) students in the perceived importance of the wiki in the preclinical and clinical years (Table 2). The lower ratings of the upper-year students ( $P<.001$ ) may be due to their unfamiliarity with the wiki because it was not available to them at the onset of their curriculum. The lower-year students would have been aware of the wiki

during their preclinical years and then further referenced it during their clinical education. Overall, the rating of perceived importance of the wiki fell on the lower end of the Likert scale for both preclinical (mean 2.73, SD 1.25 out of 5.00) and clinical (mean 1.88, SD 1.12) years. The greater response rates of the classes of 2013 and 2014 (46% and 36%) most likely lowered the overall averages. Other subtle, yet significant, differences were seen in the ease of finding and willingness to contribute content. The classes of 2015 and 2016 found it easier to find content than their more senior counterparts. This is perhaps due, again, to their familiarity with navigating the wiki beginning in their first or second year of study. The greater perceived importance of the wiki may be reflected in the greater willingness of the classes of 2015 and 2016 to contribute content to the resource. Two variables did not yield significant groups differences (ie,  $P > .05$ ): (1) ease of making changes and (2) confidence of adding content. Although there was a trend toward a greater ease of making changes by the classes of 2013 and 2014, a very limited number of response to this survey item ( $n=20$ ) likely unpowered our ability to detect any true differences. The rating of confidence across each class was very close to the middle of the Likert scale (3.00), which could be viewed positively and account for the successful development of the wiki with potential improvement in the presence of early formal guidance on adding content.

If the wiki is migrated to an on-campus server, then there will be an opportunity to significantly redesign the wiki structure to better conform to guidelines of good user interface. According to Sandars and Lafferty [21], visual design, consistency, accessibility, interactivity, and many other factors should be considered for e-learning resources in medical education. As part of the redesign process, focus groups and usability testing could be leveraged to create a standardized and easy-to-use layout to replace the existing layout, which evolved organically with the wiki and has been challenging to adapt to certain topics.

The survey results revealed several interesting trends. Overall, they show that similar to many learning tools, the CUSOM wiki is useful to some but not others, and depends greatly on individual learning style. For example, students who spend more time using digital study resources unsurprisingly consider the wiki more useful. Many students found the learning objective content to be helpful, but found it difficult to locate the content they needed or were frustrated by the number of embedded documents, which were harder to edit. Additional features, such as a template that makes it easier to arrange learning objectives or a small committee of appointed editors, could address some of these shortcomings, whereas others may have to wait for a complete redesign.

## Limitations

Major limitations of this study include a poor survey response rate (26%). In addition, responses were mostly from the classes of 2013 and 2014 (79% of respondents) and this likely introduced bias into the results from the survey. The usage survey in our study was constructed and reviewed by the authors for content validity. The survey quality could have been improved had reliability been tested (eg, Cronbach alpha) and validity demonstrated (eg, Kendall tau). Only responses from completed surveys were included in the analysis. Several survey items only had the end point of response options labeled, which left the meaning of unlabeled options open to respondent's interpretation. This ambiguity may have introduced measurement error. Our use of a convenience sample was also a limitation of this study. Detailed demographic data for the survey respondents were not collected. Although we suspect our cohort of medical students is similar to those of other institutions, demographic data would assist in determination of generalizability. Objective data about how students actually used the wiki (eg, usability testing) were not gathered. In addition, implementation of a theory-based approach would also assist in understanding the barriers to using and contributing to a wiki in medical education.

## Future Work

Possible areas for future research on the wiki include repetition of the survey with future classes, investigation of the effect of requiring students to contribute, and—if the wiki is moved to a password-protected campus server—analysis of usage data at the level of individual users. Future attempts to engage students in editing the wiki will need to utilize multiple methods including a simple tutorial to reduce technical barriers, increased use of page templates to ensure user and editor-friendly pages, and possibly a curriculum component requiring students to edit the wiki to increase student buy-in and comfort. As indicated by the wide range of answers, there are users throughout the range of willing and able, unwilling and unable, willing but unable, and unwilling but able. Therefore, no single strategy will suffice to increase engagement. However, it is advisable to reduce the potential number of interventions to only those that are theory-based. Archambault et al [22] provide an excellent example of a theory-based approach in the field of medical education.

## Conclusions

This study details the creation of a medical curriculum-specific wiki, which was led by students. The wiki received a high volume of Web traffic that grew over time and was reported to be an important resource during preclinical and clinical years by students exposed during their first and second year of medical school.

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## Conflicts of Interest

None declared.

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## Multimedia Appendix 1

The text of the survey distributed to all four current classes in the School of Medicine (n=640 students; Classes of 2013 to 2016).

[[PDF File \(Adobe PDF File\), 127KB - mededu\\_v4i1e16\\_app1.pdf](#)]

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**Abbreviations**

**CUSOM:** University of Colorado School of Medicine

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Original Paper

# Evaluating the Effect of a Web-Based E-Learning Tool for Health Professional Education on Clinical Vancomycin Use: Comparative Study

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## Abstract

**Background:** Internet-based learning for health professional education is increasing. It offers advantages over traditional learning approaches, as it enables learning to be completed at a time convenient to the user and improves access where facilities are geographically disparate. We developed and implemented the Vancomycin Interactive (VI) e-learning tool to improve knowledge on the clinical use of the antibiotic vancomycin, which is commonly used for treatment of infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA).

**Objective:** The aims of this study were to evaluate the effect of the VI e-learning tool on (1) survey knowledge scores and (2) clinical use of vancomycin among health professionals.

**Methods:** We conducted a comparative pre-post intervention study across the 14 hospitals of two health districts in New South Wales, Australia. A knowledge survey was completed by nurses, doctors, and pharmacists before and after release of a Web-based e-learning tool. Survey scores were compared with those obtained following traditional education in the form of an email intervention. Survey questions related to dosing, administration, and monitoring of vancomycin. Outcome measures were survey knowledge scores among the three health professional groups, vancomycin plasma trough levels, and vancomycin approvals recorded on a computerized clinical decision support system.

**Results:** Survey response rates were low at 26.87% (577/2147) preintervention and 8.24% (177/2147) postintervention. The VI was associated with an increase in knowledge scores (maximum score=5) among nurses (median 2, IQR 1-2 to median 2, IQR 1-3;  $P<.001$ ), but not among other professional groups. The comparator email intervention was associated with an increase in knowledge scores among doctors (median 3, IQR 2-4 to median 4, IQR 2-4;  $P=.04$ ). Participants who referred to Web-based resources while completing the e-learning tool achieved higher overall scores than those who did not ( $P<.001$ ). The e-learning

tool was not shown to be significantly more effective than the comparator email in the clinical use of vancomycin, as measured by plasma levels within the therapeutic range.

**Conclusions:** The e-learning tool was associated with improved knowledge scores among nurses, whereas the comparator email was associated with improved scores among doctors. This implies that different strategies may be required for optimizing the effectiveness of education among different health professional groups. Low survey response rates limited conclusions regarding the tool's effectiveness. Improvements to design and evaluation methodology may increase the likelihood of a demonstrable effect from e-learning tools in the future.

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## KEYWORDS

nursing education; pharmacy education; medical education; continuing education; survey methods; antibacterial agents

## Introduction

### Internet-Based Learning

Traditional face-to-face approaches to health professional education are being challenged by busy trainee schedules involving increased clinical demands and decreased available time [1,2]. These barriers can be addressed through the use of Internet-based learning (IBL) approaches, which can be completed at a time convenient to the user [3]. It may also be useful if health professional education is required across geographically disparate hospital locations. Effective IBL tools should provide entertainment and supply the user with knowledge, skills, or attitudes useful in real life [4]. Recently, there has been considerable development in novel IBL methodologies for health professional education (eg, serious games) with common topics relating to surgical skills training, critical care, and emergency triage [2,5]. Some studies showed improvements in test scores [2]; however, study design was heterogeneous and none focused on the antibiotic vancomycin as an educational target.

### Vancomycin Education

Vancomycin is the main antibiotic used for treatment of infections caused by methicillin-resistant *Staphylococcus aureus* [6]. Problems associated with vancomycin use across multiple professions include the requirement for a loading dose in serious infections, side effects when administered too rapidly, and the need to monitor vancomycin plasma levels (or concentrations) [6]. Therefore, several studies have described interventions to improve clinical use of vancomycin [7-14]. Specific topics addressed in those studies were dosing [7,9,11,14], administration [7], and therapeutic drug monitoring (TDM) [7-10,12,13]. Educational targets were nurses, doctors, or pharmacists, with one TDM study conducting multidisciplinary interventions [12]. In a previous study [15], we described the design and implementation process of a Web-based e-learning tool (Vancomycin Interactive; VI) that employed serious game design concepts including interactivity and entertainment to provide education on vancomycin. To our knowledge, this study is the first to compare outcomes of a vancomycin e-learning tool with a standard didactic email intervention.

The design and implementation methodology for the Vancomycin Interactive Web-based e-learning tool has been provided in a prior publication, "Design and Implementation of a Novel Web-Based E-Learning Tool for Education of Health Professionals on the Antibiotic Vancomycin" in the Journal of Medical Internet Research [15].

### Aims of This Study

The aims of this study were to assess the VI e-learning tool versus standard email intervention for (1) effects on health professionals' vancomycin knowledge and (2) effects on quality of vancomycin use measured by both vancomycin plasma trough levels and approvals for use recorded on a computerized clinical decision support system (CDSS; Guidance MS, Melbourne Health [16]).

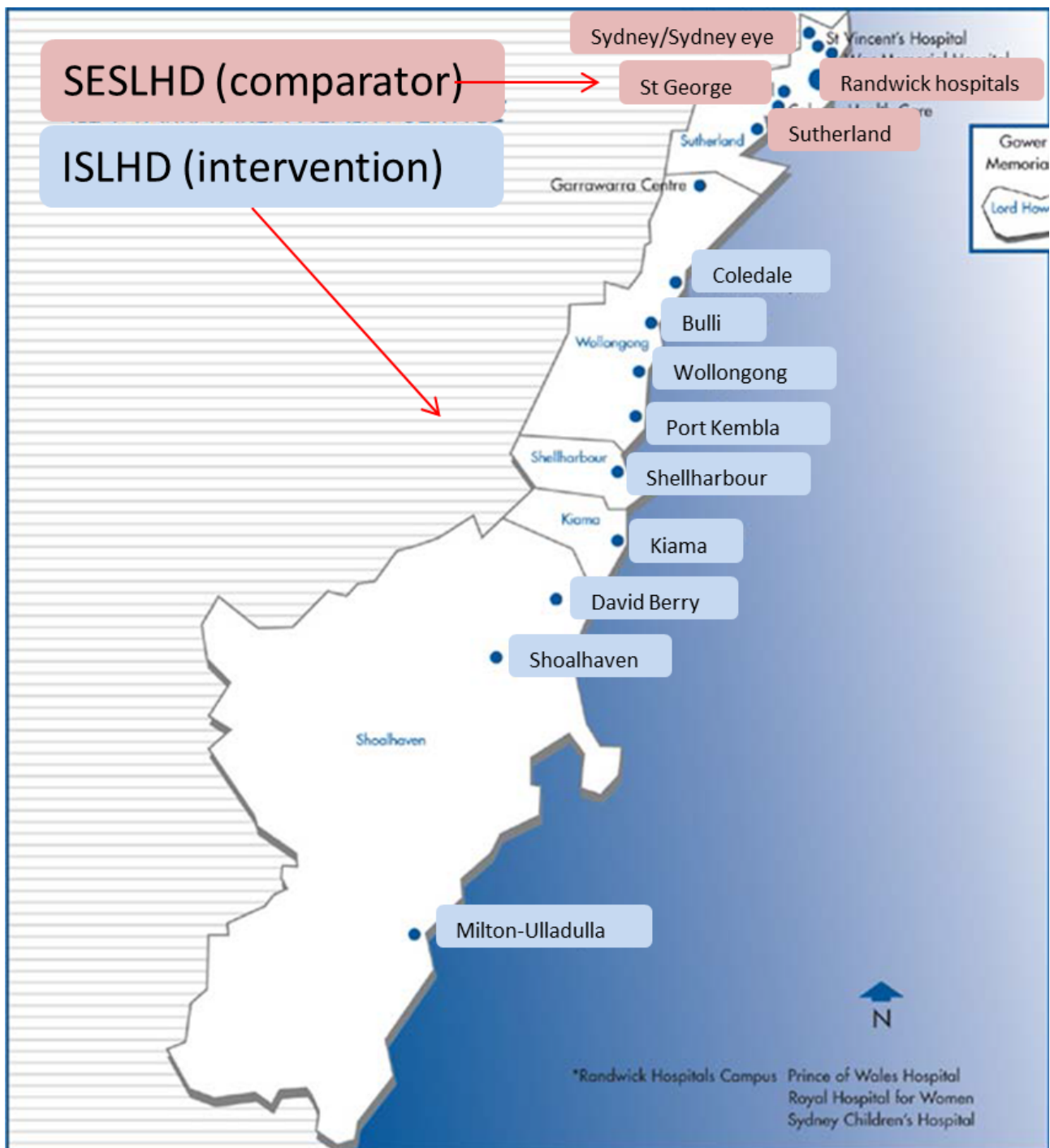
## Methods

This comparative pre-post intervention study took place in Illawarra Shoalhaven Local Health District (ISLHD; Vancomycin Interactive intervention site, 1000 total beds, 700 acute beds) and South Eastern Sydney Local Health District (SESLHD; comparator email intervention site, 1500 total beds, 1200 acute beds), located in New South Wales, Australia (Figure 1). These health districts cover a geographic area of 6331 km<sup>2</sup> and have an estimated population of 1.17 million, reaching from central Sydney to a 3-hour drive south [17]. The districts' 14 hospitals range from small rural facilities to large tertiary metropolitan hospitals. The comparator email site was selected due the following: a shared information technology platform with the e-learning intervention site, geographical proximity, and existing clinical and professional networks.

### Preintervention and Postintervention Vancomycin Knowledge Survey

An anonymous Web-based survey was created using Survey Monkey (SurveyMonkey Inc, Palo Alto, CA) to determine preintervention experience/confidence and knowledge of vancomycin use among nurses, doctors, and pharmacists across two health districts [15]. A 4-point Likert scale was used to determine levels of experience and confidence relating to knowledge questions on dosing, administration, and monitoring of vancomycin (see [Multimedia Appendix 1](#)).

**Figure 1.** Intervention (Illawarra Shoalhaven Local Health District; ISLHD) and comparator (South Eastern Sydney Local Health District; SESLHD) sites.



Postintervention, a second survey with the same questions was sent to the intervention and comparator sites. User testing indicated that the preintervention survey would take approximately 2 minutes to complete and the postintervention surveys would take 3 minutes, because additional user feedback was sought on the VI and comparator email. Requests for survey participation are included as [Multimedia Appendices 2 and 3](#). A survey question on resources used to answer the survey was also analyzed.

### Vancomycin Interactive and Clinical Email Intervention

Educational content was developed locally for the VI on dosing, administration, and TDM of vancomycin [6,18]. The learning objectives of the VI for target users (nurses, doctors, and pharmacists) were to improve knowledge of vancomycin dosing, administration, and TDM. The VI (ISLHD) [19] depicted a case study involving interaction between a patient and a health professional, both played by professional actors. The user interface consisted of video clips interspersed with interactive question and answer scenarios [15]. User testing indicated that the VI would take approximately 10 minutes to complete. An

email (taking 2-3 minutes to read) with the same clinical content and learning objectives was developed as a comparator intervention ([Multimedia Appendix 4](#)). To allow for the differences in the two media, there were some minor variations in clinical content between the VI and email that related to administration of vancomycin.

Release and advertisement of the VI (email, newsletters, link on intranet home page) to the intervention site occurred on July 27, 2015. The clinical email intervention was then sent to nurses, doctors, and pharmacists at the comparator site ([Multimedia Appendix 4](#)). Following completion of the second survey, the VI website was also advertised to the comparator site. To allow for sufficient dissemination of the interventions, the postintervention survey was open from December 1, 2015 to January 31, 2016.

### Vancomycin Trough Plasma Levels and Approvals on the Clinical Decision Support System

Vancomycin plasma levels from a 4-month period before and a 2-month period after the VI and comparator email were analyzed to determine changes in the proportion of levels in the therapeutic range. The postintervention period was limited to 2 months in order to conclude before the annual intake of new junior doctors. Criteria for dose adjustment were as follows: (1) 0-9 mg/L: increase dose; (2) 10-14 mg/L: maintain or increase dose (depending on severity of infection and clinical status); (3) 15-20 mg/L: maintain current dose; (4) 20-25 mg/L: maintain or reduce dose (depending on severity of infection and clinical status); and (5) >25 mg/L: withhold dose until trough level less than 20 mg/L and seek expert advice [6]. The number of vancomycin levels as a proportion of the total number of vancomycin CDSS approvals was analyzed to determine frequency of vancomycin use. Pharmacy dispensing software did not allow for patient-level data on vancomycin dispensing to be analyzed because vancomycin was distributed as ward stock in some hospitals. Hence, vancomycin CDSS approvals were used as the best-available indicator for total vancomycin use.

### Outcome Measures

We compared total vancomycin knowledge survey scores preintervention and postintervention, within and between e-learning intervention and comparator email intervention sites. The number of vancomycin levels in the therapeutic range, the median number of vancomycin levels and ratio of vancomycin levels to CDSS vancomycin approvals between sites were also analyzed.

### Statistical Analyses

Chi-square and Fisher exact tests were used for proportions. For continuous data, normality was assessed using a skewness/kurtosis statistic [20]. A skewed distribution was denoted by  $P < .05$ . Kruskal-Wallis and follow-up Wilcoxon rank-sum tests were used to investigate between effects with nonnormal distributions. Multivariate analysis was performed to examine influential factors (profession, site, pre- or postintervention) on correct survey responses. Given the limited literature in this field of research, a sample size calculation was conducted based on Monte-Carlo simulations of pilot data. This calculation was performed to estimate the sample size required for the effect of site on total knowledge score. The expected distributions of knowledge scores for the intervention (mean 3.30, SD 1.47) and control sites (mean 2.85, SD .48) were derived from pilot data. These hypothesized data structures were then randomly resampled with 10,000 iterations under different sample size conditions to estimate the required sample size to detect a difference. Based on these simulations, it was calculated that a sample size of 226 in each group was required to achieve 90% power for significance of  $P < .05$ . Statistical analyses were performed using Stata statistical software release 14 (Statacorp LP, College Station, TX, USA).

### Ethics

Ethics approval was granted by the Joint University of Wollongong and Illawarra Shoalhaven Local Health District Health and Medical Human Research Ethics Committee (EC00150), approval number HE15/005. The VI website contained a disclaimer that anonymous data collected from the video could be used for educational and research purposes.

## Results

### Vancomycin Knowledge Survey

The response rate to the preintervention survey was 26.87% (577 responses from 2147 email recipients). The response rates by profession were 24.4% (236/967) for nurses, 25.33% (271/1070) for doctors, and 63.6% (70/110) for pharmacists ( $P < .001$ ; previously reported [15]). Postintervention, there were 177/2147 survey responses (8.24% response rate), comprising 88 nurses, 69 doctors, and 20 pharmacists ( $P < .001$ ).

The median knowledge survey score for nurses increased post-VI ( $P < .001$ ; [Table 1](#)). No significant differences pre- and post-VI were observed for doctors or pharmacists. At the comparator email intervention site, the median knowledge survey score increased postintervention for doctors ( $P = .04$ ; [Table 1](#)).

**Table 1.** Preintervention and postintervention vancomycin knowledge survey scores for the intervention site using Vancomycin Interactive and the comparator email site.

Profession	Vancomycin Interactive intervention site, median (IQR) <sup>a</sup>			Comparator site, median (IQR) <sup>a</sup>		
	Pre (n=278)	Post (n=107)	P value	Pre (n=299)	Post (n=70)	P value
Nurse	2 (1-2)	2 (1-3)	<.001	2 (1-3)	3 (2-4)	.17
Doctor	3 (2-4)	4 (2-4)	.28	3 (2-4)	4 (2-4)	.04
Pharmacist	5 (4-5)	4 (4-5)	.40	5 (4-5)	5 (4-5)	.87

<sup>a</sup>IQR: interquartile range; Out of a maximum of 5.

**Table 2.** Preintervention (4 months) and postintervention (2 months) vancomycin plasma trough levels for intervention and comparator sites.

Trough level (mg/L)	Vancomycin Interactive intervention site			Comparator email site		
	Pre (n=429)	Post (n=151)	P value	Pre (n=1571)	Post (n=316)	P value
0-9 (subtherapeutic), n (%)	48 (11)	17 (11)	.98	259 (16)	50 (16)	.77
10-14 (low therapeutic), n (%)	91 (21)	28 (19)	.49	362 (23)	62 (20)	.18
15-20 (therapeutic), n (%)	168 (39)	54 (35)	.46	515 (33)	98 (31)	.54
21-25 (high therapeutic), n (%)	72 (17)	36 (24)	.06	260 (17)	66 (21)	.06
>25 (supratherapeutic), n (%)	50 (12)	16 (11)	.73	175 (11)	40 (13)	.44
Median (IQR) <sup>a</sup>	18 (13-21)	17 (13-22)	.62	16 (12-21)	17 (12-22)	.14

<sup>a</sup>IQR: interquartile range.

## Resources Used to Answer Survey Questions

To the question, "Did you refer to any resources to answer these questions?" 595 of 754 (78.9%) participants responded "no." Of those 595, 424 (71.3%) self-reported that they guessed some or all of the answers, whereas 171 (28.7%) reported that they knew the answers. The remaining 159 of 754 (21%) respondents self-reported that they referred to resources for answering the questions. The resources quoted were local guidelines (49/159, 30.9%) and the *Australian Medicines Handbook* or *Therapeutic Guidelines: Antibiotic* (110/159, 69.1%).

## Multivariate Analysis of Knowledge Survey Scores

Several factors were associated with an increased knowledge survey score. Compared to nurses, pharmacists (regression coefficient 1.93, 95% CI 1.63-2.23;  $P<.001$ ) and doctors (regression coefficient 0.89, 95% CI 0.70-1.09;  $P<.001$ ) had increased likelihood of a higher survey score. Postintervention survey participation was also associated with a higher score (regression coefficient 0.41, 95% CI 0.20-0.62;  $P<.001$ ) than preintervention. Referring to online resources was associated with a higher score compared with responses that participants self-reported that they knew or guessed the answers (regression coefficient 0.98, 95% CI 0.75-1.20;  $P<.001$ ). The comparator site was not significantly associated with increased likelihood of higher survey scores (regression coefficient 0.16, 95% CI -0.02 to 0.34;  $P=.08$ ).

## Vancomycin Therapeutic Drug Monitoring

From January 1 to April 30, 2015, there were 429 vancomycin trough plasma levels taken at the intervention site (ISLHD) and 1571 levels for the comparator site (SESLHD). During the postintervention period of December 1, 2015 to January 31, 2016, there were 151 levels reported at the intervention site and

316 levels at the comparator site. As shown in [Table 2](#), there were no significant postintervention differences in the proportion of vancomycin levels in the subtherapeutic (0-9 mg/L), therapeutic (10-14, 15-20, and 21-25 mg/L), or supratherapeutic (>25 mg/L) ranges. There were increases in the number of levels in the high therapeutic range (20-25 mg/L) at both sites; however, those differences did not reach statistical significance. There were no significant pre-post intervention differences in median vancomycin levels at the intervention site or comparator site ([Table 2](#)).

## Vancomycin Trough Plasma Levels Compared With Vancomycin Clinical Decision Support System Approvals

The proportion of vancomycin trough levels to vancomycin CDSS approvals at the intervention site decreased from 429/399 preintervention (1.1 levels for every vancomycin approval) to 151/196 postintervention (0.8 levels/approval). At the comparator site, the proportion of vancomycin levels to vancomycin CDSS approvals decreased from 1571/399 preintervention (3.9 levels/approval) to 314/199 postintervention (1.6 levels/approval).

## Discussion

### Principal Findings

This study compared the educational effect of an interactive Web-based e-learning tool with a comparator email intervention. Two different learning modalities were investigated among three different health professional groups. The e-learning tool was associated with improved survey scores among nurses, whereas the comparator email intervention was associated with improved scores among doctors. Not unexpectedly, pharmacists

and doctors had higher overall knowledge scores than nurses due to the greater number of questions considered relevant to those groups. Also, participants who referred to Web-based resources while completing the survey had higher survey scores than those who did not.

Concerningly, only approximately one-third of preintervention and postintervention vancomycin levels taken at both sites fell within the recommended therapeutic range of 15-20 mg/L. This figure rose to 73% when the ranges 10-14 mg/L, 15-20mg/L, and 21-25 mg/L were combined, which includes all potential recommended therapeutic ranges [6]. The proportion of vancomycin levels to CDSS approvals decreased at both sites, perhaps signifying a reduction in the ordering of unnecessary levels or shorter vancomycin courses requiring fewer levels. A greater proportion of levels/approvals was observed at the email intervention site in both preintervention and postintervention phases, which may have resulted from differences in acuity between sites.

In previous studies, strategies for improving the clinical use of vancomycin have included use of loading doses [14], implementation of guidelines [9], education [7,10,13], and CDSSs [8,11,12]. None of those educational interventions incorporated a Web-based e-learning tool, and the predominant methodology was uncontrolled pre-post intervention at single hospital sites. One study reported development of a serious game to improve general antimicrobial prescribing, but it did not focus on vancomycin [21]. A review of educational games for health professionals emphasized the need for more research with improved study methodology [22]. Our study differed in its multisite approach, comparison of an e-learning tool with a standard email intervention, and targeting of multiple health professional groups.

### Interpretation of Results

The difference in efficacy between the VI (improved nurses' scores) and the email (improved doctors' scores) may have arisen from nurses' increased familiarity and engagement with online learning modules, whereas for doctors a didactic learning style may be more suitable. Additionally, the short time to read a clinical email may have been more convenient for doctors. Referring to resources was associated with improved survey scores, which emphasizes the importance of guideline access in the clinical setting. Some aspects of our study design may be applicable to facilities where there are geographic barriers to use of face-to-face education, such as rural and regional hospitals. Potential improvements to the structure of the VI through greater application of serious game methodology include more interactivity, scoring, and competition [23,24]. Those features could result in a greater level of user acceptance and effectiveness.

### Study Limitations

The total number of vancomycin levels at the comparator site was considerably higher than at the intervention site, which may be due to differences in case mix (number of acute beds), antimicrobial use, and background educational culture. However, the proportion of satisfactory levels (ie, those in therapeutic range) did not differ between the sites. Furthermore, similar

sizeable reductions in the number of vancomycin levels ordered were experienced at both sites. Some of this reduction may have been associated with seasonal variation of vancomycin use, although unlike other antibiotics, vancomycin is not typically associated with strong seasonal variation [25]. The low response rate to the postintervention survey limited the power of pre-post intervention comparisons; however, 78% of the desirable sample size was reached. Potential reasons for this reduction include the perception of staff that the postintervention survey was the same as the preintervention survey, despite clarifications that were provided in the email title and text, and appropriate advertisement in staff newsletters. The validity of the findings is supported by similar proportions of different health professionals in the two time periods. In addition, the denominator included all targeted health professionals including those not involved in the day-to-day clinical use of vancomycin, which is likely to have reduced the response rate.

The higher scores from the postintervention survey may have resulted from participant bias (ie, only more experienced and enthusiastic staff may have responded to the second survey). Time-dependent bias may also have influenced some of the improvement in survey scores, whereby increased time in a clinical role may have resulted in greater knowledge of vancomycin use over the study period. A crossover design might have partially alleviated this factor, but this was not possible in our case due to the rotation of junior doctors between the two sites. Absence of a code to allow matching of individual responses may also have limited conclusions about the effect of the interventions on knowledge level.

Pooled presurvey results were compared with pooled postsurvey results resulting in a dataset that included both independent and dependent data. Although unavoidable according to the study design, inclusion of dependent data increased the risk of type I error. Additionally, pooling of the survey response data when there were differences between health professional groups may have limited conclusions on pre-post differences. Although individual predictors in the multivariate regression were likely to be skewed, the normality of the error between observed and predicted values was of primary interest in this study.

There were some minor variations in clinical content between the VI and email; however, they related only to administration of vancomycin and references used for development of content were the same for both interventions. Participants who referred to guidelines while completing the survey attained higher scores than those who did not. Although this was unavoidable in a pragmatic study, it was still a desirable outcome because those participants were using recommended national or local guidelines. The time to complete the e-learning tool (10 minutes) was longer than the email intervention (2-3 minutes); the duration of the email may have been more appropriate for doctors in a busy clinical context and this has likely contributed to the low response rates. As reported in our previous study [15], there was low uptake of the VI during the study period and we did not measure the number of comparator emails read by staff. There may have been some word-of-mouth leakage of the VI to the comparator site; however, study data collection was completed before the junior doctor rotation. Given the use of paper medications charts, the number of CDSS approvals

was used as a surrogate for vancomycin prescribing. Investigation of effects of the educational tools on clinical practice was beyond the scope of this study. We did not examine quality measures of vancomycin use, such as time to first therapeutic level, levels obtained at steady state, or clinical outcomes associated with the intervention; further research aims to examine these effects. Linkage of survey-participant responses was desirable, but was not achievable within the ethical requirement for an anonymous survey. The timeframe for postintervention data collection was a relatively short 2 months, which may not have been long enough for transfer of knowledge into practice. Addressing some of these limitations

may improve the likelihood of demonstrating significant effects from an e-learning tool.

## Conclusions

Different health professional groups can be educated by using different targeted learning modalities. Significant challenges can be experienced during design and evaluation of comparative e-learning research. Further studies should aim to improve structural elements of e-learning tools and enhance evaluation, including clinical outcomes, through an approach governed by a newly proposed checklist. The impact of continuous e-learning education on clinical practice needs to be assessed continuously for a long period of time.

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## Conflicts of Interest

None declared.

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## Multimedia Appendix 1

Preintervention vancomycin knowledge survey.

[\[PDF File \(Adobe PDF File\), 21KB - mededu\\_v4i1e5\\_app1.pdf \]](#)

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## Multimedia Appendix 2

Preintervention survey request emailed to staff at intervention/comparator sites.

[\[PDF File \(Adobe PDF File\), 17KB - mededu\\_v4i1e5\\_app2.pdf \]](#)

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## Multimedia Appendix 3

Postintervention survey request emailed to staff at intervention/comparator sites.

[\[PDF File \(Adobe PDF File\), 18KB - mededu\\_v4i1e5\\_app3.pdf \]](#)

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## Multimedia Appendix 4

Clinical email update sent to staff at the comparator sites.

[\[PDF File \(Adobe PDF File\), 34KB - mededu\\_v4i1e5\\_app4.pdf \]](#)

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## Abbreviations

**CDSS:** clinical decision support system

**IBL:** Internet-based learning

**ISLHD:** Illawarra Shoalhaven Local Health District

**SESLHD:** South Eastern Sydney Local Health District

**TDM:** therapeutic drug monitoring



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Original Paper

# Integrating Patient-Centered Electronic Health Record Communication Training into Resident Onboarding: Curriculum Development and Post-Implementation Survey Among Housestaff

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## Abstract

**Background:** Electronic health record (EHR) use can enhance or undermine the ability of providers to deliver effective, humanistic patient-centered care. Given patient-centered care has been found to positively impact patient health outcomes, it is critical to provide formal education on patient-centered EHR communication skills. Unfortunately, despite increasing worldwide EHR adoption, few institutions educate trainees on EHR communication best practices.

**Objective:** The goal of this research was to develop and deliver mandatory patient-centered EHR training to all incoming housestaff at the University of Chicago.

**Methods:** We developed a brief patient-centered EHR use curriculum highlighting best practices based on a literature search. Training was embedded into required EHR onboarding for all incoming housestaff (interns, residents, and fellows) at the University of Chicago in 2015 and was delivered by institutional Clinical Applications Trainers. An 11-item posttraining survey consisting of ten 5-point Likert scale questions and 1 open-ended question was administered. Responses at the high end of the scale were grouped to dichotomize data.

**Results:** All 158 of the incoming 2015 postgraduate trainees participated in training and completed surveys (158/158, 100.0%). Just over half (86/158, 54.4%) were interns and the remaining were residents and fellows (72/158, 45.6%). One-fifth of respondents (32/158, 20.2%) were primary care trainees (defined as internal medicine, pediatric, and medicine-pediatric trainees), and the remaining 79.7% (126/158) were surgical or specialty trainees. Self-perceived pre- versus posttraining knowledge of barriers, best practices, and ability to implement patient-centered EHR skills significantly increased (3.1 vs 3.9,  $P < .001$  for all). Most felt training was effective (90.5%), should be required (86.7%), and would change future practice as a result (70.9%). The only significant difference between intern and resident/fellow responses was prior knowledge of patient-centered EHR use barriers; interns endorsed higher prior knowledge than resident peers (3.27 vs 2.94 respectively,  $P = .03$ ). Response comparison of specialty or surgical trainees ( $n = 126$ ) to primary care trainees ( $n = 32$ ) showed no significant differences in prior knowledge of barriers (3.09 vs 3.22,  $P = .50$ ), of best practices (3.08 vs 2.94,  $P = .37$ ), or prior ability to implement best practices (3.11 vs 2.84,  $P = .15$ ). Primary care trainees had larger increases posttraining than surgical/specialty peers in knowledge of barriers (0.8 vs 0.7,  $P = .62$ ), best practices (1.1 vs 0.8,  $P = .08$ ), and ability to implement best practices (1.1 vs 0.7,  $P = .07$ ), although none reached statistical significance. Primary care trainees also rated training as more effective (4.34 vs 4.09,  $P = .03$ ) and felt training should be required (4.34 vs 4.09,  $P = .10$ ) and would change their future practice as a result (4.13 vs 3.73,  $P = .02$ ).

**Conclusions:** Embedding EHR communication skills training into required institutional EHR training is a novel and effective way to teach key EHR skills to trainees. Such training may help ground trainees in best practices and contribute to cultivating an institutional culture of humanistic, patient-centered EHR use.

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## KEYWORDS

electronic health records; EHR; patient-doctor relationship; communication

## Introduction

Electronic health record (EHR) use during clinical encounters is becoming the norm worldwide [1]. Since 2006, use of EHRs by US physicians increased by over 160% with 78% of office-based physicians and 59% of hospitals having adopted an EHR by 2013 [2]. That number has only increased with time, partly due to the financial incentives put in place by the Health Information Technology for Economic and Clinical Health Act of 2009, which calls for not only expanded use of EHRs but also increased engagement with patients and families with the EHR [3].

Given their ubiquity in practice, it is important for providers to be aware of how EHR use in clinical encounters can alter the patient-provider interaction. Studies looking at the impact of EHR use on the patient-doctor relationship and communication have identified physician behaviors that may negatively impact the patient-doctor relationship; for example, typing during sensitive discussions and low rates of screen sharing can lead to a decrease in transparency of provider actions and patient confusion or distrust as to what their provider is doing on the computer [4,5]. As a result, patient satisfaction with the interaction and the perception of their overall quality of care may be decreased [4-11]. Similarly, best practices for patient-physician EHR interactions exist, and research shows that when EHRs are integrated in a patient-centered manner, physicians can foster patient activation and engagement by improving communication, enhancing patient understanding of their medical conditions, and promoting increased shared decision making [1,4,12,13].

Patient-centered care has been found to positively impact a number of measures such as patient compliance, satisfaction, and health outcomes [14]. Given these important benefits, mandates such as the World Health Organization's Global Strategy on People-Centered and Integrated Health Services have called for improved people-centered care that empowers, educates, and engages individuals and incorporates technology in an efficient and effective manner [15]. In the United States, the American Medical Association and Accreditation Council for Graduate Medical Education also recommend educating trainee physicians on these best practice behaviors [16,17] in order to ground them in best practices and promote a lifelong practice of effective, patient-centered care.

Despite the existence of these best practices and mandates, few trainees receive training on EHR communication skills. Challenges related to providing this training include difficulty in reaching trainees across different specialties, lack of time in an already crowded curriculum, lack of a patient-centered EHR

use curriculum, and lack of trained educators to provide the instruction [18]. Without formal education on best practices, trainees may pick up bad habits and develop negative "workaround behaviors," informal practices designed to help them coordinate their day's work especially under conditions of time pressure and constraints [19]. Although these workarounds may help trainees get through the tasks of their day, they are generally suboptimal and can negatively influence the delivery, safety, effectiveness, and efficiency of care [19]. As such, appropriately using the EHR and information technology to not only manage the process of patient care but to also engage, communicate with, educate, and empower patients is an essential redesign of clinical practice today, and it is critical trainees learn best practice behaviors early on [18].

To address the need for instruction as well as the various obstacles generally encountered in providing training, we formed a novel partnership with our institutional EHR trainers and embedded an EHR use communication curriculum into the existing required EHR onboarding process for all incoming housestaff at the University of Chicago.

## Methods

After conducting a literature review of best practices for patient-centered communication use, we developed a comprehensive patient-centered EHR use curriculum for medical students at the Pritzker School of Medicine as part of the second-year clinical skills course [20,21]. This curriculum consisted of a 1-hour interactive lecture addressing the impact of EHR use on patient-provider communication and summarized best practices using the HUMAN LEVEL mnemonic (ie, "Honor the golden minute" to elicit patients' concerns before engaging the EHR) (Table 1) [7,20,22,23]. Students then participated in a group observed structured clinical examination where 1 student per group directly interacted with a standardized patient while the remaining students and a faculty member observed. Students were tasked with logging into and navigating a mock patient chart in the EHR and interacting with the standardized patient to discuss their chief concern, review prior labs, and provide counseling using the EHR in a patient-centered manner. A debrief and feedback from the faculty facilitator, standardized patient, and peer observers was conducted immediately after the exercise in order to highlight areas for improvement.

The above curriculum has successfully become an ongoing part of the Pritzker School of Medicine clinical skills course since 2013; however, it is time- and resource-intensive, thus limiting its direct application to all institutional postgraduate trainees [21]. As such, we consolidated the key themes and practical points of the training into a brief 15- to 20-minute, 8-slide

curriculum on key patient-centered EHR use skills targeting postgraduate trainees. The curriculum highlighted best practices for patient-centered communication skills and included a review of the HUMAN LEVEL mnemonic (Table 1) [7,20,22,23].

**Table 1.** HUMAN LEVEL—10 tips to enhance patient-centered electronic health record use.

Letter	Tip	Explanation
H	Honor the “Golden Minute”	Make the start of the visit completely technology free. Greet the patient, start with their concerns, and establish an agenda for the visit <i>before</i> engaging technology.
U	Use the “Triangle of Trust”	Create a triangle configuration that puts you, the patient, and the computer screen at each of the three corners. This allows you to look at both the patient and screen without shifting your body position and also enables shared screen viewing.
M	Maximize patient interaction	Encourage patient interaction. Pause for questions and clarification. Allow time for questions and to verify understanding.
A	Acquaint yourself with chart	Review the chart before you enter the room to prepare, inform, and contextualize your visit.
N	Nix the screen	When discussing sensitive information, completely disengage from the electronic health record (EHR) (look at the patient, turn away from screen, take hands off keyboard, etc).
L	Let the patient look on	Share things on the screen with your patients.
E	Eye contact	Maintain eye contact with patients as much as possible. Treat patient encounters as you would a conversation with friends or family members.
V	Value the computer	Praise the benefits of the EHR and take advantage of opportunities to use technology as a tool to engage patients (pull up lab result to review together, use graphics, etc).
E	Explain what you’re doing	Be transparent about everything you do. Avoid long silences, aim for conversational EHR use by explaining what you are doing as you are doing it.
L	Log off	At the end of the visit, log off of the patient’s chart while they are still in the exam room. This reassures the patient that their medical information is secure.

The curriculum was embedded in the required 4-hour EHR ambulatory onboarding for all incoming housestaff at the University of Chicago in August 2015. One of the authors (MAA) delivered a 1-hour training to 5 institutional EHR trainers and provided individual feedback on practice presentations of the material. The curriculum was not embedded in the actual EHR itself; rather, it was embedded in the training of how to use the EHR. The training was provided in person (ie, not a webinar or via webcast) and was led by our institutional EHR trainers. Learners attended the training session in groups, and during the training each learner had a desktop computer that allowed them to explore and practice the various functional abilities of the EHR with respect to their provider role (eg, how to log in, view labs and studies, place orders, write notes).

The entire EHR training session was 4 hours in length, and our content on patient-centered EHR use training was 20 minutes in length. It consisted of 8 PowerPoint slides that highlighted barriers to and best practices for patient-centered EHR use as well as institutional documentation expectations (ie, authorship and professionalism, refraining from indiscriminate importing of labs or radiology reports, keeping notes succinct and up to date).

An 11-item survey consisting of ten 5-point Likert scale questions and 1 open-ended question was administered to all participants posttraining (Multimedia Appendix 1). Average responses are reported and for some questions, responses at the high end of the scale were grouped to dichotomize data (ie,

4=agree and 5=strongly agree were simply categorized as “agree”). Differences between intern versus resident or primary care versus specialty/surgical trainee responses were analyzed using Wilcoxon rank-sum tests, and differences in overall pre-versus posttraining responses were analyzed using Wilcoxon signed-rank tests. Differences in trainee responses in relationship to the EHR instructor delivering the content were analyzed using Kruskal-Wallis tests.

## Results

A total of 158 postgraduate trainees attended the training and completed surveys (158/158, 100%). Over half (86/158, 54.4%) were interns and the remaining were residents and fellows (72/158, 45.6%). One-fifth of respondents (32/158, 20.2%) were primary care trainees (defined as internal medicine, pediatric, and medicine-pediatric trainees), and the remaining 79.7% (126/158) were surgical or specialty trainees with representation from 27 different specialties.

Overall, trainees reported significant increases in their knowledge of barriers, best practices, and ability to implement best practice strategies (3.1 vs 3.9 for all,  $P<.001$ ). On a 5-point Likert scale, 90.5% of respondents (143/158) either strongly agreed or agreed that the training was effective, and 86.7% (137/158) strongly agreed or agreed that it should be required for physicians and anyone interacting with patients and the EHR. A total of 70.9% of trainees (112/158) felt they planned to change their practice and how they interact with patients and the EHR as a result of the training.

Five different EHR instructors provided the training, and there was no significant difference in ratings of training effectiveness ( $P=.29$ ), need for required training ( $P=.53$ ), usefulness of the mnemonic ( $P=.58$ ), and likelihood of changing practice ( $P=.43$ ) across instructors.

When comparing responses with regard to training level, the only significant difference between intern and resident/fellow responses was prior knowledge of barriers to patient-centered EHR use, with interns endorsing higher knowledge than their more experienced peers (3.27 vs 2.94 respectively,  $P=.03$  from Wilcoxon rank-sum test).

Response comparison of specialty or surgical trainees ( $n=126$ ) to primary care trainees ( $n=32$ ) showed no significant differences in prior knowledge of barriers (3.09 vs 3.22,  $P=.50$ ), best practices (3.08 vs 2.94,  $P=.37$ ), or prior ability to implement best practices (3.11 vs 2.84,  $P=.15$ ). Primary care trainees tended to have larger increases posttraining than their surgical or specialty peers in knowledge of barriers (0.8 vs 0.7,  $P=.62$ ), best practices (1.1 vs 0.8,  $P=.08$ ), and ability to implement best practices (1.1 vs 0.7,  $P=.07$ ), although none reached statistical significance. Likewise, they rated the training as more effective (4.34 vs 4.09,  $P=.03$ ) and tended to agree more with the statements that training should be required (4.34 vs 4.09,  $P=.10$ ) and that they would change their future practice as a result (4.13 vs 3.73,  $P=.02$ ).

Responses to the open-ended question “What other suggestions/comments do you have about this session?” were in general quite positive. Of note, 1 trainee stated they would have preferred more expectations of what is to be documented in patient notes. Another trainee indicated they would have preferred additional practical training, stating “I would have preferred a longer hands-on portion with more exercises rather than the entire lecture portion. Doing a training that is more case-oriented with staff helping answer questions along the way would be a much more effective use of time.” Last, only 1 respondent mentioned that they had previously learned the HUMAN LEVEL mnemonic of best practices.

## Discussion

It is imperative that today's health care trainees are able to manage the demands of the EHR while maintaining a meaningful relationship with the patient and foster patient-provider communication. Our short training resulted in measurable improvement on self-assessed patient-centered EHR use knowledge, attitude, and skills, as well as likelihood to affect future practice for incoming trainees regardless of resident and fellow levels or specialty type. It is interesting to note that interns endorsed higher prior knowledge of barriers than their more experienced peers. It may be that younger trainees are more attuned to obstacles with EHR use, whereas their more experienced peers have developed EHR workarounds and are thus less likely to endorse barriers. Whether those informally learned workarounds promote or undermine patient-centered EHR use is unclear, however, and the importance of grounding all trainees in best practices remains. Also, given primary care trainees rated training as more likely to change their future

practice, there is likely a need to tailor training for specialty and surgical trainees in order to increase its effectiveness.

Based on trainee feedback, future curricular development should aim to provide further reinforcement and specific guidance in terms of expectations of what is to be documented in patient notes. Additional opportunities for a more involved practical session with documentation exercises and real-time feedback and guidance may also be beneficial in providing reinforcement of a practical skill set as trainees begin clinical practice with patients. Furthermore, additional training touchpoints using a variety of methods (visual reminders, in-person training with standardized patients, and perhaps even embedded reminders in the EHR) not just for trainees but for attendings as well may be helpful in ensuring providers of all levels remember and employ best practices in their clinical care.

Most importantly, it is critical to provide opportunities for trainees to obtain feedback about their skills with real patients. This can come in the form of direct feedback from patients themselves as well as from faculty supervisors observing their actual clinical practice. Tools such as the validated electronic Clinical Evaluation Exercise may be helpful in order to structure feedback on patient-centered EHR use behaviors and highlight areas for improvement [24].

Our novel approach of embedding communication training into required EHR onboarding was an effective and efficient way to teach housestaff these key EHR-related skills. It is essential to teach housestaff at this critical and early point in training when they are primed to learn and incorporate skills into practice. It is equally important, however, to provide additional booster curricula in order to reinforce and promote maintenance of behaviors and elicit feedback from actual patients on provider practice in order to identify areas for improvement.

Use of institutional EHR trainers, professional information technology specialists who already routinely educate physicians on EHR use, takes advantage of existing resources at most institutions. Also, the difficulty of delivering curricula to all housestaff across specialties is alleviated by embedding it in required onboarding training. Last, strategies for best practice exist and are easily teachable to trainees. Introducing these skills early on contributes to a culture in which professional patient-centered EHR use is the norm.

While our project is currently single site and relies on self-assessed survey questions, our future work aims to provide longitudinal reinforcement of these skills and feedback on EHR communication skills in real clinical encounters to provide continued feedback and training. In addition, we realize the importance of correlating changes in patient satisfaction with training and are focusing on training faculty to promote positive role-modeling and proactively shape the “hidden curriculum” of EHR use. We are also working toward informing patients of their role with the EHR, educating them about the function of the computer in their care and inviting them to become more involved with its use not only during the visit with their provider but afterward via patient portals and secure messaging systems.

Importantly, most trainees felt that although the training was short, it was effective and should be required. As a result, our

curriculum has become a permanent part of the onboarding process for all incoming housestaff, and there are plans to expand our training to target attending physicians, midlevel providers, nurses, and support staff at the University of Chicago.

Patient-centered care has been found to positively impact a number of measures such as patient compliance, satisfaction, and health outcomes [13]. Given the increasing rates of EHR adoption, it is critical to provide physicians with formal education on patient-centered EHR communication skills; however, finding the time to teach these skills in crowded training programs poses a challenge. We found partnering with

EHR trainers who deliver required onboarding training is a novel, timely, and effective method to facilitate training on patient-centered EHR communication strategies across a variety of residency and postresidency training programs. This curriculum capitalizes on existing EHR trainers and leverages resources in a cost-effective manner to provide training to a captive audience of diverse incoming trainees. Similar training can be easily replicated at other institutions and may help ground trainees in best practices and contribute to cultivating a culture of high-quality patient care and meaningful, humanistic patient-centered EHR use.

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## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Patient-centered electronic medical record use training survey.

[PDF File (Adobe PDF File), 32KB - [mededu\\_v4i1e1\\_app1.pdf](#)]

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## Abbreviations

**EHR:** electronic health record

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Review

# Medical YouTube Videos and Methods of Evaluation: Literature Review

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## Abstract

**Background:** Online medical education has relevance to public health literacy and physician efficacy, yet it requires a certain standard of reliability. While the internet has the potential to be a viable medical education tool, the viewer must be able to discern which information is reliable.

**Objective:** Our aim was to perform a literature review to determine and compare the various methods used when analyzing YouTube videos for patient education efficacy, information accuracy, and quality.

**Methods:** In November 2016, a comprehensive search within PubMed and Embase resulted in 37 included studies.

**Results:** The review revealed that each video evaluation study first established search terms, exclusion criteria, and methods to analyze the videos in a consistent manner. The majority of the evaluators devised a scoring system, but variations were innumerable within each study's methods.

**Conclusions:** In comparing the 37 studies, we found that overall, common steps were taken to evaluate the content. However, a concrete set of methods did not exist. This is notable since many patients turn to the internet for medical information yet lack the tools to evaluate the advice being given. There was, however, a common aim of discovering what health-related content the public is accessing, and how credible that material is.

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**KEYWORDS**

social media; YouTube; internet; health literacy; online education; videos

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## Introduction

In today's world, the internet and social media are a part of everyday life. Within seconds, a handheld device can provide more information than one can possibly read. The ease and simplicity of finding information on the internet translates directly to answering health questions and concerns. By 2011, 59% of adults were looking up health information online, and internet access has expanded exponentially since then [1]. One of the most frequently used social media sites is YouTube, which was created in 2005 and now has over one billion users, allowing for hundreds of millions of hours of total video watch time each day [2]. Social media has great potential to provide easy access to medical information, but it is likely that the

information received is neither accurate nor free of bias. A YouTube search on tanning bed use gives results with 68% of the videos having a positive view of bed use, with no mention of dangers such as melanoma. This is an obvious problem for the field of dermatology to address [3]. Issues related to online videos for patient education and their quality and accuracy have drawn more attention recently. Analyses of YouTube videos on heart failure, mammography, and asthma among others have been published since 2015, but there are no standardized methods or guidelines of evaluation [4-7]. The lack of regulation within online medical education is hindering progress made by physicians, but with knowledge of how YouTube videos can be assessed, the public as well as health care providers can better assess the quality of information they are receiving. The goal



of this review is to determine how studies have been able to evaluate educational videos and to give an overall look at the most common methods used.

## Methods

A thorough search was performed within both Embase and PubMed in November 2016. A data management librarian determined the search terms after a preliminary search to find which key words would supply relevant articles. Many search combinations did not generate any articles as this is a relatively new topic and YouTube was not created until 2005. Thus, our inclusion date for articles encompassed anything published after the year 2005. PubMed and Embase were chosen as the literature databases to search, as they are reputable sources of medical literature and PubMed also includes literature from the Medline database. The first search was performed in Embase with the term “patient education” AND “YouTube” OR “Online Videos” OR “Online video.” In PubMed, two separate searches were performed. The first search term was (“Patient Education as Topic” [Medical Subject Headings] OR “patient education”) AND (“YouTube” OR “online videos”), and the second search term was “YouTube health guidelines.” One author analyzed all of the included articles, and the results were reviewed and approved by another author. Each included article was read in

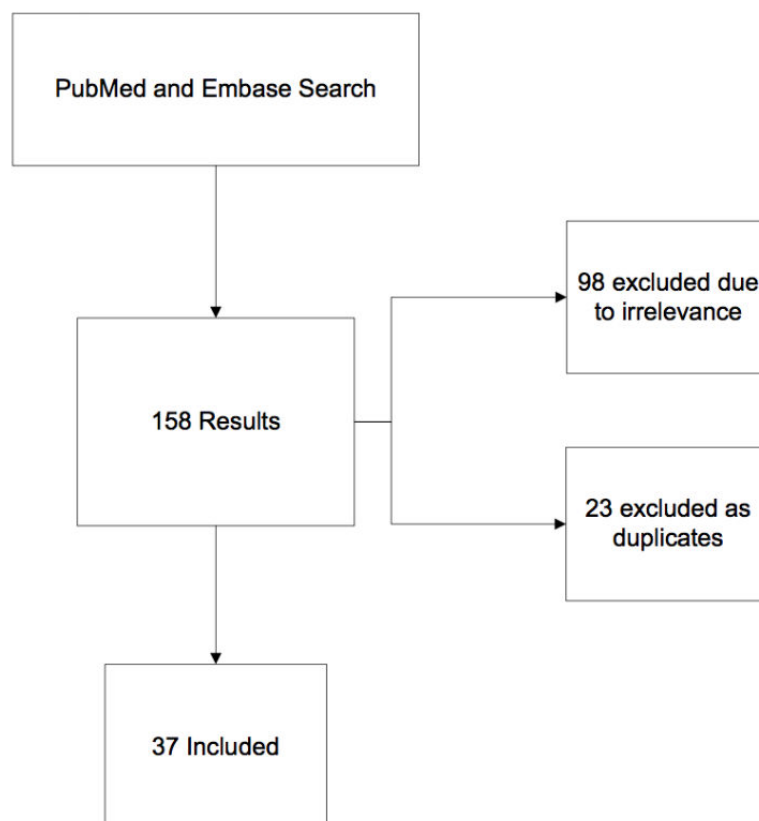
its entirety, and the methods as well as unique characteristics for each study were recorded in MS Excel formatting and compared.

The inclusion criteria for the studies to be reviewed were as follows: (1) analysis of videos intended for patients or guardians, (2) contains detailed and repeatable methods of analysis, (3) English language, and (4) analysis of videos that are made available to the public.

The Embase search (“patient education” AND “YouTube” OR “Online Videos” OR “Online video”) generated 65 results, of which 20 were included for review. The first PubMed search (“Patient Education as Topic” [Medical Subject Headings] OR “patient education”) AND (“YouTube” OR “online videos”) had 77 results and 13 articles met the inclusion criteria. The last PubMed search (“YouTube health guidelines”) gave 16 results, of which 4 articles were reviewed. This resulted in a total of 37 studies to be reviewed (see [Multimedia Appendix 1](#)). Most excluded articles were left out due to irrelevance, meaning that the studies focused more on websites than videos, tested the efficacy of personal physician-created videos on their own patients, or the videos analyzed were intended for physician use only. The excluded studies are summarized in [Figure 1](#).

This study was exempt from requiring Institutional Review Board approval.

**Figure 1.** Search results and excluded studies.



## Results

The same chronological process was generally followed within each piece of literature reviewed, but no two video evaluations were performed in an identical manner. The first step within each study included determining the search term(s) to be used. Multiple search terms were used to ensure that all possible patient searches could be evaluated. For example, “gallbladder disease,” “gallstone disease,” and “gallstone treatment” were all used to assess YouTube videos about gallstone disease, as they are likely terms used by the public [7]. Other studies used search operators in order to create comprehensive search terms [8]. Another method used for searching techniques was multiple search dates.

Methods and techniques used to determine search terms and searching criteria for YouTube videos included multiple search terms (20 studies), autocomplete function within search bar, use of search operators, multiple search dates, limited number of pages within a particular search to be analyzed (30 studies), and changing the video results to be sorted by “most viewed” (3 studies).

The next step involves determining which videos should be included in the study. Some researchers set a maximum time limit for included videos. Only one study excluded videos based on number of views, in which the videos were required to have greater than 2500 views [6]. The predetermined inclusion criteria used by various studies were English language; must not be a duplicate video; must have audio; videos directed towards the public and not only a physician; video length not greater than a predetermined maximum number of minutes (7 studies), most commonly being 10 minutes (4 studies); and must have a predetermined number of video views (1 study).

Most studies had multiple reviewers and stated the qualifications of the reviewers, which included students, residents, or physicians. The most rigorous qualification requirements involved a 1-month clinical rotation in the department of allergy and clinical immunology and successful completion of a series of learning objectives [5]. The videos were reviewed separately, followed by comparison of results, but how the differences were settled varied. The most common method deferred the discrepancy to another qualified individual or physician who would determine the final result. One study averaged the individual reviewer scores and accepted that result as the final evaluation [9]. Since these evaluations are largely subjective, interrater reliability was assessed in 15 of the articles through the calculation of a kappa score.

The source of upload allowed for categorization of videos. An analysis of educational videos on children’s dental caries separated the videos into health care professionals, academic

institutes, professional organizations, individual users, and product companies [10]. These were the most common source categories, but others included news agencies and health care websites as well. Three of the studies assessed the reliability of the upload sources through a modified DISCERN method for which the reliability score ranges from 0 to 5. The criterion from the original DISCERN model were clear aims, balanced/unbiased, reliable sources of information, additional resources provided, and mention of uncertainty [11-13].

To determine the accuracy of the videos, 22 of the studies created a novel scoring system. These scoring systems and other methods are summarized in Table 1. In a study on the accuracy of YouTube videos about stopping epistaxis, a point was awarded for each of the necessary steps mentioned [14]. In another study, the scoring ranged from -10 to 30, where a point was awarded for each accurate piece of information included, and a point was subtracted for each incorrect fact that could harm a patient [5]. Through the *Journal of the American Medical Association* guidelines used, a point is given for authorship, disclosure, source, and currency of the video [15]. Health on the Net (HON) Foundation has also created a set of 8 principles for websites to abide by called the HONcode [16]. Another method of evaluation was categorization of videos as useful, misleading, or as personal experiences. A useful video contains accurate information about any facet of the disease such as epidemiology, treatments, and procedures performed, and is misleading if it presents inaccurate information or promotes a scientifically unproven treatment [17].

Ten studies evaluated the quality of the video presentation, of which five assessed video quality according to global quality score guidelines. This rates the quality from a score of 1-5 while taking into account video flow and usefulness [11,18]. Other quality assessment guidelines constructed by reviewers included evaluation of lighting, audio, and number of pixels as well as other video characteristics [7,19].

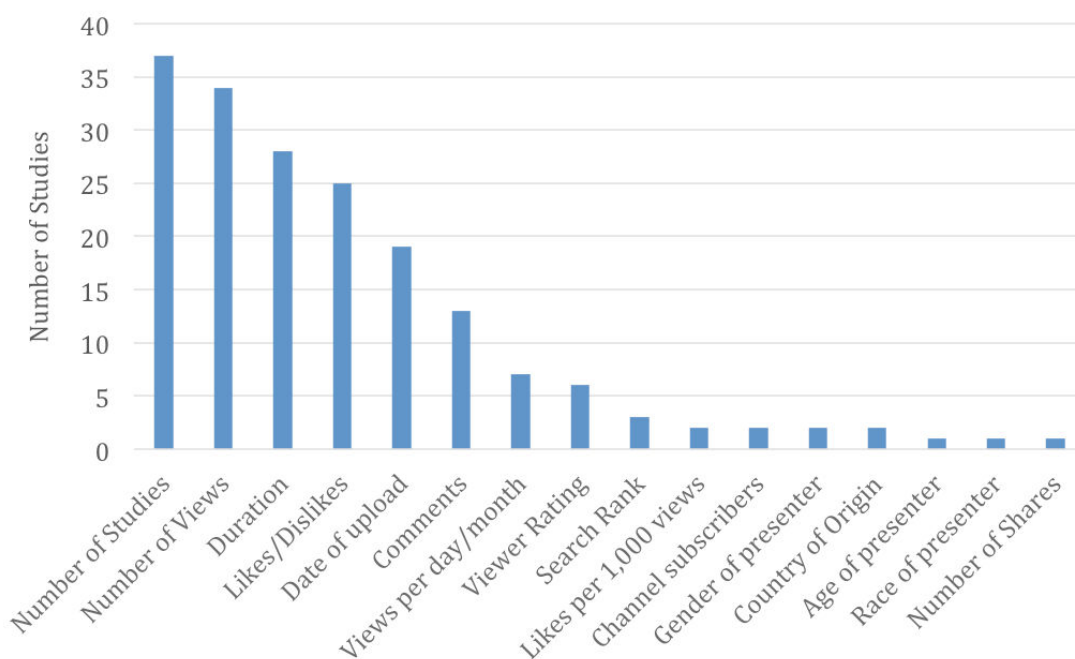
The most common video characteristics recorded were number of views, followed by source of upload. These data, along with the frequencies of other parameters taken into account by the various studies, are summarized in Figure 2. In addition, 5 studies measured popularity by either calculating likes per 1000 views or views per day/per month.

The most common sequence of methods performed is as follows: (1) determine a search term(s); (2) establish inclusion criteria for videos; (3) determine video reliability scoring/what parameters will be taken into account; (4) review videos individually; (5) convene to discuss discrepancies and determine final results; and (6) analyze results and determine the reliability or usefulness of videos and which characteristics determine that quality.

**Table 1.** Methods for determining accuracy and usefulness of videos.

Method	Description
Creation of a novel scoring system (22 studies)	Formation of guidelines based on scientific literature and physician expertise with a corresponding point system
HONcode <sup>a</sup>	Health on the Net Foundation guidelines for websites adapted for YouTube videos
<i>Journal of the American Medical Association</i> website guidelines	Adaptation of these guidelines to be implemented for YouTube videos
Judgment as useful, misleading, or personal experiences	Subjective categorization by the researchers based on knowledge of the topic as well as on predetermined criteria

<sup>a</sup>Health on the Net (HON) Foundation created a set of 8 principles for websites to abide by called the HONcode.

**Figure 2.** Video data collected by various studies as of Nov 2016 (results based on all 37 studies reviewed).

## Discussion

### Principal Findings

Our review found that defining a search term, determining how to judge or score the videos, and determining the reliability of the video sources and information were the primary methods discussed throughout the studies. There were also many steps taken to ensure that the evaluations were indicative of how the general public and patients would receive and understand the information given in the YouTube videos. For example, YouTube content is constantly being modified, thus researchers performed content searches at later dates to give insight into the evolution of viewership [18]. They also took measures to include search terms that were more likely to be used by patients. A recent study on consumer health-related activities on social media determined that much of the involvement was based on convenience [20]; many researchers limited the page number and search rank of the videos to be included in their analysis. Most people searching YouTube do not take the time to look at search results in later pages, and evaluating these videos would not be an accurate representation of what the public is viewing. The previous study on consumer

health-related social media activities also revealed that many social media users turn to the internet for emotional support during a chronic disease or illness [20]. Within the studies of this literature review that judged videos as either useful, misleading, or personal experiences, there was an emphasis on the personal experience videos, which were further evaluated for accuracy. This was not without reason as many patients feel that the information provided by their physicians is not sufficient and they turn to their online peers for support [20].

Throughout the reviewed literature, there was considerable focus on determining which video characteristics could be quantified and compared to reveal a positive correlation with video accuracy. The most commonly statistically analyzed parameters were video score versus number of likes, and video score versus source of upload. One study discovered that younger patients as well as patients with higher education are more likely to use the internet as source of health information due to their increased ability to search the Web and identify reliable information and sources [21]. If video parameters and sources can be linked to predictability of accuracy, then perhaps patients within the health literacy gap will feel more confident in navigating this pool of easily accessible medical knowledge.

## Limitations

This paper is a comprehensive review, but it is not a systematic review. All efforts were taken to include all articles possible, but we cannot guarantee that some were not missed. In addition, this is a newly popular topic and it is likely that use of these search terms at a later date will result in an increased number of results.

## Conclusions

Social media has the potential to aid in closing the health literacy gap and can present information in novel ways that allow even illiterate populations to learn [22]. The Internet has increased opportunities for open discussion about health and medicine as well as a created a platform for moral support [22]. However, with this increased opportunity also comes a chance for dissemination of inaccurate and even harmful information. Physicians and researchers have realized the increased impact

of social media on the knowledge and compliance of their patients, as evidenced by a recent increase in published studies regarding medical YouTube video reliability. Thus, these general steps as well as the unique processes detailed throughout this review could be of use to patients in search of online medical advice. While a common sequence of methods was able to be determined, there are no substantial similarities between study methods. The inconsistency stems from the fact that there are a multitude of possible variables that contribute to both the popularity and the efficacy of educational videos. This creates a barrier to analysis duplication and the formation of a systematic process that ensures adequate information and regulation for patients. However, there was a common sequence of steps found. This topic will be an ongoing field for further research as social media engagement continues to increase across the world and as more people realize the dire need for increased health education in all populations.

## Authors' Contributions

BD is the primary author of the paper and performed the review and analysis. EC determined the search terms and the databases employed. AS developed the concept and approved the final draft for submission.

## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Titles of the included studies that complied with all inclusion criteria.

[[PDF File \(Adobe PDF File\), 29KB - mededu\\_v4i1e3\\_app1.pdf](#) ]

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## Abbreviations

**HON:** Health on the Net

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Original Paper

# The Impact of a Small Private Online Course as a New Approach to Teaching Oncology: Development and Evaluation

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## Abstract

**Background:** Oncology involves complex care and multidisciplinary management of patients; however, misinformation and ineffective communication remain problematic.

**Objective:** The educational objective of our study was to develop a new teaching method to improve cancer treatment and management by emphasizing the link between hospitals (inpatients) and their surrounding communities (outpatients).

**Methods:** A team of 22 professionals from public and private institutions developed a small private online course (SPOC). Each offering of the course lasted 6 weeks and covered 6 topics: individual health care plans, cancer surgery, ionizing radiation, cancer medicines, clinical research, and oncological supportive care. For participants in the course, we targeted people working in the cancer field. The SPOC used an active teaching method with collaborative and multidisciplinary learning. A final examination was offered in each session. We evaluated participants' satisfaction rate through a questionnaire and the success of the SPOC by participants' completion, success, and commitment rates.

**Results:** Of the total participants (N=1574), 446 completed the evaluation form. Most participants were aged 31 to 45 years. Participants included 56 nurses, 131 pharmacists, 80 from the medical field (including 26 physicians), 53 from patients' associations, 28 health teachers, and 13 students (medical and paramedical). Among the participants, 24.7% (90/446) had an independent medical practice, 38.5% (140/446) worked in a public institution, and 36.8% (134/446) worked in a private institution. After completing the SPOC sessions, 85.9% (384/446) thought they had learned new information, 90.8% (405/446) felt their expectations were met, and 90.4% (403/446) considered that the information had a positive impact on their professional practice. The completion rate was 35.51% (559/1574), the success rate was 71.47% (1025/1574), and the commitment rate was 64.67% (1018/1574).

Concerning the cost effectiveness of SPOC compared with a traditional classroom of 25 students, online education became more effective when there were more than 950 participants.

**Conclusions:** SPOCs improved the management of oncology patients. This new digital learning technique is an attractive concept to integrate into teaching practice. It offered optimal propagation of information and met the students' expectations.

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## KEYWORDS

oncology; health education; continuing education; e-learning; SPOC; small private online course; education, medical; education, medical, continuing

## Introduction

International business schools and large companies have evolved in their thinking about new forms of teaching and collaborations, whereas medical universities retain a classical teaching approach [1]. Over the last few years, many massive open online courses (MOOCs) and small private online courses (SPOCs) have taught millions of students in virtual classrooms, changed learning techniques, and redefined the traditional boundaries in university teaching [2-6]. This digital learning is a new and attractive concept to integrate into teaching methods. One major positive benefit is its wide accessibility ("anytime, anywhere, on any device"). However, a significant problem with MOOCs is their completion rate of less than 10%, with an additional drop-off rate within the first week of the course [7].

In oncology, we constantly seek new approaches to improve the management of patients. The use of MOOCs seems to be supported by some parts of the oncological community, as demonstrated in the MOOC *Diagnostic Strategies of Cancers*, which opened in autumn 2016. The first results seem promising, with 23% of participants being successfully certified [4,5].

We are also supported by improvements in communication and networking between hospitals and different caregivers, including general practitioners, nurses, physiotherapists, pharmacists, and the medical community at large. Indeed, the complexity of medical care (especially in oncology), with the multidisciplinary management of patients, is not optimal due to some ineffective communication and misinformation [8-12]. To share information and experiences, practitioners could create an environment in which individuals can express concerns and alert team members to unsafe situations.

Thus, we decided to create a SPOC, which is limited to an invited audience, whereas a MOOC is generally open to all. The educational objective was to develop a new teaching method that could help to improve cancer treatment and its management by emphasizing the community-hospital interface.

To evaluate the relevance of this new teaching method, we analyzed the main characteristics of participants, their satisfaction with the course through a feedback questionnaire, and the cost effectiveness of the SPOC compared with theoretical face-to-face education.

## Methods

Our objective was to form a strong link between all participants on the same topic. To reach our objective, we used the following

methods: (1) a SPOC with free user access, (2) oncology-specific information delivered by specialists, (3) a virtual platform that allowed for discussion and meetings on oncological matters, and (4) a final evaluation.

## SPOC Development Team

The development team comprised 22 professionals specializing in cancer care plus French faculty members. We divided the team into 2 subgroups: a teaching group and a project management group. Among the 22 professionals, 12 worked in a hospital, 8 worked outside the hospital (in the community), 1 specialized in the hospital-community network (and worked in the hospital and the community), 1 was an industrial pharmacist, and 1 worked within an institution (ie, Director of a Regional Health Agency).

The teaching team for the course was composed of 8 coordinator lecturer surgeons, radiotherapists, internal medical practitioners, clinical pharmacologists, a clinical researcher, and supportive care specialists; 14 other lecturers (senior nurses, hospital pharmacists, and physicians); and 8 general practitioners, dispensary pharmacists, physiotherapists, nurses, dentists, research and development managers from the pharmaceutical industry, patients, and caregivers, who provided testimonies. Teachers were volunteers and were chosen by the teaching council (ie, the course manager that introduced the SPOC, the project manager, and the Dean of the Medical Faculty of Toulouse III University). Among the 8 coordinators, we chose 6 lecturers for the 6 weeks of the SPOC, as they were specialists at our hospital (Institut Universitaire du Cancer de Toulouse-Oncopole, Toulouse, France). These 6 coordinators then chose 10 other assistant lecturers to help explore the specialties.

The teaching team and the SPOC project were managed by the project management team, which comprised 4 professionals: a project manager to oversee the project, a social officer to manage registration and forum moderation, a communications officer in charge of advertising, and a technical officer responsible for managing the multimedia elements.

## Target Learners and Accessibility

Participation in the course was open to all people involved in the management of cancer patients. Our public population included health students (medical and paramedical), health professionals, and members of patient associations.

Two sessions of the SPOC have been available since October 2016, but the offerings were not linked. Registration in the first session was not needed to register in the second session.

We initially offered open access to the SPOC to facilitate dissemination of knowledge, but then decided to restrict registration to students and professionals, and then, only after verifying their motivation, we also included volunteers from patients' associations.

We limited the first offering of the course to 600 participants, whereas we did not limit inclusion for the second offering. The first SPOC opened its virtual doors on October 24, 2016, and the second on March 27, 2017. Participants registered on an outside platform and provided their characteristics. The registration home page also asked for the student's identification number or health professional identification number [13].

### Course Content

We built the SPOC according to previously published information [14,15]. We planned 2 offerings of the course, each lasting 6 weeks, plus 3 supplementary weeks to provide adequate time for students to prepare for the final examination or to finish chatting on the forum.

The course covered 6 topics—week 1: individual health care plans; week 2: cancer surgery; week 3: ionizing radiation; week 4: cancer medicines; week 5: clinical research; and week 6: oncological supportive care (Figure 1).

These 6 topics were chosen by the teaching council. For each topic, at least 5 subthemes were determined in collaboration with the coordinator lecturer, and each subtheme was the subject of a video, as detailed in Table 1.

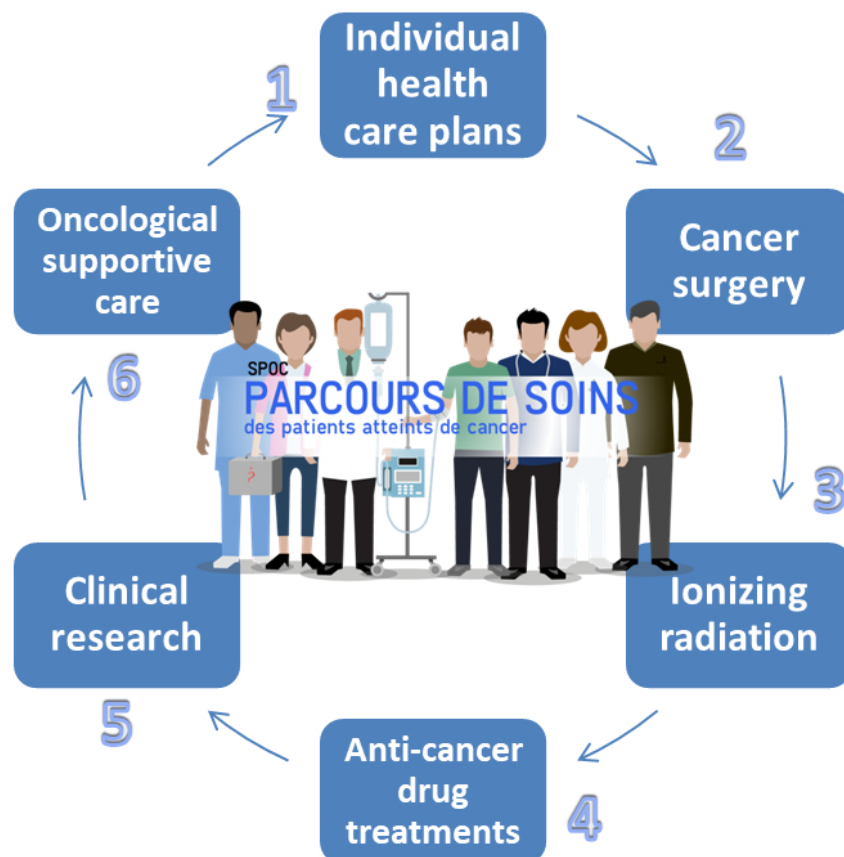
Each week, depending on the video that was shown, between 1 and 3 quizzes were presented (with a total of 75 quizzes for the 6 weeks). These consisted of multiple-choice questions with answers of true or false, fill-in-the-gap exercises, and drag-and-drop exercises.

The training was personalized: each participant could learn step-by-step and could choose his or her own learning pace. They could stop or rewatch videos, which was especially pertinent for difficult topics, or students could accelerate through a video if they were familiar with the subject. After the first session, we modified interactive parts of the forum and some of the exercises for the second session.

### Social Interactive Platform

To create social and active online communication, we opened a forum and links to Facebook, Twitter, and LinkedIn for discussion. We had 23 groups of 10 or 11 participants each who worked on 3 subjects: the new secondary effects of a drug, clinical trials, and supportive care. A webinar was suggested after 3 weeks (in the middle of the SPOC). Participants could then direct questions directly to a professional in the field.

**Figure 1.** The 6 topics of the 6-week small private online course covering the sequential steps in the care of cancer patients.





**Table 1.** Topics covered in the small private online course and details of the accompanying videos.

Topic	Subject of video
Introduction	<ul style="list-style-type: none"> <li>• Cancer as a chronic disease</li> </ul>
Week 1: Individual health care plans	<ul style="list-style-type: none"> <li>• Development of personalized care programs</li> <li>• What are the elements of the health care pathway?</li> <li>• A closer look at the multidisciplinary team meeting</li> <li>• Link between health care facilities and home</li> <li>• Care coordination mechanisms</li> <li>• <i>Interviews: Overview of the health care pathway and how to be helpful and patient—first-hand account</i></li> </ul>
Week 2: Cancer surgery	<ul style="list-style-type: none"> <li>• Role of surgery in cancer treatment</li> <li>• Various types of surgery</li> <li>• Making the surgery less invasive</li> <li>• Multidisciplinary preoperative planning is vital</li> <li>• Postoperative follow-up</li> <li>• <i>Interviews: Role of the physical therapist in private practice</i></li> </ul>
Week 3: Ionizing radiation	<ul style="list-style-type: none"> <li>• What is radiation therapy?</li> <li>• Use of external radiation therapy</li> <li>• Side effects of radiation therapy</li> <li>• Innovations in radiation therapy</li> <li>• What is brachytherapy?</li> <li>• Different types of brachytherapy</li> <li>• <i>Interviews: Role of the dental surgeon</i></li> </ul>
Week 4: Cancer medicines	<ul style="list-style-type: none"> <li>• Overview of drug-based (chemotherapy) treatment strategies</li> <li>• The medication circuit (full motion design)</li> <li>• Innovative cancer drugs</li> <li>• Side effects</li> <li>• Pharmacovigilance and adverse drug reaction reporting</li> <li>• Individualized patient monitoring</li> <li>• Initiation of oral cancer chemotherapy: important messages</li> <li>• <i>Interviews: Perspectives of a drug manufacturer, focus on reconciling drug treatments, role of the retail pharmacist</i></li> </ul>
Week 5: Clinical research	<ul style="list-style-type: none"> <li>• Clinical research: general principles</li> <li>• Joining a clinical trial</li> <li>• Conduct of a clinical trial</li> <li>• Monitoring of a patient participating in a clinical trial</li> <li>• Focus on chemotherapy assistance by phone (EVAL COACH)</li> <li>• Focus on a multidisciplinary meeting on going back home (CREDO)</li> <li>• <i>Interviews: Role of the primary care physician</i></li> </ul>
Week 6: Oncological supportive care	<ul style="list-style-type: none"> <li>• What is supportive cancer care (SCC)?</li> <li>• Various types of SCC (Part I)</li> <li>• Various types of SCC (Part II)</li> <li>• Fundamental role of patient education programs</li> <li>• A continuously evolving field</li> <li>• <i>Interviews: Role of visiting nurses and home health aids</i></li> </ul>
Conclusion	<ul style="list-style-type: none"> <li>• Cancer affects everyone</li> </ul>

## Evaluation

Throughout the SPOC, we evaluated each participant's satisfaction through a questionnaire that included 29 questions, which were validated by the teaching and communication teams. Each question could be answered using a 4-point scale. Categorical data were presented using numbers and percentages. Participants completed an evaluation form so that we could assess their characteristics and their expectations before starting the SPOC. Participants could also complete a satisfaction feedback form after the course. The SPOCs were certified for

continuing professional development (CPD) by the Développement Professionnel Continu, according to French national recommendations (Haute Autorité de Santé). A final examination was suggested for each course. Each participant obtained a continuing health training certificate if their final score was greater than 50% (or 10/20), as recommended for CPD programs. The feedback form was designed by the project management team according to the French national recommendations for CPD programs.

We evaluated the success of the SPOCs according to the completion rate (percentage of participants who completed the

6-week course out of the total number of participants registered), success rate (percentage of participants who successfully completed the examination), and commitment rate (percentage of participants who completed the 6-week course out of the total number of participants who completed the first week of the course). We performed descriptive analyses on our population. All qualitative variables are described by numbers and percentages. Categorical variables are expressed as counts and frequencies (percentages). Quantitative variables, following a Gaussian distribution in our study, are described by their means and standard deviations. We used the chi-square test to compare results between the 2 SPOC offerings.

### Ethical Considerations

Our SPOC sessions were hosted by a private Web platform that respected the ethical considerations for personal data, in agreement with French law. The details are available on the FunCampus [16] and 360 Learning websites [17].

Students provided information outside these platforms (eg, through our anonymous surveys). Since we did not consider this to be personal data, in agreement with French law (Commission Nationale de l'Informatique et des Libertés), we did not need any ethical approval [18].

### Cost Effectiveness

To compare the overall cost of the SPOC and the theoretical costs of comparable face-to-face education, we calculated the overall cost of the online course compared with traditional classroom teaching for the same number of participants (eg, 1000 participants). We assumed a group of 25 participants in a traditional classroom. We calculated the point where online education became more effective.

The overall cost included salaries of a project manager, course director, teachers, a community manager, a beta tester, legal assistance, a communication department, and an administrative partner (a private enterprise, specific to a SPOC).

## Results

### Access and Participants' Characteristics in the First Session

The first course session began on October 24 and finished on December 31, 2016. It lasted 6 weeks plus 3 supplementary weeks to allow adequate time for students to prepare for the final examination.

Among the 600 participants, 176 completed the questionnaire, which provided the following data. Most participants were aged 31 to 45 years (range 18 to >50 years); 68.4% (120/176) of participants were aged over 46 years. The paramedical group was well represented, with 26.1% (46/176) being nurses. A total of 24 (13.8%) were pharmacists, pharmacy students, and dispensary pharmacists, and 17 (9.7%) were in the medical field (doctors, medical students, and residents). The completion rate

of this SPOC was 36.0% (216/600), the success rate was 66.0% (396/600), and the commitment rate was 72.0% (432/600).

### Participants' Characteristics and Course Modifications for the Second Session

The second session ran between March 27 and May 31, 2017. The course ran for 6 weeks plus 3 supplementary weeks to enable adequate time for students to prepare for the final examination.

We modified some elements of the SPOC for the second session, as follows. (1) Responding to the feedback form completed in the first SPOC, we rewrote some sentences and modified the format of the collaborative exercises. (2) To ensure that the second SPOC suited the participants, we created a beta test group from the first SPOC to test the format of the exercises and to detect any technical problems before starting the second SPOC. (3) A total of 6 volunteers from the first SPOC participated in moderating the forum, creating collaborative exercises, and encouraging engagement of the participants in the collaborative exercises. (4) We modified the format of the collaborative exercises. The initial format was a pluriprofessional discussion on one predefined subject, but there were few interactions. Each participant answered the question without considering the comments from the other participants. Thus, we switched to an exercise that fostered more collaborative homework. Moreover, participants had to evaluate the homework of the other groups.

In this second course session, of the 975 participants, 270 completed the questionnaire, which supplied the following data. Most participants were aged 31 to 45 years. The age distribution was the same as in the first course. Of the paramedical group, 42.9% (116/270) were nurses. A total of 124 (45.9%) were pharmacists, pharmacy students, and dispensary pharmacists, and 10 (3.7%) were medical students. The completion rate was 34.8% (339/975) the success rate was 76.9% (550/975) and the commitment rate was 56.9% (555/975).

### Evaluation of the 2 Sessions

Of the total 1574 participants, 446 completed the evaluation questionnaire. Most participants were aged 31 to 45 years. There were 121 paramedical and social workers (including 56 nurses), 131 pharmacists, 80 participants from the medical field (including 26 physicians), 53 participants from patients' associations, 28 teachers, 17 administrative or industrial, 13 students, and 3 others (nonclassified) (Table 2).

Registration was open to participants from all countries as long as they could understand the French language; most participants lived in France (n=427, 95.7%) (Figure 2). Other participants mainly lived on African continent (n=6, 1.4%), the United States (n=6, 1.4%), or Canada (n=4, 0.9%) (Figure 3).

Among the participants, 24.9% (111/446) had an independent medical practice, 38.9% (173/446) worked in a public institution, and 36.9% (165/446) worked in a private institution.

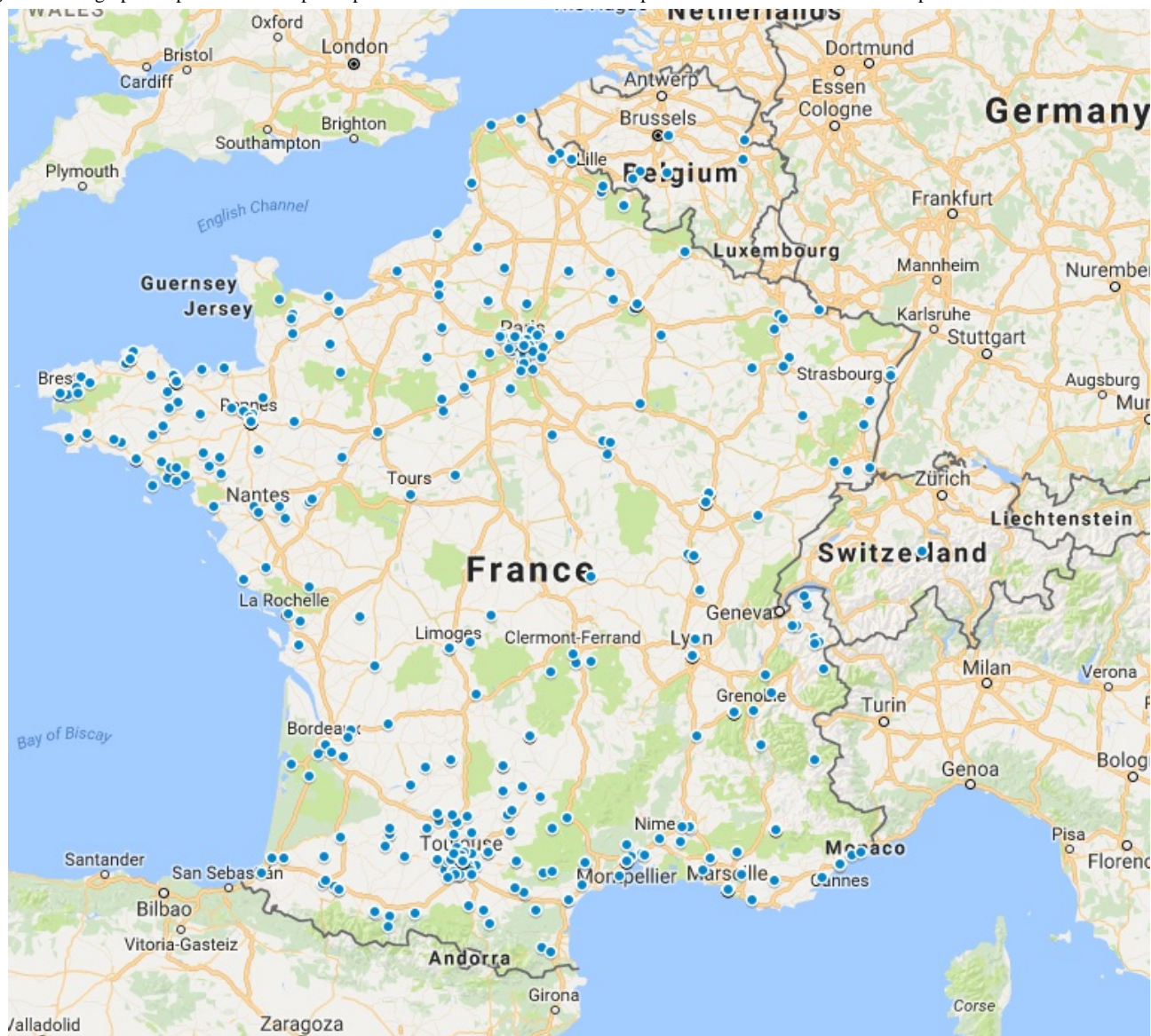
**Table 2.** Characteristics of participants who completed the questionnaires in the first and second offerings of the small private online course.

Characteristic	First session (n=176)	Second session (n=270)	Overall results (n=446)
<b>Age range (years), n (%)</b>			
18-25	40 (22.7)	21 (7.8)	61 (13.7)
26-30	21 (11.9)	39 (14.4)	60 (13.5)
31-45	59 (33.5)	125 (46.3)	184 (41.3)
46-50	24 (13.6)	30 (11.1)	54 (12.1)
>50	32 (18.2)	55 (20.4)	87 (19.5)
<b>Profession or specialty, n (%)</b>			
Medicine	65 (36.9)	15 (5.6)	80 (17.9)
Pharmacist	8 (4.5)	123 (45.5)	131 (29.4)
Paramedical and social <sup>a</sup>	32 (18.2)	89 (33.0)	121 (27.1)
Teachers	9 (5.1)	19 (7.0)	28 (6.3)
Students	3 (1.7)	10 (3.7)	13 (2.9)
Administrative/industrial	7 (4.0)	10 (3.7)	17 (3.8)
Patients' association	50 (28.4)	3 (1.1)	53 (11.9)
Other	2 (1.1)	1 (0.4)	3 (0.7)
<b>Place of practice</b>			
Independent medical practice	N/A <sup>b</sup>	45 (24.7)	45 (24.7)
Public institution	N/A	70 (38.5)	70 (38.5)
Private institution	N/A	67 (36.8)	67 (36.8)

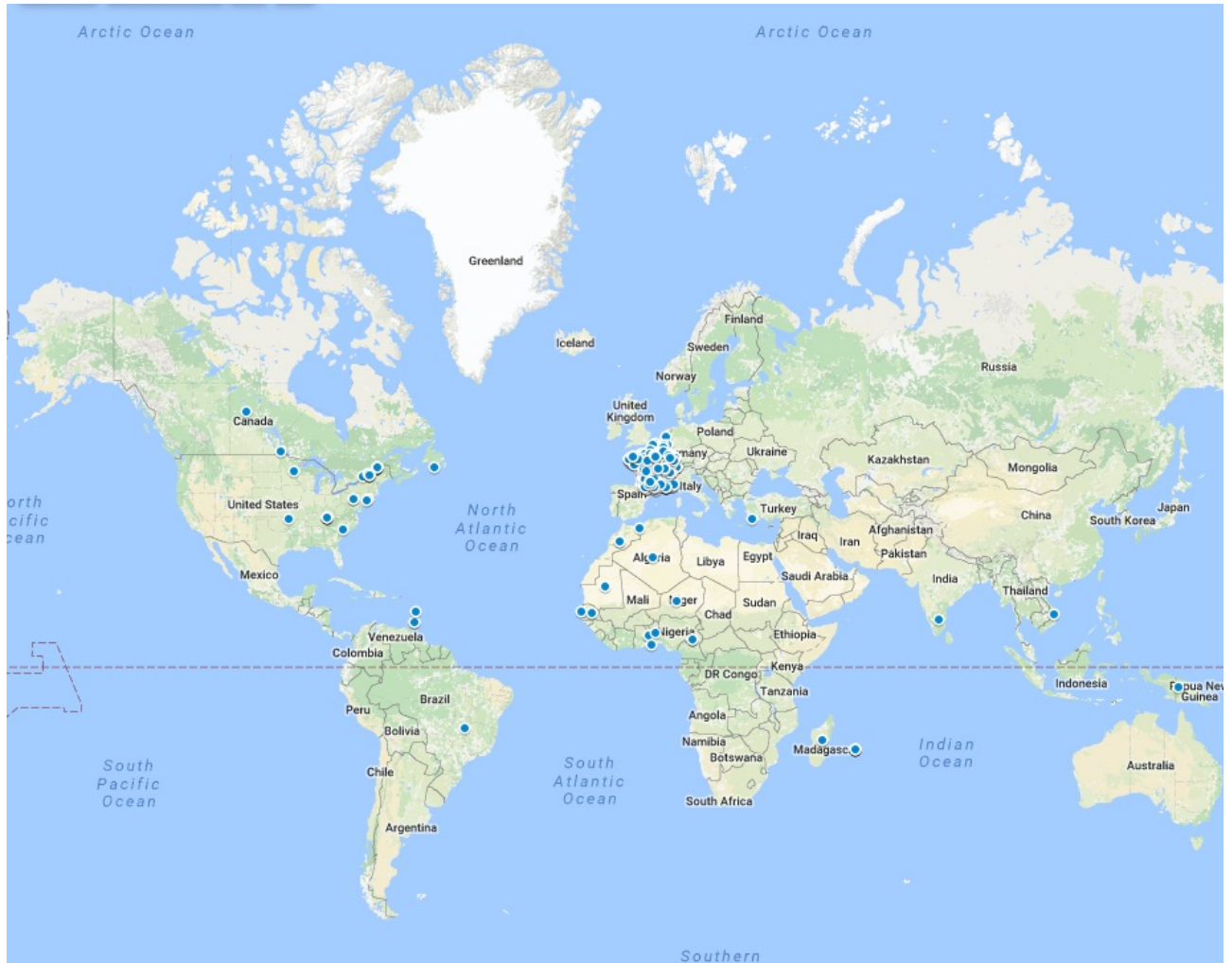
<sup>a</sup>Including nurses, physiotherapist and osteopath, psychologists, social workers, nurse's aide, radiotherapist and radiologist technician, socioaesthetician, medical assistant.

<sup>b</sup>N/A: the question was not in the questionnaire during the first session.

**Figure 2.** Geographic representation of participants from France. Each blue dot represents a connection to the small private online course.



**Figure 3.** Geographic representation of participants from around the world. Each blue dot represents a connection to the small private online course.



Among the participants, 85.9% (383/446) thought they had learned new information (moderately: 179/446, 40.2%; considerably: 205/446, 45.9%), 90.8% (405/446) felt their expectations had been met (fully: 204/446, 45.7%; relatively: 201/446, 45.1%), and 89.9% (401/446) considered the course had a positive impact on their professional practice as a caregiver (Figure 4). The completion rate was 36.02% (567/1574), the success rate was 71.98% (1133/1574), and the commitment rate was 64.99% (1023/1574).

### Interactive Social Platform

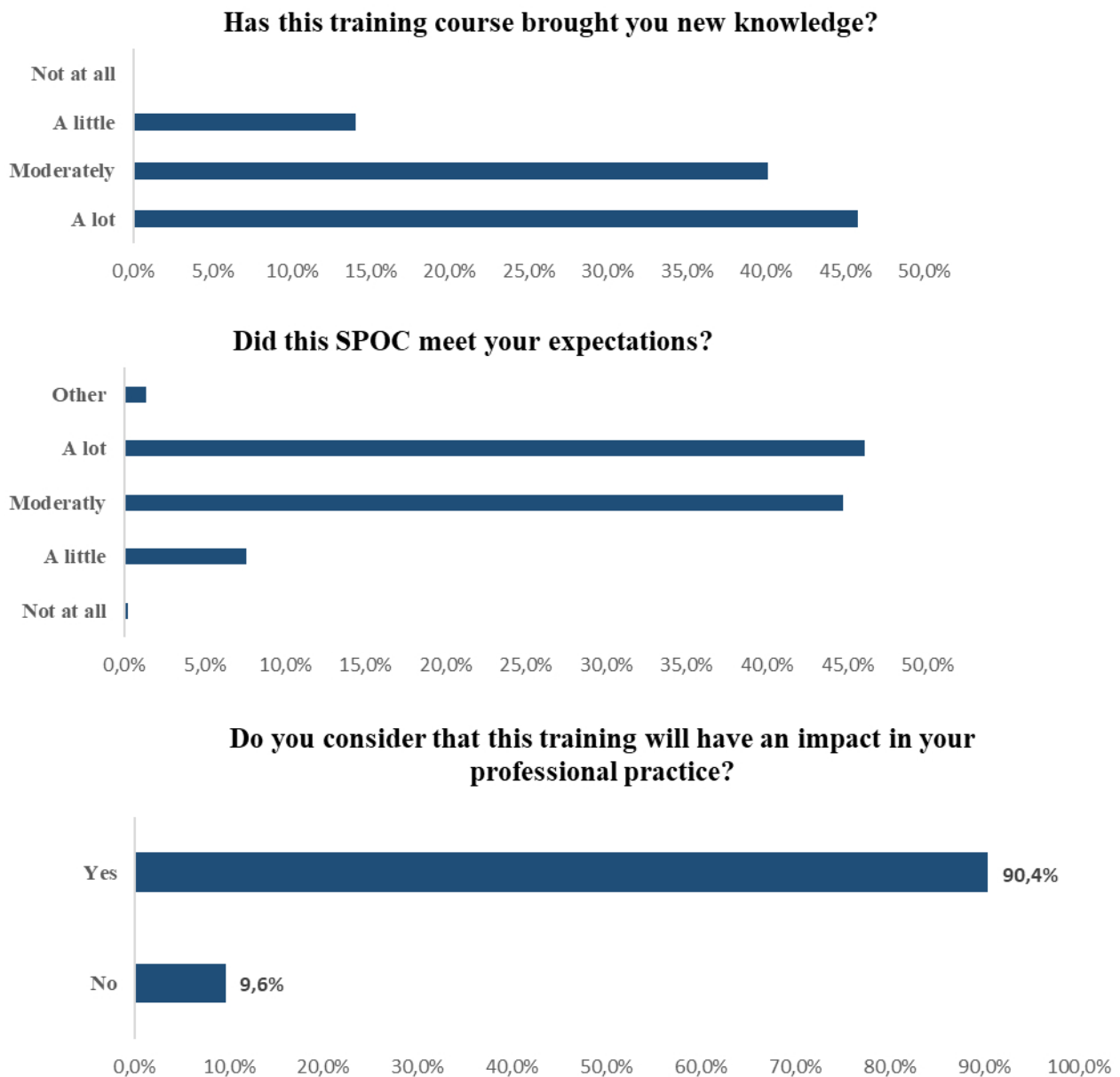
Many participants expressed their satisfaction (or dissatisfaction) by posting comments on the forum during the courses. In total, 2812 comments were posted on videos and the forum: 2367

“liked” (the first session) and nearly 84.9% (379/446) considered it positive, with 15% suggesting improvements.

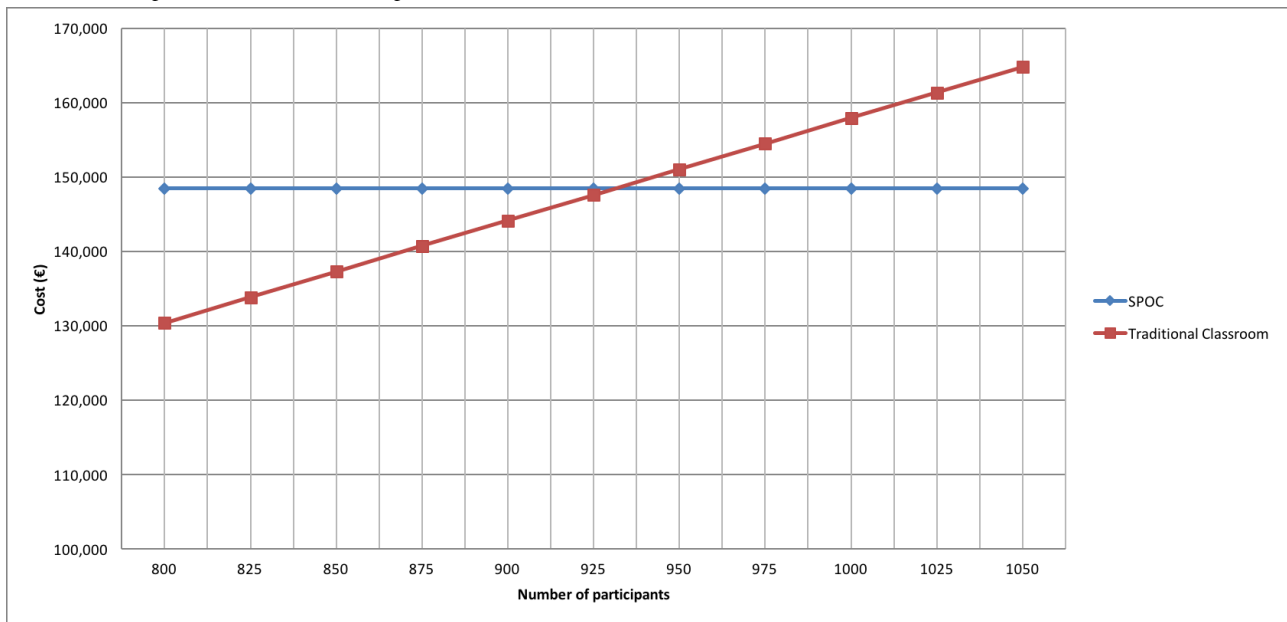
### Cost Effectiveness

There was an initial and fixed high cost to developing the SPOC, independently of the number of participants. The only costs that could be modified were the animations, the forum, and the registration platform. In contrast, traditional face-to-face classrooms have a low cost initially, but this then increases according to the number of students. For example, for 1000 participants, the overall cost of the SPOC was €148,000, versus €154,000 for face-to-face education (€154 per student). If we assumed a classroom with 25 students, the point where online education became more effective was 950 participants (Figure 5).

**Figure 4.** Representative responses to questions assessing satisfaction with the 2 sessions of the small private online course (SPOC). The original questionnaire was in French but responses were translated for this paper.



The original questionnaire was in French that responses were translated for this paper

**Figure 5.** Cost comparison between the small private online course (SPOC) and traditional face-to-face classroom education.

## Discussion

### Principal Findings

This SPOC was a positive experience with a completion rate of 35.5%, a success rate of 71.5%, and a commitment rate of 64.7%. Among the 1574 participants, most were aged 31 to 45 years and were paramedical practitioners (nurses, pharmacists). Most (90.4%) considered that this course had a positive impact on their professional practice. The cost effectiveness of this online education became more effective at more than 950 participants.

This SPOC was an innovative oncological teaching method and had a high completion rate (35.5%). In general, on MOOC platforms, the completion rates are between 5% and 10% [7]. Hoy suggested that, in medicine, MOOCs could be used in continuing medical education [19]. However, few medical universities use this kind of teaching [4,5,15,20-22].

A high completion rate (38%) was observed in an Australian MOOC on dementia: 4409 registrants took part in discussion boards and 3624 completed the course [23]. In addition, a French MOOC that opened in 2016, the *Diagnostic Strategies of Cancers*, had a satisfactory completion rate (23%) [4,5].

From that experience, we decided to design a SPOC that was a modified MOOC. In our SPOC, the number of registered participants and the completion rate in the second session (341/975, 34.9%) were similar to rates in the first session (261/600, 36.0%). This demonstrated that students' interest in this SPOC remained high and was not only an initial enthusiasm for a new teaching method. Also, the large difference in completion rates between MOOCs and our SPOC could be because SPOCs are developed for a targeted audience and are, therefore, able to better suit the educational needs and interests of their participants [3-5,7].

In the MOOC *Diagnostic Strategies of Cancers*, there were 2 types of learners: students in health and biology, and members

of the general public. Of the participants, 71% chose to go on to student teaching. Of the 5285 participants from 81 different countries, 1237 (23%) were successfully certified [4,5].

In our SPOC, we targeted the participant profile at medical and paramedical caregivers to create a stronger link between professionals sharing an interest in oncology. We found that nurses were the main group represented in the first session, whereas pharmacists were the main group in the second session. This could be because more information was delivered by the pharmaceutical community about this SPOC after the first course offering. Moreover, regarding age, we found that most participants were not very young: 41% were aged 31 to 45 years, 20% were aged over 50 years, and 12% were aged 46 to 50 years. Yet digital learning is a modern methodology.

The SPOC allowed experiences to be shared. The participant did not need to train alone in front of his or her computer but could also be involved in social and collaborative work. In fact, Uijl et al [24] recently evaluated 4 courses from the University Medical Center Utrecht's international Master's Program in Epidemiology. The 71 included students benefited from extended social interactions during the SPOC. There were around 1500 interactive posts across the 4 courses, in 575 discussions, of which 43% were social discussions. Of these, 90% were initiated by students, and 94% was aimed at students. The authors of this study concluded that the SPOC had a sustainable concept and created an environment suitable for learning, thus fitting with the need for social interactions in higher education [24]. The same results have been observed in other studies [25-27], as well as in our SPOC.

In the second course offering, we improved interactions between the participants through a dedicated forum with collaborative exercises. We deliberately mixed professionals from different areas and institutions: about one-third were in private practice, one-third worked in a public hospital, and one-third worked in a private institution. The result of these interactions was further complemented by peer evaluation. All these activities

contributed to the development of a social learning environment and (in large part) to the high completion rate. Indeed, most participants felt their expectations had been met (91%).

As shown in an online accreditation course, a professional practice forum improved learning outcomes through sharing expertise [28]. The SPOC seemed to be a good way to strengthen coherence and communication between the different caregivers (nurses, doctors, pharmacists, physiotherapists, etc). It became clear that digital learning improved communication and united the participants' efforts on one subject, thus forming a link between those working in the hospital and those working in the surrounding community. In study of a MOOC on diabetes, Wewer Albrechtsen et al reported that, among 845 caregivers, the MOOC had a positive effect on their practice of 88% and extended the professional network of 48% [29].

One major positive aspect of this teaching method is its wide accessibility. As demonstrated in our SPOC, training was accessible from a participant's computer or tablet from anywhere and at any time. We observed that 4.26% (19/446) of our participants lived outside France: they were either expatriates or foreigners who spoke French.

We analyzed the cost effectiveness of this type of education. In our study, we compared the overall cost of our SPOC with that of a traditional classroom for the same number of participants. We found that the online course was more cost effective when there were more than 950 participants. This may be for three main reasons. First, the overall cost of the SPOC was higher (because we chose a private enterprise as the service provider, outside of the university). Second, this SPOC was free of charge to participants, whereas many online teaching courses charge fees. Third, face-to-face education does not allow for the course to be offered in foreign countries (due to, for example, extra travel costs). Thus, the cost for SPOCs could be less than we have calculated. Other researchers have analyzed costs and compared them with costs of traditional education. In a randomized study, Nilsson et al [30] compared the cost effectiveness of a mobile app-guided versus a textbook-guided ultrasound course. Of the 34 participants who completed the course, there were no statistically significant differences in test

performance or diagnostic accuracy between the 2 groups. Yet textbook-guided training was significantly more cost effective than mobile app-guided training [30]. Erbe et al described different methods to study common mental health disorders; they reported that blended interventions (combining the strengths of face-to-face and Internet approaches) were feasible and could be more effective [31]. More randomized clinical trials on the effectiveness and cost effectiveness of blended treatments are necessary. Recently, Tolsgaard and Cook discussed the costs and outcomes of improving educational programs according to their context. They concluded that, even if the costs and outcomes were individually very important, perceived value also must be considered in order to decide change of current educational practices [32].

Moreover, our questionnaire raised some points that need improvement. For example, participants commented on the general nature of the topics covered during the courses and would have liked more detail, for example, about the secondary effects of chemotherapy and radiotherapy. This feedback helped us improve the content and structure of the second SPOC offering. Indeed, SPOCs are constantly evolving, with the possibility that new modules can be added, and thus forums can be developed for discussion, collaborative exercises, and interactivity between participants. Our SPOC will be integrated further for medical and paramedical (nurse) educational institutions and universities in France. To evaluate the educational effectiveness of our SPOC, we plan to test retention of knowledge over time by sending an evaluation form to participants at 1 year after they have completed the SPOC.

## Conclusion

The clarity (information, support, access, registration, and content), communication (exercises and forum), and interactivity (assessment, collaborative exercises, and feedback) in our SPOC made this a good educational method for CPD and interprofessional education. This relatively new digital learning tool is an attractive concept to integrate teaching, especially in oncology. It offers optimal propagation of information in a cost-effective way and meets the students' expectations for training.

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## Conflicts of Interest

None declared.



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## Abbreviations

**CPD:** continuing professional development

**MOOC:** massive open online course

**SPOC:** small private online course

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Original Paper

# Self-Reflected Well-Being via a Smartphone App in Clinical Medical Students: Feasibility Study

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## Abstract

**Background:** Well-being in medical students has become an area of concern, with a number of studies reporting high rates of clinical depression, anxiety, burnout, and suicidal ideation in this population.

**Objective:** The aim of this study was to increase awareness of well-being in medical students by using a smartphone app. The primary objective of this study was to determine the validity and feasibility of the Particip8 app for student self-reflected well-being data collection.

**Methods:** Undergraduate medical students of the Dunedin School of Medicine were recruited into the study. They were asked to self-reflect daily on their well-being and to note what experiences they had encountered during that day. Qualitative data were also collected both before and after the study in the form of focus groups and “free-text” email surveys. All participants consented for the data collected to be anonymously reported to the medical faculty.

**Results:** A total of 29 participants (69%, 20/29 female; 31%, 9/29 male; aged 21-30 years) were enrolled, with overall median compliance of 71% at the study day level. The self-reflected well-being scores were associated with both positive and negative experiences described by the participants, with most negative experiences associated with around 20% lower well-being scores for that day; the largest effect being “receiving feedback that was not constructive or helpful,” and the most positive experiences associated with around 20% higher scores for that day.

**Conclusions:** The study of daily data collection via the Particip8 app was found to be feasible, and the self-reflected well-being scores showed validity against participant’s reflections of experiences during that day.

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**KEYWORDS**

mental health; medical students; medical education; bullying; teaching; mhealth

## Introduction

**Background**

There is an increasing number of studies that have suggested that medical students experience high rates of depression and suicidal ideation [1]. A systematic review conducted in 2016 by Rotenstein et al from 167 cross-sectional studies (n=116,628) and 16 longitudinal studies (n=5728) from 43 countries found that depressive symptom prevalence is substantially higher

among medical students than among individuals of similar age in the general population. The finding in the longitudinal analysis of this review showed an increase in depressive symptom prevalence with the onset of medical school. The overall pooled crude prevalence of depression or depressive symptoms was 27.2%, compared with 2 large representative epidemiological studies, which estimated depressive symptom prevalence in nonmedical students ranging from 13.8% to 21.0% [1,2].

Furthermore, the Australian National Mental Health Survey of Doctors and Medical Students showed that approximately one in 5 medical students (20%) had thoughts of suicide in the previous 12 months [3]. Similarly, the Rotenstein review showed a prevalence rate for suicidal ideation, extracted from 24 cross-sectional studies (n=21,002) from 15 countries, of one in 10 medical students. Currently, there are no available data on suicide rates in medical students. However, two systematic reviews of qualified doctor suicides conducted by Schernhammer and Colditz in 2004 and Damasceno et al in 2017 revealed the aggregate suicide rate ratio for male doctors, compared with the general population, was 1.41. For female doctors in the same studies, the ratio was 2.27 [4].

Many factors contribute to poor well-being and may include occupational factors, emotionally demanding situations, unrealistic expectations, and confrontations with illness, death, and dying [5-8]. Degrading experiences such as bullying or harassment at work have been shown to be associated with suicidal thoughts [9]. The New Zealand Medical Students' Association (NZMSA) surveyed their members in 2015 and reported that 54% had experienced bullying or sexual harassment while on clinical placement [10]. It has been suggested that sometimes accusations of bullying can be linked to situations that are an inevitable part of training [7]. For example, trainers giving feedback to trainees that they are not performing at the expected level [11]. However, research has clearly shown that perceived mistreatment regardless of the intention of the perpetrator is viewed by medical students as a major source of stress and well-being depletion [5,12].

Due to the reported high prevalence of depressive and suicidal thoughts in medical students, there is a need for additional research to identify the root causes of emotional distress. Recommendations from past studies have suggested adopting prospective study designs, so that the same individuals can be assessed over time [1].

## Objectives

The primary objective of this study was to assess the feasibility of utilizing a smartphone app, such as the Particip8 app, for the collection of students' individual self-reflected experiences and sense of individual well-being. Secondary objectives were to correlate daily experiences with the self-reflected well-being score and to assess the use of the "safety pop-up feature" in prompting students to access help at an earlier stage. Qualitative data were also collected to assess the effectiveness of the Particip8 app in increasing self-awareness of well-being.

## Methods

### Study Design

The methodology used for this feasibility study was a mixed qualitative and quantitative approach. The quantitative aspect utilizes the ecological momentary assessment (EMA) methods as described by Shiffman et al [13]. The qualitative data were based on grounded theory methodology and analyzed with a narrative thematic approach based on descriptions in Glaser and Strauss (2017) and Braun and Clarke (2006), respectively [14,15]. The data for the qualitative analysis were obtained from

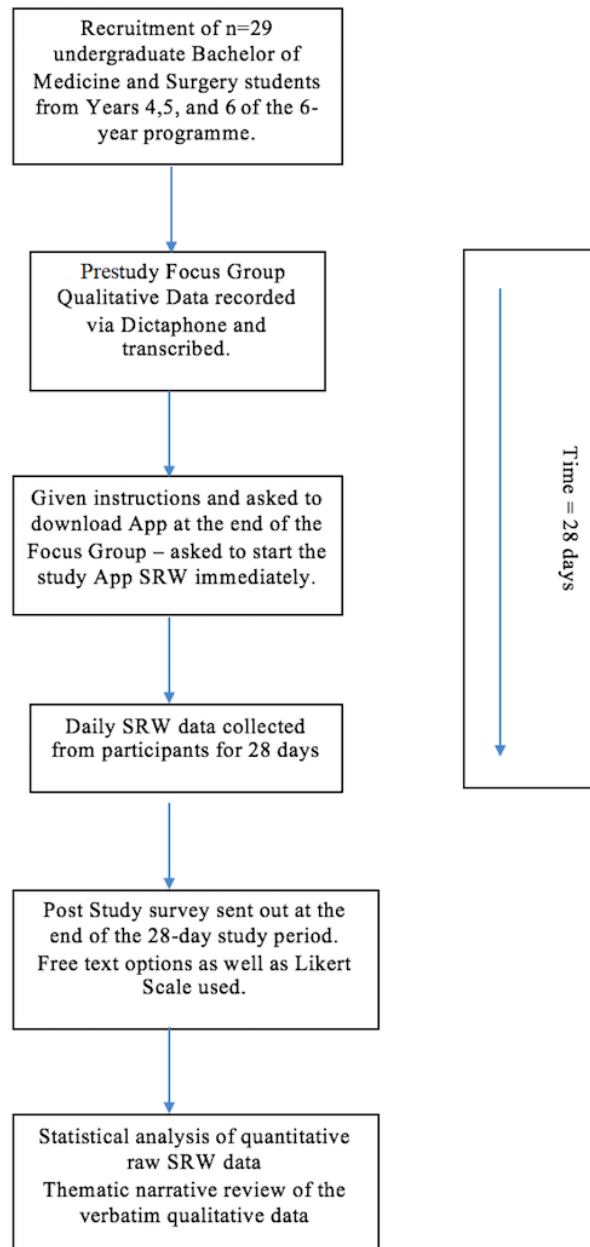
prestudy focus groups, as well as poststudy email surveys. An overview of the methodology is set out in Figure 1. The necessary sample size for the feasibility component of the study was determined to be 30 participants, and the duration of the study was determined to be 28 days. This was to allow sufficient opportunities for participants to explore the Particip8 app under different conditions and to achieve effective saturation of their experiences. Participants were asked to use the Particip8 app on a daily basis to record their self-reflection on well-being. Participants were able to select a face emoticon scale to indicate how they felt on that particular day. Additionally, participants were also asked to select from a list provided, the experiences that they had been exposed to during that day. Participants could choose multiple experiences for the day; however, they could only log one self-reflected well-being score.

Consultation with key stake holders was undertaken before applying for ethics approval. These key stake holders included the Pro-Vice Chancellor of Health Sciences, the Dean of Māori, and the Dean of Pacifica. Other key stakeholders such as student groups that included the Otago University Medical Students Association, Te Oranga Aotearoa, NZMSA, and the Pacific Island Health Professional Student Association were also consulted. Feedback from these stakeholders was taken into consideration during the study, and as a result, previous aspects were changed and amended. Ethics approval was granted by the University of Otago Head of Department (Ethics no. D16/308).

### Participant Recruitment

The participants were students recruited from the Dunedin School of Medicine. Recruitment was conducted via posters in student areas, lecture announcements, and through social media posts. A total of 29 students voluntarily applied for the study, and all 29 students met the inclusion criteria. As a result, all 29 students were enrolled in the study. The inclusion criteria included (1) The ownership of a personal Android or apple smartphone device; (2) Enrolled at the Dunedin School of Medicine in the bachelor of medicine and surgery (MBChB) degree; (3) Were currently in their 4th, 5th, or 6th year of the undergraduate MBChB program; and (4) Currently undertaking a clinical placement. The participants were provided with a code for downloading the Particip8 app once they had inquired about the study, or when they attended the prestudy focus group. A webcast was made available to students with instructions on how to download and use the Particip8 app. Both iPhone operating system (iOS, Apple Inc) and Android platforms were made available. The Particip8 app was not available for those who owned a Windows phone, or for nonsmartphone mobile devices.

The app was named "Particip8" because students were required to be active participants in their own well-being. There were eight daily questions that the students were required to answer. For example, one question asked what placement the student was on that day, another question had five questions from the World Health Organization's (five) Well-Being Index (WHO-5), and other questions related to the experiences that the student had experienced that day.

**Figure 1.** Methodology flowchart. SRW: self-reflected well-being.

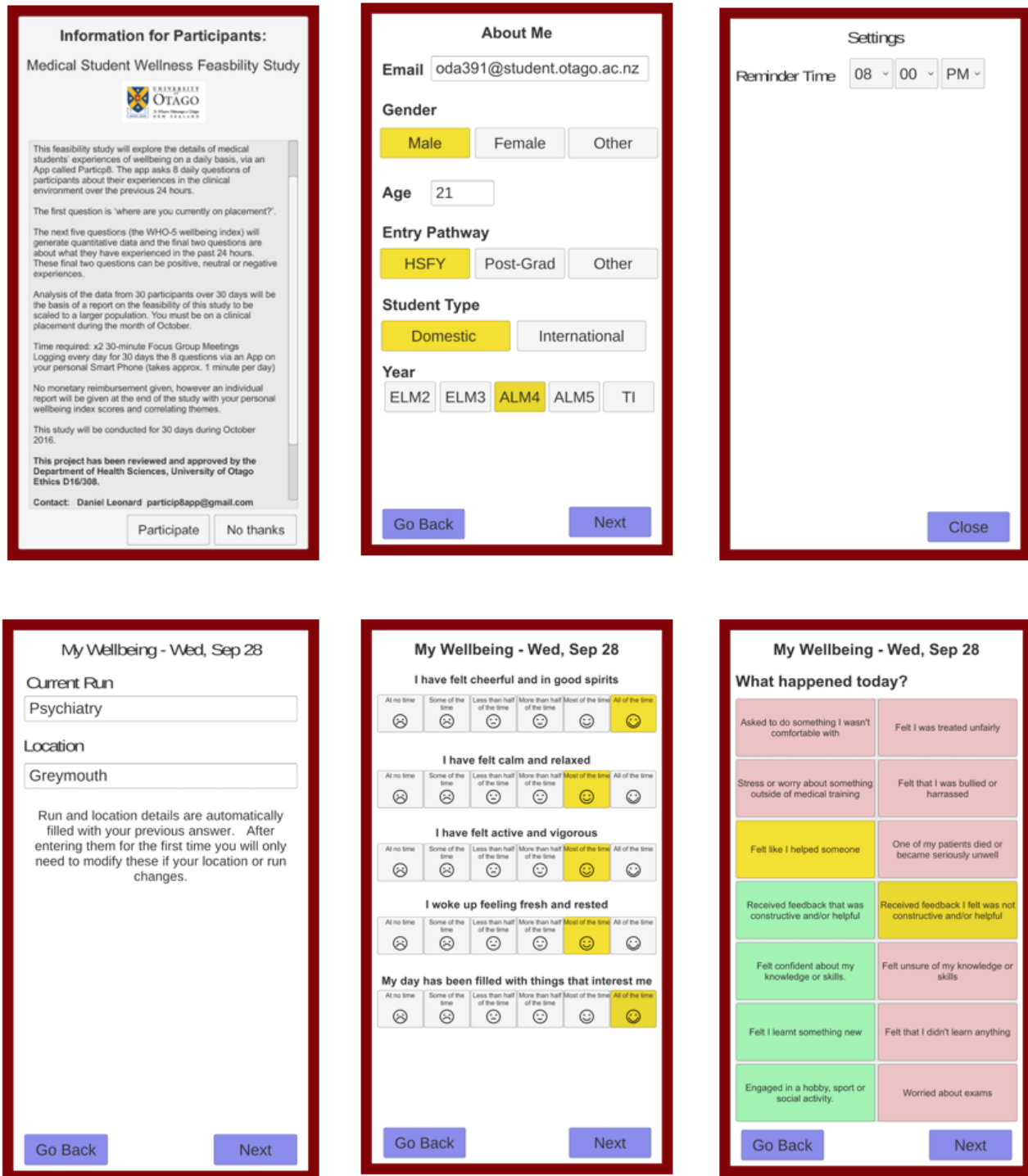
Upon downloading the Particip8 app, the initial log-in page had the details of the study and asked for the participant's consent to participate in the study. All participants gave consent via the Particip8 app to be in the study. Participants were offered no financial incentives or reimbursement for participation in the study. The second page of the Particip8 app required each participant to enter their baseline demographic data such as their age, entry into medical school (either from secondary school after completing the health science first year (HSFY) program, after completing a previous degree (postgraduate), or from the "other" category that included those who have an undergraduate or postgraduate degree and have worked in allied health for a minimum of 5 years, ethnicity, as well as their gender. The webcast that had the download instructions also had instructions

on how to complete the survey and how to customize the time setting for the daily push notification reminder.

### Evaluation of the Screening Tool Used

The Particip8 app was specifically developed for clinical medical students, by clinical medical students. It involved using an international validated survey, the WHO-5. The question wording and order in the WHO-5 did not change. The time period of interest, however, was changed from "the last 14 days," to asking "the last 24 hours" to suit daily recording. This adaptation was reviewed by the New Zealand World Health Organization Quality of Life Group and deemed suitable to be used in this shortened time frame. Notably, however, no other published research has used it as a daily survey before. The WHO-5 was chosen because it has a sensitivity of 0.93 and a specificity of 0.83 in the detection of depression [14].

Figure 2. Screenshots of the app.



The Particip8 app asked the WHO-5 questions daily and utilized the visual aid of a facial emoticon scale. The emoticon scale was selected to help with ease, speed, and accuracy of answering the five questions. The next page of the Particip8 app was a list of experiences that the student possibly could have experienced during the day. These experiences were chosen from the “NZMSA 2015 Bullying and Harassment Survey” and commonly experienced situations of clinical medical students [10]. Screenshots from the Particip8 app are presented in Figure 2.

### Statistical Methods

The size of the study, being a total of 30 participants, was determined to be sufficient for the quantitative component. The size of the study would provide sufficiently precise estimates for standard deviations, correlations between repeated measures, and rates and patterns of missing data for designing larger studies in the future.

Appropriate summary statistics were calculated for all variables of interest. Analysis included linear mixed models (LMMs), with a random participant effect to accommodate the repeated measures over the study days. The LMMs were used to examine

associations between each of the WHO-5 items and its combined score and each of the situational (day of week, location), experiential (eg, learning something new), demographic (age, gender, ethnicity, and entry pathway), and study-related (day of study and delay before reporting) variables. Model diagnostics included examining model residual normality and homoscedasticity. Subsequently, the experiential variables (yes or no) were examined for associations with the situational, demographic, and study-related variables by using mixed logistic regression models. All statistical analyses were conducted using Stata (StataCorp) 14.2, with two-sided  $P < .05$  considered statistically significant in all cases. No formal adjustment was made for the multiple comparisons, and marginal results should be interpreted with caution.

## Results

### Participant Characteristics

A total of 29 participants were analyzed in this study. Participant characteristics (Table 1) showed the age range from 21 to 29 years, with a median age of 23 years (starting at age 19 years with high school leavers completing HSFY entry method, the majority of students would be either aged 21 years or above in 4th year medical school). The majority of participants (69%, 20/29) identified as female, with the remaining participants (31%, 9/29) identifying as male. Ethnicity was 24% (7/29) Māori, 38% (11/29) New Zealand European, and 38% (11/29) identifying as “other” (Indian, Sri Lankan, Chinese, South East Asian, and Pacific Islander). Entry pathway and student type and gender percentage were both reflective of the cohort group from which the participants were selected.

**Table 1.** Participant demographics.

Variable	n (%)
<b>Student-level</b>	
<b>Age (years)</b>	
21	3 (10)
22	6 (21)
23	8 (28)
24	4 (14)
25	3 (10)
25+	5 (17)
<b>Gender</b>	
Female	20 (69)
Male	9 (31)
<b>Year</b>	
Advanced learning in medicine (ALM) 4th year	15 (52)
ALM 5th year	5 (17)
Trainee intern	9 (31)
<b>Entry pathway</b>	
Health science first year program	21 (72)
Other	2 (7)
Postgraduate	6 (21)
<b>Student type</b>	
Domestic	26 (90)
International	3 (10)
<b>Prioritized ethnicity</b>	
Māori	7 (24)
European	11 (38)
Other	11 (38)

## App Feasibility Analysis

Compliance was measured as completing the daily survey within the allotted time period. In total, 471 days were completed over the 28-day study period, resulting in an overall median compliance rate of 71% at the day level. A total of 13 participants (45%, 13/29) completed 80% to 100% of the days, achieving the required compliance threshold for EMA studies; 4 (14%, 4/29) completed between 50% to 80% of days; and 12 participants (41%, 12/29) completed less than 50% of the days. The longitudinal data showed that compliance rates steadily declined over the 28 days (data not shown). Females were nonstatistically significantly more compliant than men, and there was no evidence for associations with compliance for any of the other student demographics (age group, ethnicity, or year of study).

## Well-Being by Day of the Week and Type of Day

For the overall score ([Multimedia Appendix 1](#)), there were differences between various days of the week (overall  $P=.003$ ). Tuesday had the lowest overall well-being mean (2.91/5.00), and Saturday had the highest mean (3.51/5.00). The same pattern was observed for the five individual questions, but only feeling cheerful (Q1), waking up fresh and rested (Q4), and day filled with things that interested (Q5) were statistically significantly different by the particular day of the week. Days off (mean=3.44) had higher well-being scores than days where the students attended placements (3.01,  $P<.001$ ). Four of the questions showed statistically significant differences, except feeling active and vigorous (Q3).

## Ethnicity

Māori students were 1.22 times more likely to engage in sports, social activities, or hobbies than New Zealand European students and 2.27 times more likely compared with non-New Zealand European students (overall test for ethnicity  $P=.009$ , results not shown).

## Entry Pathway Into Medicine

Postgraduate and “other” students were 2.2 times more likely to feel that they “did not learn anything” (19.5% vs 8.9%,  $P=.02$ ). Postgraduate and “other” students were 2.5 times more likely to feel more unsure of their knowledge and skills (46.9% vs 18.4%,  $P=.009$ ) and were 3.4 times more likely to worry about exams (68.1% vs 19.8%,  $P=.01$ ; results not shown).

## Rural Location

Another finding was that there were differences in the results between students who were on placement in Dunedin and those who undertook placement outside of Dunedin. Some areas, such as the West Coast of the South Island, are the most isolated locations in New Zealand. Although anecdotal reports from students are that the learning and experiences in these isolated locations are extremely beneficial, the results from the study show that well-being scores are lower when students undertake a placement outside of Dunedin. Students undertaking Dunedin-based placements were 2.4 times more likely to receive

constructive feedback compared with their colleagues based outside of Dunedin ( $P=.04$ ). Students on placements away from Dunedin were 2.1 times as likely to experience stress or worry ( $P=.009$ ; [Table 2](#) OR results not shown) and in [Multimedia Appendix 1](#), reported 0.6 lower (21%) scores in relation to the question about waking up feeling refreshed and well rested (Q4;  $P=.02$ ).

## Well-Being Scores by Placement

There were apparent differences in well-being scores between students assigned to different specialties for their clinical placement ([Multimedia Appendix 1](#), overall  $P<.001$ ) ([Figure 3](#)). General practice scored highest of all the specialties (mean 4.02/5.00), followed by “other” (emergency department, intensive care unit, and public health; 3.78), and surgery (3.13). The lowest scores were reported by students undertaking the lecture-based whole class learning week (2.63), psychological medicine (2.63), and women and children’s health (2.51).

## Experiences Effect on Well-Being

[Multimedia Appendix 2](#) details what participants experienced and the effect on well-being score. A total of five incidents of bullying or harassment were reported by students during the study. These incidents showed to have had a significant adverse effect (AE) on the participant’s well-being, and in particular, there was an AE recorded for three of the five questions; for example, feeling cheerful (Q1), feeling calm and relaxed (Q2), and day filled with things that interest me (Q5). However, the daily score ( $P=.06$ ; [Multimedia Appendix 2](#)) was not statistically significantly lower overall. “Receiving feedback that was not constructive or helpful” had the greatest impact on a participant’s overall well-being score, being associated with 1.18 lower mean scores, equivalent to a 37% reduction in a participant’s well-being ( $P<.001$ ). Other large overall well-being decreases included “Felt like I didn’t learn anything” (29% lower for overall score,  $P<.001$ ), followed by “Felt like I was treated unfairly” (21% lower for overall score,  $P<.001$ ), and “stress or worry about something outside of medical training” (20% lower for overall score,  $P<.001$ ). On the other hand, the recorded experiences that increased well-being scores were as follows: “Felt confident about my knowledge or skills” (19% higher,  $P<.001$ ), “engaged in a hobby, sport, or social activity” (18% higher,  $P<.001$ ), and “received feedback that was constructive or helpful” (17% higher,  $P<.001$ ).

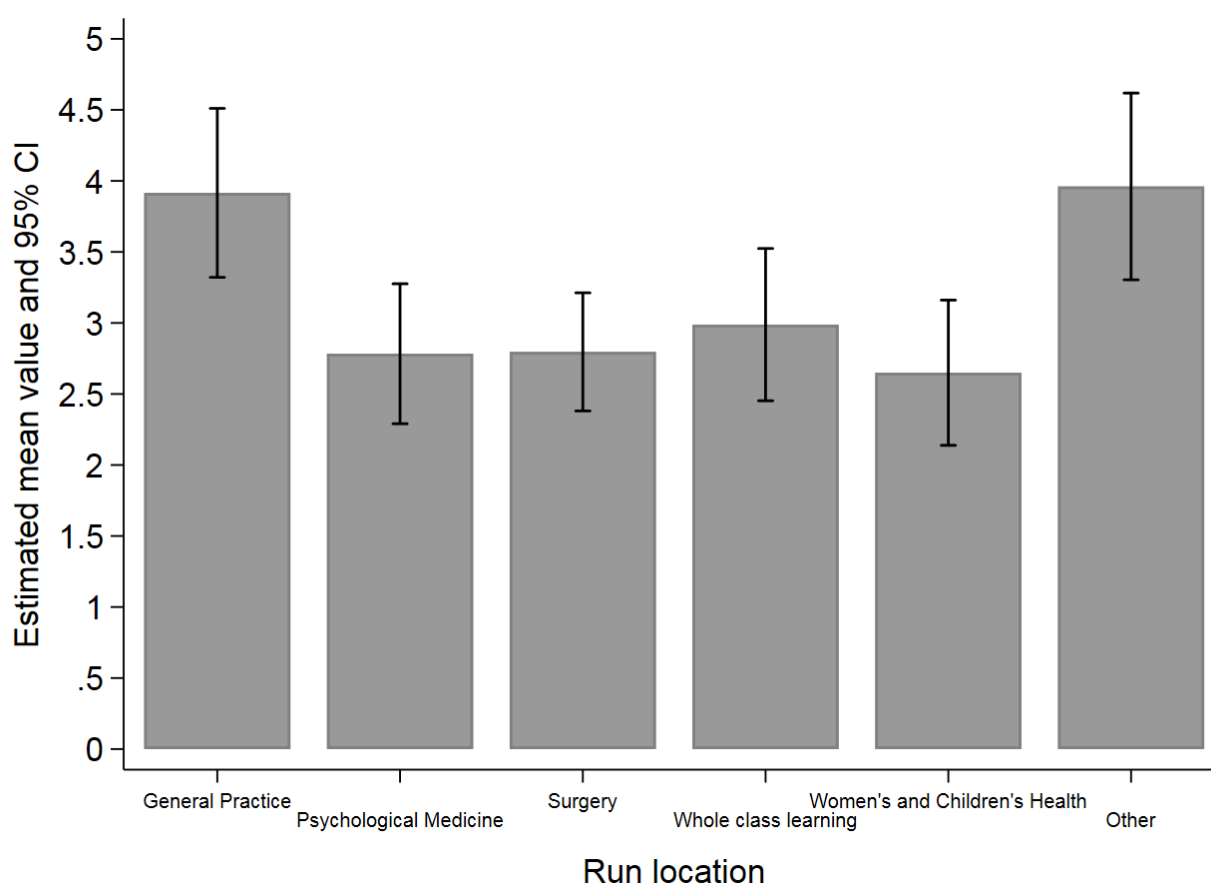
## Constructive Feedback

Due to the low levels of participants in the category “other specialities,” it is difficult to interpret these results. However, for the other placements, there was sufficient data to analyze. With respect to “receiving constructive feedback,” although there was no overall evidence for differences ( $P=.19$ ), general practice was the highest at 40.0%, followed by surgery (30.5%), psych medicine (24.6%), and women and children’s health (24.4%). Not surprisingly, whole class learning week, which is lecture and small tutorial-based learning, had the least amount of constructive feedback for students (14.8%).



**Table 2.** Experiences versus mean well-being score.

Experience	Not experienced	1 or more days	Difference	P value
<b>Increased well-being</b>				
Felt confident about my knowledge or skills	3.02	3.59	+0.57	<.001
Engaged in a hobby, sport, or social activity	2.92	3.45	+0.53	<.001
Received feedback that was constructive or helpful	3.05	3.57	+0.52	<.001
Felt I learnt something new	2.96	3.41	+0.45	<.001
Felt like I helped someone	3.05	3.45	+0.40	<.001
<b>Decreased well-being</b>				
Received feedback that was not constructive or helpful	3.21	2.03	-1.18	<.001
Felt I was bullied or harassed	3.41	2.33	-1.08	.005
Felt I didn't learn anything	3.28	2.34	-0.94	<.001
Stress or worry about something outside of medical training	3.29	2.63	-0.67	<.001
Felt I was treated unfairly	3.19	2.53	-0.66	<.02
Worried about exams	3.37	2.74	-0.63	.001

**Figure 3.** Mean well-being scores by placement.

### Qualitative Results

The results are from a narrative analysis of the focus group verbatim text and the “free-text” email surveys. Participants felt that using the Particip8 app to track well-being was feasible because they often had small amounts of time available to complete the survey.

### Theme 1: Finding the Time

Some of the participants stated the following:

*I feel like it would be quite easy because as a 4th year there is a lot of times there is waiting around and a lot of those times I tend to go on my phone, so I think that it will be easy to find time for a few minutes to*

*go on [and do the Particip8app]. [4th-year medical student participant]*

*There is a lot of down time sitting outside out-patients, waiting for consultants, etc, it is a good way to use the time productively and easily. [6th-year medical student participant]*

Students are taught that regular reflection is important, but it is difficult to establish a habit. Participants also thought that an app would help establish these patterns and habits.

### **Theme 2: A Tool to Help Create Habits on Self-Reflection**

Some of the participants stated the following:

*I think that it would be difficult at the start to get into the habit of it, but, if I say do it every day at 5 o'clock, I would like to get into the habit of it, like doing it on the bus or something. [4th-year medical student, participant]*

*...thinking about these questions every day, kind of makes you a bit more mindful of it, then you then, "ah," like if you are having a particularly good day, "I've had a really good day," or if things haven't gone so well, you actually sort of think about that and sort of realise things that you might have otherwise missed. [4th-year medical student participant]*

### **Theme 3: Daily Reflection Increased Self-Awareness of Well-Being**

Some of the participants stated the following:

*Sometimes it is hard to know that you are actually quite stressed out. [4th-year medical student participant]*

*I think as well that the environments that we're working in the hospitals, can be quite stressful environments, so it's important that we are able to take care of our well-being so that we are able to best respond to those stressful environments in a way that's not going to be like self-destructive or damaging to ourselves. [4th-year medical student participant]*

*I think that it is very important. It is the kind of the core of what we need to do, to do anything else you need to be well. [5th-year medical student participant]*

On the email poststudy survey questionnaire, students confirmed that their overall awareness of well-being had increased by 20% on a Likert scale from poststudy qualitative results.

### **Analysis of the Safety Feature**

Participants who had logged 3 days of low well-being scores triggered a safety feature on the Particip8 app, which alerted them and suggested places that were available for help and assistance. During the study, 41.7% (12/29) of all participants received the safety pop-up message at some stage during the study period. When asked if they sought support, most participants said that they talked to a trusted person, and 5 participants went to student health services. No participants

stated that they had gone to the Medical School Associate Dean of Student Affairs for assistance.

After taking part in the study, over 90% (26/29) of students say a measure of their own wellness was useful. A further 75% (22/29) of participants said that they would be happy for their data to be reported back to the medical school faculty with some identification, such as demographics. The remainder of the participants (25%, 7/29) agreed to the data being reported to the medical school faculty on the provision that their data remained completely anonymous.

## **Discussion**

### **Principal Findings**

This study provides several important academic and practical outcomes. This feasibility study has examined the ability to collect self-reflected well-being data from medical student users via a smartphone app. The results collected, including focus group feedback and compliance percentages, show that this was overall a feasible method of collecting these data, although strategies to increase compliance would be advisable and worthwhile.

Prior studies in psychology suggest that use of the face emoticon scale can make participation more enjoyable. The study did not encounter any issues with regard to the inconvenience to participants to use the Particip8 app. A suggestion for the future development of the Particip8 app would be to add a dashboard page with a graph of a personal self-reflected well-being results over a week. Such a mechanism would allow participants to view the trends of their data and enable them to look back on past logged days themselves. The academic implication shown by this study is that surveys can be administered with ease and minimal burden to participants. This has potential generalized implications on future study methodologies, which require participants to complete short questionnaires at regular intervals.

The recorded well-being data was associated with experiences in ways that seem plausible, providing some degree of validation.

There are many challenges and practical implications that arise from conducting research by utilizing a smartphone app such as Particip8. Studies such as this are able to provide "real-time" data on the experiences of medical students and can generate a wealth of accurate prevalence data on well-being scores. However, the issue of "big data" and how to best analyze and interpret this becomes the next challenge.

### **Limitations**

Several limitations influence the conclusions and recommendations drawn from this research. First, the sample was small, self-selected, and drawn from a medical student population. This allowed, as intended, for a detailed exploration of an at-risk group who are likely to benefit from reflection of personal well-being. However, this adds limitations as the sample may differ from other young people, and the extent to which the themes discerned here are applicable across other populations or university groups is unclear. Second, there is also the limitation that comes with all self-reported data,

whereby the participants may not be completely honest and candid in their reflections. One advantage of the methodology used in this study that counters this concern is that the daily survey detects change in the participants' self-reflected well-being score when experiencing different situations. This comparison with the WHO-5 score increases the credibility of the self-reflections, rather than relying on the WHO-5 score alone.

Third, there may be concerns that the collection of data, with only a small number of survey questions, may not be adequate to accurately decipher trends. On the basis of findings from this research, it is argued that because daily reporting via the Particip8 app increases the amount of data received overall, this compensates for any disadvantage of the kind identified. Furthermore, the data collected from this study were sufficient to demonstrate several statistically significant results.

Finally, another concern is that daily self-reflection could become a burden or inconvenience to users of the Particip8 app. Users may become annoyed and resentful toward the Particip8 app's daily "pop-up alerts" and push notifications to complete surveys. Despite this concern, the focus groups and poststudy results did not indicate any issue with annoyance or inconvenience. In fact, participants felt that because the survey could be usually completed in less than 1 min, the Particip8 app itself was not burdensome. Participants also noted that they appreciated the ability to complete the Particip8 app whenever they wanted, rather than at predetermined times stipulated by the researchers. Nonetheless, this feasibility study provides an initial understanding of the opportunities for successful smartphone-based collection of real-time self-reflected well-being data.

### Future Research

As this was only a feasibility study with a small sample size and was of a relatively short duration, future studies should

investigate the feasibility over longer durations, in particular, to assess any further decline in compliance rates.

Future research is now focused on developing an updated Particip8 app. Such an app will have additional functions such as anonymous reporting of inappropriate behavior experienced. Notably, the anonymous reporting of inappropriate behavior is something that over half of participants said that they would find useful. Participants in the study also requested a "free-text" area so that they could write and record more detailed accounts of experiences during the day. This free-text area would be similar to a reflective journal and would be useful to the user.

Another potential area for further research is the incorporation of "interventions" into the Particip8 app. These could be either online interventions that are contained within the Particip8 app itself, such as a mindfulness recording, or could be "in-person" interventions, such as attending workshops. Any changes to a user's baseline well-being could be monitored by real-time monitoring from the Particip8 app's self-reflected well-being scores. Furthermore, the data from these studies could be used to determine whether there is any correlation between improvements in self-reflected well-being scores and reduced clinician burnout, depression, anxiety, and suicide. Ultimately, this would result in optimal patient outcomes in the long term.

Given the limitations of this study, its findings serve as research questions for future investigations and studies, rather than for providing definitive answers.

### Conclusions

In conclusion, the findings of this study suggest that the 28-day longitudinal collection of daily self-reflection well-being data via the Particip8 app was feasible. Further research is required to determine how to sustain the compliance with methodology over a longer period of time, as well as how to use the data to improve the well-being in clinical medical students.

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### Conflicts of Interest

EB and DL were both undergraduate medical students at the University of Otago, Dunedin School of Medicine, during the study period. The development of the app and software was self-funded by EB and DL. There were no financial contributions by any organization toward this feasibility study.

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### Multimedia Appendix 1

Demographic and situational predictors of well-being scores.

[[XLSX File \(Microsoft Excel File\), 39KB - mededu\\_v4i1e7\\_app1.xlsx](#) ]

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### Multimedia Appendix 2

Experiential predictors of well-being scores.

[[XLSX File \(Microsoft Excel File\), 41KB - mededu\\_v4i1e7\\_app2.xlsx](#) ]

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## Abbreviations

**AE:** adverse effect

**EMA:** ecological momentary assessment

**HSFY:** health science first year

**LMM:** linear mixed model

**MBChB:** bachelor of medicine and surgery

**NZMSA:** New Zealand Medical Students' Association

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Review

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# Online Lectures in Undergraduate Medical Education: Scoping Review

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## Abstract

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**Background:** The adoption of the flipped classroom in undergraduate medical education calls on students to learn from various self-paced tools—including online lectures—before attending in-class sessions. Hence, the design of online lectures merits special attention, given that applying multimedia design principles has been shown to enhance learning outcomes.

**Objective:** The aim of this study was to understand how online lectures have been integrated into medical school curricula, and whether published literature employs well-accepted principles of multimedia design.

**Methods:** This scoping review followed the methodology outlined by Arksey and O'Malley (2005). Databases, including MEDLINE, PsycINFO, Education Source, FRANCIS, ERIC, and ProQuest, were searched to find articles from 2006 to 2016 related to online lecture use in undergraduate medical education.

**Results:** In total, 45 articles met our inclusion criteria. Online lectures were used in preclinical and clinical years, covering basic sciences, clinical medicine, and clinical skills. The use of multimedia design principles was seldom reported. Almost all studies described high student satisfaction and improvement on knowledge tests following online lecture use.

**Conclusions:** Integration of online lectures into undergraduate medical education is well-received by students and appears to improve learning outcomes. Future studies should apply established multimedia design principles to the development of online lectures to maximize their educational potential.

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**KEYWORDS**

online lectures; undergraduate medical education; multimedia design; assessment; scoping review; e-learning

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## Introduction

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The modern classroom has changed significantly since the days of paper and pencil learning. Increasing numbers of elementary and secondary school students are using online textbooks, writing their tests online, and watching videos created by their teachers [1]. Accordingly, medical students who have grown up in this digital age are currently experiencing one of the most significant transformations in medical education [2]. In

particular, the adoption of the flipped classroom model is reshaping undergraduate medical education by calling on students to learn from a variety of self-paced tools—including online lectures—before attending live teaching sessions [3]. This allows class time with instructors and peers to focus on a discussion of applications, clinical context, and more nuanced or challenging topics. Thus, the design of online lectures merits special attention as they become a more widespread teaching modality for foundational medical concepts.

**Textbox 1.** Summary of multimedia design principles with definitions reproduced from the Association of American Medical Colleges Institute for Improving Medical Education's Effective Use of Educational Technology in Medical Education.

- Coherence: exclude extraneous words, pictures, and sounds
- Pretraining: ensure students possess prior knowledge about names and characteristics of the main concepts
- Spatial contiguity: present corresponding words and pictures in close proximity to one another
- Temporal contiguity: present corresponding words and pictures simultaneously rather than successively
- Signaling: highlight important words
- Redundancy: pair animation and narration together without on-screen text
- Voice: use non-accented human spoken voice for narration over a machine simulated or foreign-accented human voice
- Personalization: employ conversational style, instead of formal, to present words
- Segmenting: offer narrated animation in learner-paced segments rather than a continuous unit
- Modality: pair animation and narration together instead of pairing animation and on-screen text

For the purposes of this review, online lectures were defined as primarily didactic lectures accessed through digital platforms that do not require active interaction with the video playback interface. Examples of interactivity which would merit exclusion as an online lecture included instructional media in which students “click through” or complete “drag and drop” activities.

In 2007, the Association of American Medical Colleges Institute for Improving Medical Education (AAMC-IIME) published the landmark report *Effective Use of Educational Technology in Medical Education*. One principal recommendation was that medical educators employ established multimedia design principles when developing instructional materials. These design principles initially emerged from educational psychology literature, as described by Richard Mayer's *Theory of Multimedia Learning*. Mayer described empirical evidence that people learn more effectively from multimedia, or words and pictures together, than words alone. However, simply adding words to pictures is not effective, as instructional media must be designed in accordance with how the human mind works. Based on his empirical research, Mayer outlined multimedia design principles as guiding concepts to enhance learning from multimedia presentations [4]. These principles include pragmatic concepts such as removing extraneous words, employing a conversational style, and reducing redundancy across animation, narration, and on-screen text [5]. A comprehensive list of multimedia design principles can be found in [Textbox 1](#). In the context of medical education, it has been shown that applying multimedia design principles to medical student lectures leads to improved attainment of learning objectives both immediately and long-term [6,7].

Despite the purported benefit of careful multimedia design, it is unclear whether best practice has become routine practice in medical education. The AAMC-IIME note that a cultural lag often occurs between the development of novel educational technologies and their effective implementation [5]. Therefore, the purpose of this scoping review was to understand how online lectures have been integrated into medical school curricula, and whether multimedia design principles are being utilized in their creation. With the emergence of online lectures as an increasingly prevalent teaching modality—and given the significant resources being allocated to their

development—understanding the application of best practice in online lecture design is of significant and immediate relevance.

## Methods

We searched OVID Medline (1946 to present, In Process & Other Non-Indexed Citations), OVID PsycINFO (1806 to present), OVID Social Work Abstracts (1968 to present), EBSCO Education Source, PROQUEST Abstracts in New Technology & Engineering, ASSIA, Canadian Research Index, CBCA Education, Computer & Information Systems Abstracts, ERIC, Computer Science Collection, Engineering Journals and PSYCTESTS, and FRANCIS, to identify articles addressing the subjects of online learning and medical education. Search strategies were developed by an academic health science librarian (APA) with input from the project leads and content experts (ML, BT). The search strategies were translated using each database platform's command language, controlled vocabulary, and appropriate search fields. Medical Subject Headings terms, American Psychological Association thesaurus terms, and text words were used for the search concepts of “e-learning”, “video lectures”, “medical education”, and “medical students”. Searches were completed on July 1, 2016 and limited to articles published between July 1, 2006 and July 1, 2016, given that we were predominantly interested in examining literature published since the release of the AAMC-IIME report in March 2007. English-language limits were applied to all databases.

All articles were independently screened (by 2 of BT, AC, AQ, or HB) through a 2-step process of abstract and full-text review to determine eligibility for inclusion. Only articles that were not excluded through abstract review underwent full-text review. Articles that ultimately met inclusion criteria were then analyzed and charted according to the following iteratively developed categories: (1) lecture topic; (2) participants and setting; (3) lecture design components; (4) process of lecture design; (5) method of assessment; and (6) results.

Primary research articles written in English were included if they (1) discussed online, didactic lectures whose primary purpose was to teach or review curricular content; (2) did not

require active interaction with the video playback interface; (3) were created by or for a medical school; (4) involved undergraduate medical students; (5) were watched independently by students; and (6) included either video, a slide deck, or an informal talking head. Articles were excluded if they discussed teaching modalities that required active participation (eg, problem-based learning), were not online, involved nonmedical doctor health care students, involved advanced trainees (eg, medical residents), were not designed by or for the medical school (eg, external YouTube channel), were watched by students in a group setting, or involved a lecture that was not a core educational component (eg, used for an extracurricular activity).

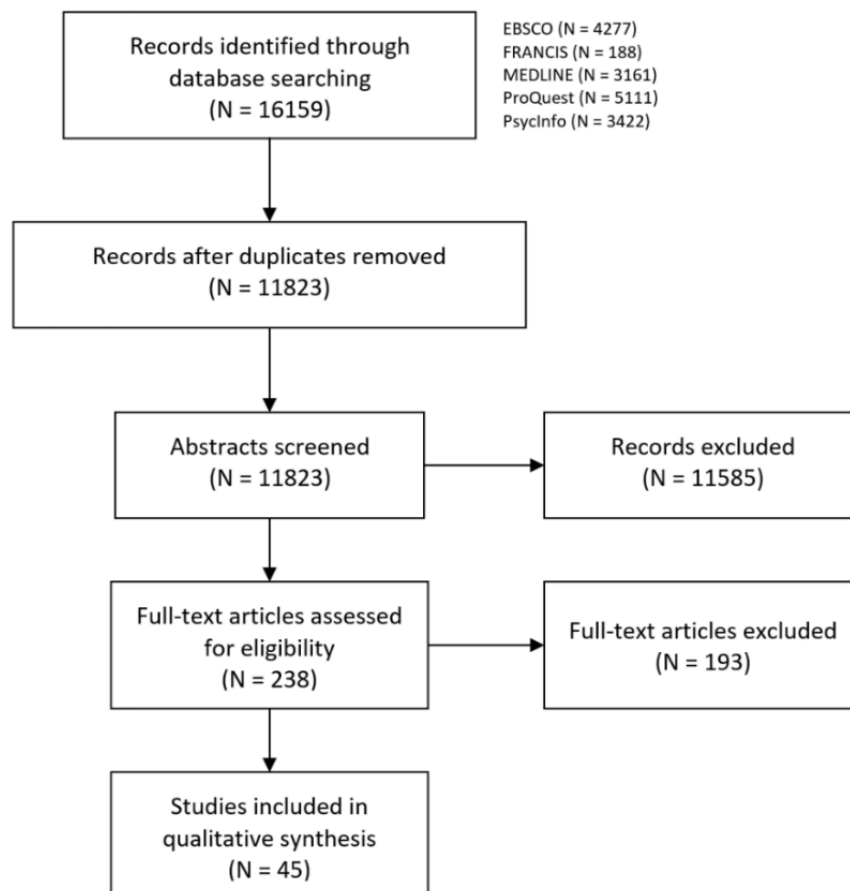
Assessment methods were then categorized according to the Kirkpatrick 4-level model of evaluation, interpreted in the context of online lecture evaluation [8]. Level 1 (reaction) was defined as learner satisfaction or confidence; Level 2 (learning) was defined as knowledge of information directly taught in the online lecture; Level 3 (transfer of learning) was defined as improved outcomes in tasks not directly taught in the online lecture (eg, practical examinations or final course grades); and Level 4 was defined as benefit to patients or organizational practice (eg, improved clinical outcomes such as quality of care).

Lastly, the rigor of studies included in the final analysis was assessed using the Newcastle-Ottawa Scale (NOS) [9]. The NOS is a widely used scale with established content validity and inter-rater reliability. It judges studies based on the following key parameters: (1) the selection of the study groups; (2) the comparability of the groups; and (3) the outcome measures employed. Within the context of this work, 2 of the authors (BT and AC) coded the articles included in the final analysis (N=45) according to the criteria outlined in the NOS. Any disagreements were resolved via a consensus discussion, and remaining areas of ambiguity were deliberated with other members of the research team.

## Results

Our search revealed 16,159 potentially relevant studies, of which 45 articles ultimately met inclusion criteria (Figure 1). Of the 238 articles that underwent full-text review, 193 (193/238, 81.1%) were excluded because they involved nondidactic lectures (75/193, 38.9%), were not primary research (51/193, 26.4%), involved nonmedical student populations (25/193, 13.0%), were duplicate articles identified through different search databases (24/193, 12.4%), had no involvement of online lectures (16/193, 8.3%), or involved videos that were not designed by the medical school (2/193, 1.0%).

**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart for the article search.





## Lecture Topics, Participants, and Setting

Online lectures were employed in preclinical and clinical years, covering diverse topics such as basic sciences (12/45, 27%), clinical medicine (16/45, 36%), and clinical skills (17/45, 38%). Please refer to [Multimedia Appendix 1](#) for a summary of all included studies, tabulated by lecture topic(s), participants and setting, lecture component(s), lecture design process, assessment method(s), assessment Kirkpatrick Level(s), and summary of results.

## Lecture Components and Design Processes

The most common elements of online lectures included slide decks (25/45, 56%), narration (23/45, 51%), and video (18/45, 40%), with slide decks and narration typically occurring in conjunction. Several studies used the terminology online “lecture” or “module”, but did not clarify the specific design of these interventions (5/45, 11%). A summary of design features can be found in [Table 1](#). Approaches to delivering online lectures were occasionally described as well, with 16% (7/45) of lectures reported as case-based, 13% (6/45) of lectures including self-assessment questions, and 11% (5/45) of lectures including links to additional resources.

Of the studies, 56% (25/45) commented on the development of online lectures in terms of process, content, or design ([Table 2](#)). The most frequently described process of lecture design included partnership with medical students (6/45, 13%), and either redesigning existing live lectures for an online platform

or uploading recordings of live lectures onto an online portal (10/45, 22%). Only 3 studies (3/45, 7%) commented on the use of multimedia design principles, such as the purposeful design of slide topography to enhance student learning [10-12]. Lecture content was typically selected based on existing curriculum objectives or according to expert recommendations from national organizations (7/45, 16%), such as the 6-step approach to curriculum development developed by Kern et al [13].

## Methods of Assessment

All studies assessed learning outcomes ([Table 3](#)), with the most common method (39/45, 87%) being self-assessment of satisfaction, knowledge acquisition, or confidence. These all represent Kirkpatrick Level 1 and involved surveys, questionnaires, or focus groups for evaluation purposes. Higher-order assessment (Kirkpatrick Level 2) included various knowledge tests such as multiple choice, true/false, matching, key feature, or free response questions (30/45, 66%). Of all studies, 18% (8/45) assessed learning through objective structured clinical examinations (OSCEs) or other practical examinations, while 24% (11/45) correlated the use of online lectures with other performance measures, such as final course grades or *United States Medical Licensing Examination* (USMLE) scores. Both practical examinations and correlation to other external measures (eg, USMLE) were typically defined as Kirkpatrick Level 3, given that knowledge from the online lectures was being applied to new contexts beyond the content directly addressed in the lecture.

**Table 1.** Summary of online lecture design components (N=45).

Design component <sup>a</sup>	n (%)
Slide deck (eg, Microsoft PowerPoint)	25 (56)
Audio or narration	23 (51)
Video (eg, procedural demonstration; does not include video recordings of slide decks)	18 (40)
Unspecified design (eg, only described as online “lecture” or “module”)	5 (11)
Animation (eg, dynamic 2D or 3D images)	4 (9)
Visible lecturer (eg, talking head)	1 (2)

<sup>a</sup>Articles often utilized more than one design component.

**Table 2.** Summary of online lecture development (N=45).

Development process <sup>a</sup>	n (%)
<b>Lecture design</b>	
No comment on development process	20 (44)
Developed from live lectures or recordings of live lectures	10 (22)
Medical student consultation	6 (13)
Consideration of multimedia design principles (eg, slide topography)	3 (7)
<b>Lecture content</b>	
Literature-driven development of content (eg, 6-step approach to curriculum development from Kern et al [13] or national specialty-specific guidelines or learning objectives)	7 (16)
Faculty or expert selection of content	6 (13)

<sup>a</sup>Articles often utilized more than one development process.

**Table 3.** Summary of assessment methods for online lectures (N=45). OSCE: objective structured clinical examination; USMLE: *United States Medical Licensing Examination*.

Assessment method <sup>a</sup>	Kirkpatrick Level	n (%)
Any method	1 to 3	45 (100)
Self-assessment of satisfaction, attitudes, knowledge, or confidence (eg, survey, questionnaire, or focus group)	1	39 (87)
Knowledge assessment (eg, multiple choice, true/false, matching, key feature, or free-response questions; content-specific knowledge test such as electrocardiogram interpretation)	2	30 (66)
Correlation to other performance measures (eg, final course grades, or USMLE)	3	11 (24)
Practical assessment (eg, OSCE, practical examination, or direct observation)	3	8 (18)
Written assignment or project	2	4 (9)

<sup>a</sup>Articles often utilized more than one assessment method.

In some cases, a practical examination was defined as Kirkpatrick Level 2, when the examination tested direct transfer of knowledge from the lecture (eg, lecture on differential diagnosis generation and an oral examination on the same topic).

Regardless of the method of assessment, almost all studies reported high satisfaction and increased knowledge following the intervention. Student self-assessment typically revealed positive attitudes toward online lectures as a teaching modality [10,11,14-31]. Moreover, students showed increased knowledge in the subject material at hand, as evaluated by pre- and postlecture knowledge assessment [14,16-18,20,22,24,25,27,28,30,32-35]. Finally, multiple studies demonstrated that knowledge was equivalent (or better) between students learning through online lectures compared to traditional learning modalities, such as live didactic lectures [11,12,15,22,25,26,28,31,36-41], with the exception of one study that found superior student knowledge acquisition from live lectures [42].

The quality and rigor of studies included in the final analysis (N=45) were evaluated based on the criteria set out by the NOS [9]. Out of 45 studies, only 21 (21/45, 47%) had clearly established “control” and “intervention” groups, whereas the remaining studies examined learning outcomes by following a specific cohort of students over time. Moreover, studies that randomized students into 2 (or more) specific groups had, on average, more participants (210 versus 168). With regards to outcomes, the majority of studies (37/45, 82%) utilized some form of blind—or at least, objective—assessment of learning, most commonly via test performance (eg, USMLE, pre- versus postintervention testing, OSCEs, etc). The remaining minority of studies (8/45, 18%) relied solely on student satisfaction ratings of the online media.

## Discussion

### Integration of Online Lectures into Medical Curricula

This review demonstrated that online lectures have been integrated into several aspects of undergraduate medical education curricula, tailored toward diverse subject matter and learners at all levels. This suggests that the flipped-classroom model—and associated online lectures—have become widely embraced by medical educators. Although preclinical students appear to prefer live lectures when given the option, online lectures are perceived to allow for increased rate and quantity

of knowledge acquisition [43]. Online lectures may also be valuable for students in clinical settings, given the time constraints on preceptors to simultaneously teach and tend to their clinical responsibilities [44].

### Online Lecture Design

Results from this review demonstrated that 10 years after the publication of *Effective Use of Educational Technology in Medical Education* [5], there has been a cultural lag in implementing multimedia design principles. As stated earlier, emerging evidence suggests that applying multimedia design to medical student lectures can improve learning outcomes [6,7]. Moreover, since the publication of the AAMC-IIME report in 2007, the importance of applying multimedia design principles in medical education has been emphasized in multiple publications [45,46]. Previously described barriers to implementing best practice in clinical medicine may explain the cultural lag in applying multimedia design principles in medical education, including time constraints (organizational context) and existing standards of practice (social context) [47]. Multiple studies included in this review implemented online lectures as part of broader educational interventions, and therefore, lack of time or resources may have reduced the attention paid to online lecture design. Moreover, clinician-teachers who participate in online lecture design may be unaware of multimedia design principles or may not have integrated these concepts into their standard practice. In line with this, findings from this review suggest an overall lack of awareness of the importance of conscientious online lecture design in the medical education community. Almost half of all included articles did not comment on the development process for online lectures, while nearly a quarter of studies simply uploaded lecture recordings online or repurposed slide decks from live lectures into online lectures.

### Assessment of Learning Outcomes

The most common method of assessment involved student self-assessment (Kirkpatrick Level 1), consistent with other reports of assessment in medical education [48]. However, several studies did examine learning outcomes in a more objective way (eg, written test or OSCE), with the general trend being one of noninferiority for students participating in an online and/or blended educational intervention. Nonetheless, it is also important to note that in some studies, online lectures represented only one aspect of a broader curricular intervention

(eg, a new program to teach bedside ultrasound). Therefore, the impact of online lectures cannot always be delineated from other aspects of an intervention, especially with respect to complex outcome measures that integrate multiple knowledge domains.

Essentially all studies reported high student satisfaction with online lectures and improved knowledge following such an intervention. However, each study assessed the use of online lectures within a particular context of students, educational topics, and assessment methods, making it difficult to directly compare relative effectiveness. Nonetheless, the broader body of literature suggested that online lectures, as a whole, were widely applicable and effective. Although positive outcomes were almost uniformly described, multimedia design principles were employed in only 3 studies, suggesting that these interventions could further optimize student learning by applying these well-established concepts [10-12].

Multiple studies reported equivalent or superior learning outcomes in medical students learning from online lectures compared to traditional didactic teaching. These findings are consistent with a large meta-analysis conducted by the United States Department of Education, which found that kindergarten to grade 12 (K-12) students in online learning conditions had better learning outcomes than those receiving in-person instruction [49]. However, the authors of this study cautioned that this does not necessarily suggest that online learning is the superior medium. Rather, it may be the conditions associated with online lectures (eg, additional learning time or access to extra resources), that lead to improved learning outcomes.

### Towards More Effective Use of Online Lectures

Online teaching modalities included didactic online lectures (the definition employed in this review), interactive online

modules, online courses, and many other interventions. However, the term “online lecture” was used to refer to a diverse range of online teaching modalities in published studies, and sometimes without an accompanying description of the lecture. Applying common terminology when describing online teaching modalities would help medical educators communicate more clearly about the nature of interventions, as well as delineate between different intervention designs to facilitate the study of their relative effectiveness.

In line with this goal, we propose standardized definitions to describe different online teaching modalities (Textbox 2). Accordingly, precise documentation of design processes for these different modalities can counter the cultural lag described and better disseminate an approach to transitioning toward “flipped classroom” undergraduate medical education curricula.

Further research would be helpful to identify the specific design features of online lectures that best facilitate medical student learning, given the widespread but variable application of this teaching modality. For example, future research could investigate which multimedia design principles correlate best with improved learning outcomes. Moreover, an understanding of the effectiveness of online lectures (didactic) compared to online modules (interactive), and the settings in which each modality is best applied, would allow for more purposeful application of online teaching interventions. Finally, to bridge the gap between effective use and common practice, findings from this review suggest that enhanced faculty development, updated guidelines incorporating the latest evidence on multimedia design, and fostering a culture of conscientious development of online lectures are all necessary for the continued expansion and application of online education.

#### Textbox 2. Proposed glossary for online teaching modalities.

- Traditional lecture
  - Description: delivered live, in-person, and with no or minimal online component; typically limited student-lecturer interaction, unless a flipped classroom format is applied
  - Design components: video, slide decks, and drawing on projector screen or blackboard
  - Interactivity: minimal (students ask questions, but do not influence lecture output or pace)
- Online lecture
  - Description: intended for students to independently watch online, at their own pace; defined by low student interaction with the teaching modality (in some ways akin to a traditional lecture except viewed online)
  - Design components: audio, slide decks, drawings on blackboard (similar to Khan Academy or other educational channels), talking head
  - Interactivity: low to minimal (students can control speed of lecture, rewind, and fast-forward)
- Online module
  - Description: intended for students to independently complete online, at their own pace; involves interactivity, in which students “click through” the module or complete “drag and drop” or other activities
  - Design components: “click-through” modules, embedded exercises (eg, matching, multiple choice questions); may also include components of online lectures
  - Interactivity: moderate to high (students actively engage with the online interface)

## Limitations

The definition of online lecture utilized in this scoping review excluded interactive teaching tools such as self-paced online modules, meaning that it did not comprehensively capture all literature involving the use of online learning modalities in medical education. This was a purposeful decision given our understanding that Richard Mayer's principles of multimedia design were initially developed through experimentation on traditional slide deck lectures. A final limitation is that although the majority of studies did not describe the use of multimedia design principles, it is possible that these concepts were employed without being explicitly mentioned.

## Conclusion

The integration of online lectures into undergraduate medical education is well-received by students and appears to improve knowledge, clinical skills, and other learning outcomes. Moreover, it appears that the use of multimedia design principles is not yet standard practice in the development of online lectures for medical students. As the adoption of flipped classroom learning and online lectures continues to expand, employing multimedia design principles could further optimize the potential for student learning. Further research on the design of online lectures and other online teaching modalities, enhanced faculty development, incorporation of best practice, and recognition of the importance of conscientious design are critical as online lectures become a mainstay of undergraduate medical education.

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## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Summary of included studies.

[[XLSX File \(Microsoft Excel File\), 27KB - mededu\\_v4i1e11\\_app1.xlsx](#)]

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## Abbreviations

**AAMC-IIME:** Association of American Medical Colleges Institute for Improving Medical Education  
**NOS:** Newcastle-Ottawa Scale  
**OSCE:** objective structured clinical examination  
**USMLE:** United States Medical Licensing Examination

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Original Paper

# An Internet-Based Radiology Course in Medical School: Comparison of Academic Performance of Students on Campus Versus Those With Absenteeism Due to Residency Interviews

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## Abstract

**Background:** Imaging and its optimal use are imperative to the practice of medicine, yet many students don't receive a formal education in radiology. Concurrently, students look for ways to take time away from medical school for residency interviewing. Web-based instruction provides an opportunity to combine these imperatives using online modalities.

**Objective:** A largely Web-based course in radiology during the 4th year of medical school was evaluated both for its acceptance to students who needed to be away from campus for interviews, and its effectiveness on a nationally administered standardized test.

**Methods:** All students were placed into a structured program utilizing online videos, online modules, online textbook assignments, and live interactive online lectures. Over half of the course could be completed away from campus. The Alliance of Medical Student Educators in Radiology test exam bank was used as a final exam to evaluate medical knowledge.

**Results:** Positive student feedback included the freedom to travel for interviews, hands-on ultrasound training, interactive teaching sessions, and quality Web-based learning modules. Negative feedback included taking quizzes in-person, a perceived outdated online textbook, and physically shadowing hospital technicians. Most students elected to take the course during the interview months of October through January. The Alliance of Medical Student Educators in Radiology final exam results (70.5%) were not significantly different than the national cohort (70%) who took the course in-person. Test scores from students taking the course during interview travel months were not significantly different from students who took the course before ( $P=.30$ ) or after ( $P=.34$ ) the interview season.

**Conclusions:** Students desire to learn radiology and often choose to do so when they need to be away from campus during the fall of their 4th year of study to accomplish their residency interviews. Web-based education in radiology allows students' interview traveling and radiology course objectives to be successfully met without adversely affecting the outcomes on a nationally normed examination in radiology. A curriculum that includes online content and live Web-based teleconference access to faculty can accomplish both imperatives.

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**KEYWORDS**

radiology clerkship; online education; imaging; radiology rotation; Web-based education



## Introduction

Imaging is an essential part of modern medicine and its proper instruction is integral to desired patient care outcomes. As important as imaging is to diagnosis, undergraduate medical education in radiology has traditionally been an elective that often occurs in a small, closed, dark room. While the images have become digital and formal interpretation of these images often occurs hundreds or thousands of miles away through the use of the internet, medical school education in radiology is generally taught in a fixed site using a single student sitting beside a single radiologist who is talking into a dictation device. These “reading sessions” slow the learning process due to the general inability to select progressive teaching cases at the level of the learner. A realistic experience in an active radiologic reading room is unfortunately limited by the random manner in which disease occurs.

Despite the necessity for radiology in most medical specialties, only 25% of medical schools require a formal education in imaging. Of the remaining schools (where radiology is not required), 63% of students express their intentions to take it as an elective [1]. Intersecting with the imperative to become fluent in modern imaging technologies, medical students frequently choose to take radiology as an elective during the months when they are away from campus interviewing for residencies [2]. Internet blogs reference “radiation vacations” as an acknowledgment that this course may offer relaxation and a chance to be away [3]. This attitude is contrary to the needs of most future physicians and further diminishes the importance of learning the use of important tools for making diagnoses.

The science of radiology is at the forefront of a digital world, but the teaching of radiology often occurs in a very “analog” manner. Since imaging technologies are now digital, they can be presented digitally to the learner. The 96.5% of graduating medical students who will not be radiologists deserve an education that emphasizes intelligent utilization of digital imaging and imaging technology [4]. These future physicians will routinely order imaging studies without consultation from radiologists. They will perform bedside ultrasound in the emergency departments and when placing central venous access catheters. Students (and their future patients) will benefit from structured medical school lessons that include appropriate didactics and clinical scenarios. Clinical judgment is enhanced by the structured review of appropriately selected experiences and supervised critical thinking. These conditions are replicated better with a structured program than with a 4-week rotation that relies heavily upon the empiric pathology of random imaging cases. The University of California, Riverside School of Medicine mandated a 4-week radiology clerkship in the 4th year of the medical school curriculum that adheres to the principles of educating new physicians in technologies of the future and that advantages the internet learning modalities of the 21st century.

## Methods

Fourth-year medical students at the University of California, Riverside enrolled in the mandatory course in radiology

consisting of 20 days of instruction over 4 weeks, and optional activities on weekends. An online standard textbook [5] was used with hyperlinks given almost daily for reading assignments. Substantially more chapters were assigned in the initial weeks of the course so that students could quickly establish a foundation of knowledge upon which they may learn more efficiently. Videos from multiple online sources and a series of online modules from the website, Aquifer [6], were assigned throughout the course, with the preponderance assigned in the first 2 weeks. A copy of the curriculum is provided in [Multimedia Appendix 1](#). Graded quizzes were given on days 1, 2, 3, 5, 8, 12, and 16 to add motivation and to assure that the Web-based didactic lessons were taken seriously. Students were introduced to bedside ultrasounds in week 2. Ultrasound teaching sessions were taught onsite at the university by non-radiology personnel who had previously passed advanced courses in Point of Care ultrasound. No online sessions with board-certified radiologists occurred until day 6, by which time the students had a basic understanding of the risks and side-effects of imaging, its indications, and the anatomy of the underlying structures. The American College of Radiology (ACR) Appropriateness Criteria for ordering imaging studies were referenced early on, and an app from the ACR was placed onto the students’ mobile (cellular) phones. Online sessions with the radiology faculty specialist were held for 2 hours on 6 different evenings. These sessions occurred over the internet using BlueJeans or Google Hangouts technology. The radiology faculty remained at a remote university and communicated with the students, both singularly, and in small groups, at sites of the students’ choice.

During the final week, each student was responsible to return to campus and present an interesting radiologic case, with digital films, to the group. On the final day, The Alliance of Medical Student Educators in Radiology (AMSER) test bank was used to administer an 80-question online final exam.

Final exam scores from the 10 different 4-week block rotations were grouped into school “trimesters.” The first 3 months (July to September), the second 4 months (October to January), and the final months (February to May) were compared. These groupings represented rational segmentation from a student’s standpoint: prior to interview season (July to September), during interview or travel season (October to January), and after interview season (February to May). A 2-tailed *t* test was used to compare the average performances of the 3 cohorts of students.

Feedback evaluation was obtained from the students at the end of each monthly rotation in radiology. Student feedback was consistently documented and tabulated from multiple students over the course of multiple months.

## Results

Students rated highly the hands-on ultrasound training and enjoyed the flexibility of being able to do their work online while away interviewing for residency positions. There was consistent praise for the quality of the Aquifer CORE series of online modules as a teaching tool. Online teaching sessions using either Google Hangouts or BlueJeans were highly rated.

The quality of digital images given to students via Universal Serial Bus (USB) flash drives and over the internet was appreciated. The almost universal complaints were the perceived poor readability of the textbook and the feeling that in-person quizzes were unnecessary. The most popular segment of the course was the online review of select imaging cases with the radiologist. The need for time away to interview for residency

positions was highly valued, and the ability to perform online readings and modules allowed the students the freedom to travel during the radiology course while staying up with the course content (Textbox 1).

Mean final exam scores from the AMSER 80-question online quiz test bank showed no significant changes based upon the trimester that the radiology course was taken (Table 1).

**Textbox 1.** Student feedback on the online modules.

Positive student feedback
<ul style="list-style-type: none"> <li>• Hands-on ultra-sound workshop was motivating</li> <li>• Flexibility for time away from school allowed low-stress interview travel</li> <li>• CORE series of modules from Aquifer were excellent for learning</li> <li>• Self-instruction independence was appreciated</li> <li>• Webinars with radiologists allowed efficient understanding of didactics</li> <li>• Final exam from The Alliance of Medical Student Educators in Radiology was fair</li> </ul>
Negative student feedback
<ul style="list-style-type: none"> <li>• Quizzes felt unnecessary and should be eliminated</li> <li>• Textbook was poor and did not align well with online didactics</li> <li>• Time with imaging techs was wasted and should be eliminated</li> <li>• The American College of Radiology app tables are tedious to review</li> <li>• Opportunities to shadow with radiologists should be available</li> </ul>

**Table 1.** Mean final exam scores (N=40).

Months	n (%)	Mean % score	P value <sup>a</sup>
July, August, and September	6 (15)	73.3	.30
October, November, December, and January (interview months)	26 (65)	69.2	N/A <sup>b</sup>
February, March, and April	8 (20)	72.6	.34
Total	40 (100)	70.5	N/A <sup>b</sup>

<sup>a</sup>P values calculated as the given period versus the October to January period.

<sup>b</sup>N/A: not applicable.

## Discussion

### Principal Findings

Traditional instruction in imaging and radiology requires 2 to 4 weeks of time, with the largest quantity of time spent shadowing a practicing radiologist in a reading room. Understated in the teaching of radiology are the huge number of normal findings that are seen and the rarity of abnormal findings. This learner shadowing technique is therefore time-intensive and utilizes “spoon-feeding” of seldom-seen pathologic findings found within normal findings and common maladies. Efficiently reading undifferentiated images amidst the time-restraints of modern medical group economics can adversely impact the time available for the faculty to teach. As faculty pay has become more heavily influenced by productivity bonuses, limitations of time can result in more spoon-feeding of students. This may, to some extent, compromise the time

required for the students to learn to think independently and critically.

Despite the drawbacks of the traditional “analog” method of shadowing radiologists, many students still enjoy this largely passive traditional adventure. The lifestyle attributes and shift work of a radiologist, the escape from the stresses of inpatient care, and the sub-optimal effort required when being “spoon-fed” take less time each day [7] than the long call schedules of internal medicine or surgery. Students have competing urgencies, so it is little wonder this important part of their education is too often referred to as a “radiation vacation.”

Student’s preference for this passive “spoon feeding” makes sense from their point of view. Today’s students interview at an average of 13.3 residency programs [2] and travel takes time and money. Students want, and perhaps need, more time off to visit the residency programs of their choice. Radiation vacations

may be the best or only travel-friendly rotation available in some educational programs, but it may not deliver the best educational experience for the 96.5% of students who will not go into radiology.

Medical student satisfaction in German medical school subinternships showed increased student satisfaction when students were given increased academic teaching, personal involvement in learning, and more practical skills [8]. In US medical schools, students enjoy hands-on Point-of-Care ultrasound training, and believe it to be educationally useful [9]. It is clear that students in the United States are strapped for time, desire freedom, and benefit from a more independent, yet hands-on learning experience in radiology.

We accept that physicians order imaging tests without communicating with a radiologist prior to entering such an order. It is of interest, then, that 77% of medical students have not heard of the ACR Appropriateness Criteria [10] nor have they used the free ACR online app. We have an educational imperative to teach ordering physicians of the future to navigate the most effective path in their pursuit of their patients' health. We present a modular, Web-based approach, with online basic sciences and radiologic anatomy lessons preceding online selected cases. This order is similar to the method used by Ertl in which imaging technology, anatomy, side effects, risks, and content precede diagnostic decision-making and imaging [11]. Indeed, imaging diagnostics do not start the training session. Traditional radiology training focused on "spoon-feeding" (shadowing experiences) where information flowed from teacher to learner [12]. Efforts to increase educational retention and student satisfaction have been successful with activities that allow independent problem-solving, investigation, and discovery. Outcomes from such online learning programs have yielded higher learner performances in practicing evidence-based-medicine and in patient management skills [13]. Self-paced themes with faculty feedback increase student confidence and knowledge in radiology [14]. Peer-to-peer learning is highly appreciated with good outcome studies noted in teaching and learning Point-of-Care ultrasound [15]. The mix of formal online didactics, required online readings, online modules, and a de-emphasis on shadowing can improve the educational outcome of the student, increase student satisfaction, and unload the burden on the workflow of the faculty radiologist [16].

Students are still 4 to 8 years away from entering practice. It follows that their education should include training for the medical practice of the foreseeable future. New technology has delivered ultrasound images to our electronic tablets and phones. The changes in practice models have placed these compact transducers and screens into our emergency rooms and community clinics. In Peru and Nepal, a 7-day course in diagnostic ultrasound taught general outpatient practitioners to diagnose pneumonia in children with improved sensitivity and specificity compared to the World Health Organization algorithm [17]. The ultrasound exam took an average of 6.4 minutes. At a non-university hospital in Norway, cardiac and abdominal Point-of-Care ultrasounds took 5.7 and 4.7 minutes, respectively [18]. The results led to major changes in the

diagnosis of 6.5% of patients, and added additional important diagnoses in 24%.

We present a novel, largely online medical school imaging curriculum with a focus on utilization of imaging services as well as diagnostics. We believe this approach would be readily accepted by a majority of medical students who need to be away from the radiology reading rooms during interview or travel months, yet also wish to learn to efficiently and safely order imaging tests, review basic digital images, and use basic ultrasound equipment. We would argue that, with over 96% of students entering fields other than radiology, this internet-based approach could be adapted to a majority of medical colleges.

The mix of modalities, including assigned online textbook chapters, online commercial modules, video training vignettes, and teleconference didactic presentations provide for engaged learning. This is in contrast to shadowing or "spoon-feeding." The use of didactic methods that optimize Web-based independent learning makes sense for the majority of students whose priorities align with the realities of increased competitiveness for residency spots. Students can be away from campus for 4th year residency interviews and watch online videos from their hotel rooms, or while on a plane. Students may unfortunately choose "easy" clerkship electives based upon the ability to travel away from the medical school site and interview. This approach embraces the "radiation vacation" and encourages its use between the months of October and January. The absence of statistical difference in AMSER testing results from students who took the course before ( $P=.30$ ) or after ( $P=.34$ ) the interview or travel season confirms that medical knowledge learning outcomes showed no differences due to taking the course during the residency interview season. Additionally, students were pleased that they were allowed to be away from the university while continuing to study via their online links, online modules, and hyperlinked online textbook assignments. Online videoconferences with the radiology faculty received universal praise for effectiveness and enjoyment. Out-of-town travel did not degrade learning outcomes.

The use of evening faculty case presentation via Bluejeans or Google Hangout software allowed back-and-forth discussion of specific cases. Cases were individualized according to the lesson and the level of learning. This is in contrast to traditional shadowing where cases include random diagnoses, are often taken in the order the staff radiologist receives them, and are dictated in a manner respectful of radiology departmental efficiency. Teaching takes time and planning. The online curriculum avoids the pitfalls of shadowing, embraces the absenteeism inherent with the interview season, and teaches to the level of the curricular outcomes.

The peer-taught, hands-on ultrasound curriculum also received universally positive feedback. Student engagement was optimized by requiring each student to lead and facilitate a problem-based-learning presentation to the group of a clinical case using digital imaging. In contrast, the experience of following imaging techs in the hospital received negative feedback due to its passive shadowing nature. This was consistent with findings by others [19], therefore it was halted.

While our learning objectives ([Multimedia Appendix 1](#)) and mission may not precisely align with those of the traditional radiology subinternship, we found that scores on the nationally administered AMSER examination (70.5%) were in line with the national AMSER 20-question results (70%).

The capacity for lifelong learning in an environment of constant change is enhanced by our use of independent Web-based learning. Cost-effectiveness, side-effects, adverse outcomes, and unnecessary interventions related to false-positives and false-negatives are presented in a progressive and integrated manner due to the ability to control the presentation of online pathology during the curriculum. Use of the mobile app from the ACR prior to ordering imaging studies is taught and reinforced throughout the course. Indeed, one of the complaints of the students related to the tedious nature of continually looking up the ACR Appropriateness Criteria. Despite the students' complaints about the repetition of referring to the ACR

Appropriateness Criteria, they were grateful that the ACR created such an app.

## Conclusion

Students of the 21st century require and demand increased time to interview for residency positions. We have co-opted the traditional "radiation vacation" with online delivery of a mixed-modality Web-centered radiology experience that can be performed with substantial absenteeism from the physical medical school environment. Despite an absence of direct onsite radiologist shadowing and mentoring, AMSER testing outcomes were comparable. The course emphasis on the importance of evidenced-based imaging utilization and teleconference reviewing of specific case films with a paucity of in-person shadowing did not alter the students' course satisfaction. An effective internet-based imaging course which acknowledges course objectives, the immediate needs of the students, and those of their future patients can be taught to 21st century medical students.

## Multimedia Appendix 1

Curriculum of Web-based radiology course.

[\[PDF File \(Adobe PDF File\), 72KB - mededu\\_v4i1e14\\_app1.pdf\]](#)

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## Abbreviations

**ACR:** American College of Radiology

**AMSER:** The Alliance of Medical Student Educators in Radiology

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Original Paper

# Mobile Technology in E-Learning for Undergraduate Medical Education on Emergent Otorhinolaryngology–Head and Neck Surgery Disorders: Pilot Randomized Controlled Trial

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## Abstract

**Background:** The use of mobile technology in e-learning (M-TEL) can add new levels of experience and significantly increase the attractiveness of e-learning in medical education. Whether an innovative interactive e-learning multimedia (IM) module or a conventional PowerPoint show (PPS) module using M-TEL to teach emergent otorhinolaryngology–head and neck surgery (ORL-HNS) disorders is feasible and efficient in undergraduate medical students is unknown.

**Objective:** The aim of this study was to compare the impact of a novel IM module with a conventional PPS module using M-TEL for emergent ORL-HNS disorders with regard to learning outcomes, satisfaction, and learning experience.

**Methods:** This pilot study was conducted at an academic teaching hospital and included 24 undergraduate medical students who were novices in ORL-HNS. The cognitive style was determined using the Group Embedded Figures Test. The participants were randomly allocated (1:1) to one of the two groups matched by age, sex, and cognitive style: the IM group and the PPS group. During the 100-min learning period, the participants were unblinded to use the IM or PPS courseware on a 7-inch tablet. Pretests and posttests using multiple-choice questions to evaluate knowledge and multimedia situational tests to evaluate competence were administered. Participants evaluated their satisfaction and learning experience by the AttrakDiff2 questionnaire, and provided feedback about the modules.

**Results:** Overall, the participants had significant gains in knowledge (median of percentage change 71, 95% CI 1-100,  $P < .001$ ) and competence (median of percentage change 25, 95% CI 0-33,  $P = .007$ ) after 100 min of learning. Although there was no significant difference in knowledge gain between the two groups (median of difference of percentage change 24, 95% CI –75 to 36;  $P = .55$ ), competence gain was significantly lower in the IM group compared with the PPS group (median of difference of

percentage change  $-41$ , 95% CI  $-67$  to  $-20$ ;  $P=.008$ ). However, the IM group had significantly higher scores of satisfaction (difference 2, 95% CI 2-4;  $P=.01$ ), pragmatic quality (difference 1.7, 95% CI 0.1-2.7;  $P=.03$ ), and hedonic stimulation (difference 1.9, 95% CI 0.3-3.1;  $P=.01$ ) compared with the PPS group. Qualitative feedback indicated that the various games in the IM module attracted the participants' attention but that the nonlinearly arranged materials affected their learning.

**Conclusions:** Using M-TEL for undergraduate medical education on emergent ORL-HNS disorders, an IM module seems to be useful for gaining knowledge, but competency may need to occur elsewhere. While the small sample size reduces the statistical power of our results, its design seems to be appropriate to determine the effects of M-TEL using a larger group.

**Trial Registration:** ClinicalTrials.gov NCT02971735; <https://clinicaltrials.gov/ct2/show/NCT02971735> (Archived by WebCite at <http://www.webcitation.org/6waoOpCEV>)

(*JMIR Med Educ* 2018;4(1):e8) doi:[10.2196/mededu.9237](https://doi.org/10.2196/mededu.9237)

## KEYWORDS

e-learning; gamification; mobile technology; randomized controlled trial; video lecture

## Introduction

Generalism is one of the most important aspects of the novel 6-year program of undergraduate medical education (UME) that was implemented in Taiwan in 2013. The goal of UME is to provide graduates with core knowledge and skills at the highest level of competency and then to become general physicians [1]. Clinical problems associated with otorhinolaryngology-head and neck surgery (ORL-HNS) comprise 20% to 50% of presenting complaints to a primary care provider. Therefore, educating medical students about ORL-HNS is an extremely important part of their UME. However, there have been longstanding concerns regarding the low priority assigned to ORL-HNS in the UME curriculum, and a substantial mismatch between this educational need and existing curricula has been reported to result in significant downstream effects on managing ORL-HNS problems in family medical practice [2].

Since increasing the number of hours dedicated to ORL-HNS in the classroom and hospital is not practical, novel UME requires enabling self-directed learning and augmenting learning outside the classroom [3]. The use of different learning strategies is one of the most important prerequisites of academic success [4]. Mobile technology represents the next natural frontier in the evolution of e-learning [5,6], and in this context, it has been termed *mobile technology in e-learning (M-TEL)*. Using M-TEL can result in greater educational opportunities for undergraduate medical students while simultaneously enhancing the effectiveness and efficiency of learning. However, the adoption of e-learning and M-TEL requires the alignment of new educational and economic tools [7]. A blended e-learning approach has been reported to provide a cost saving of 24% compared with traditional didactic methods [8], and therefore M-TEL may be able to bridge the gap between current educational needs and that currently provided for undergraduate medical students. The successful application of e-learning requires that it meets the needs of both the learners and program, and it should be aligned with the contexts in which it is used [8]. Furthermore, individual differences may also play an important role in the effectiveness of M-TEL. For example, learners with a field-independent (FI) cognitive style have been reported to prefer e-learning technologies and to have a better

performance with hypermedia systems than field-dependent (FD) learners, because they use active approaches and make better transfer of concepts in new situations [9].

In this study, we have reported the results of a pilot study of the feasibility and qualitative evaluation of a novel interactive multimedia (IM) module versus a conventional PowerPoint show (PPS) module of e-learning using the same mobile device to teach emergent ORL-HNS disorders.

## Methods

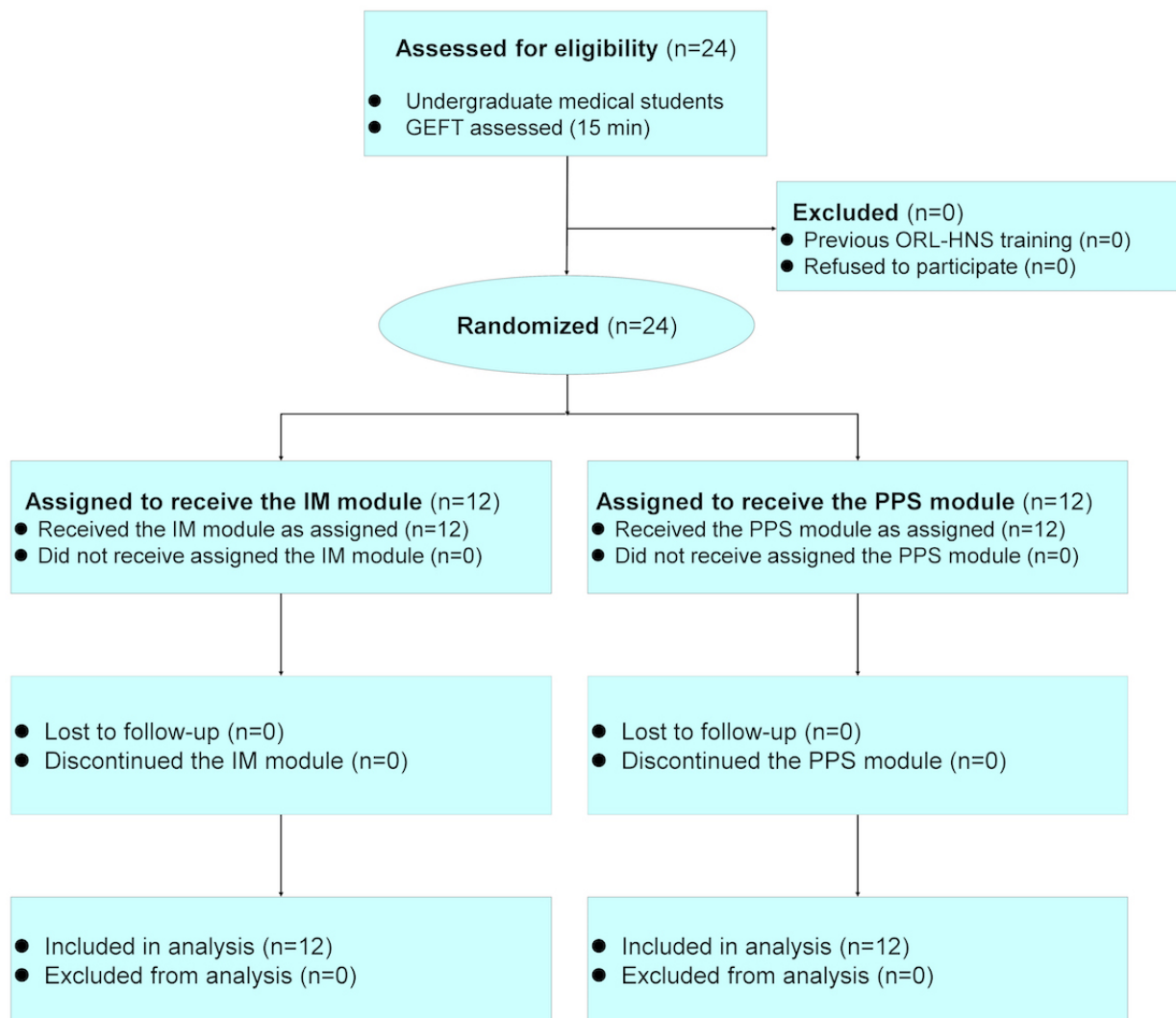
### Study Design and Setting

A convenience sample of 24 consecutive student volunteers were prospectively recruited according to accessibility and individuals willing to participate in the pilot study at an academic teaching hospital (Department of ORL-HNS, Linkou Chang Gung Memorial Hospital, Taoyuan, Taiwan) from November 23, 2016 to January 14, 2017. All of them had at least a basic level of computer literacy, and they were also introduced to the practical aspects of using tablets and applications. Blinding to the purpose of the prestudy during recruitment was maintained to minimize preparation bias. This study was approved by the institutional review board of Chang Gung Medical Foundation (No.: 105-5290C). Written informed consent was obtained from all participants. The study proposal was registered at ClinicalTrials.gov (Identifier: NCT02971735). The study flowchart following the Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines (Multimedia Appendix 1) [10] is shown in Figure 1.

### Establishing the M-TEL System for Emergent ORL-HNS Disorders

Emergent ORL-HNS disorders are sensitive and acute and require many consultations for the patients to receive appropriate point-of-care service and follow-up [11]. We selected the 10 most common emergent ORL-HNS disorders, including foreign body, epistaxis, ear trauma, acute otitis externa, deep neck infection, head and neck cancer and associated complications, acute otitis media, nasal trauma, acute pharyngotonsillitis, and sudden deafness (in descending order based on consultation frequency) among 300 consecutive patients who visited an otolaryngologist in 2004 at our Department of Emergency.

**Figure 1.** The Consolidated Standards of Reporting Trials flow diagram of this pilot study. GEFT: Group Embedded Figures Test; IM: interactive multimedia; ORL-HNS: otorhinolaryngology–head and neck surgery; PPS: PowerPoint show.



To design effective instructional material, we analyzed our tasks and topics and needs of 10 undergraduate students after traditional ORL-HNS lectures [12]. We then developed the instructional content using a two-round modified Delphi method. The first round included 10 academic physicians including 2 emergency physicians and 2 ORL-HNS department chiefs who designed the learning objectives and developed the instructional content according to the needs assessment. In the second round, 10 junior residents rated the relative importance of each item. We then developed a storyboard and courseware using an instructional system design model including five phases (analysis, design, development, implementation, and evaluation) [13].

Subsequently, the content was translated into an e-learning app including a novel gamified IM module and a conventional visual-auditory text-image PPS module. We created an 80-min storyboard for each module, and both modules had the same design of user interface (Figure 2). We also created a learning map to allow the learners to assess their progress in each session or their overall progress. Moreover, both modules contained

simple slides for review purposes after completing the brief sessions (Figure 3).

#### The PowerPoint Show (PPS) Module

In the PPS module, we used video lectures to present the visual-auditory text-image context (multimedia learning) that was intended to reduce the cognitive load [14]. We recorded the PPS presentations with audio narrations and ink gestures using Camtasia Studio software version 8 (TechSmith, Okemos, MI, USA). Each mini video (6-8 min) contained seven voice and text-image slides for each disorder. We created a playback application to allow the learners to seek the videos (Figure 4).

#### The Interactive Multimedia (IM) Module

The content for the novel IM module was derived from and corresponded to the textbook-based learning material of the conventional PPS module. In the IM module, we used a game-based learning method to implement the instruction, in which the learners operated a character to run, jump, and interact with other characters (in a parkour style) to obtain learning materials (7 text-image slides per disorder) in the four domains of the 10 disorders (Figure 5). The instructional materials were



briefly explained using scrolling text. After they had read the material for 2 disorders or completed 10 disorders, they had to complete small game-based quizzes that were designed to emphasize the key points and enhance their working memory [15]. Notably, contexts of the game-based quizzes were different from those of the multiple-choice questionnaires (MCQs) and multimedia situational tests (MSTs).

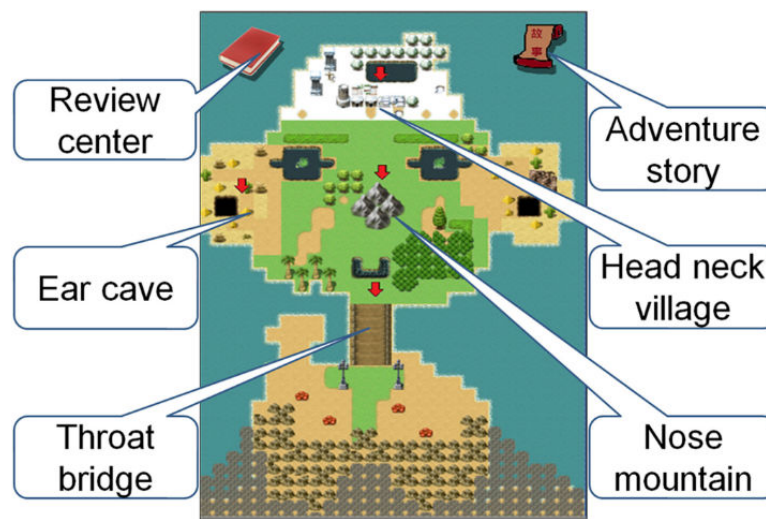
Two investigators from the study team reviewed the instructional content of each module using the Software Evaluation Checklist [16]. This checklist includes 7 items (curriculum connections, age/grade appropriates, investment justification, layout, support

materials, instructional content, graphics/multimedia) with two (yes, no) scales (a total of 28 questions). The overall items were confirmed to be significantly correlated after computing the correlation between the 2 investigators' reviews (Spearman correlation test,  $r=.91$ ,  $P<.001$ ). Major bug fixes were performed before the pilot study.

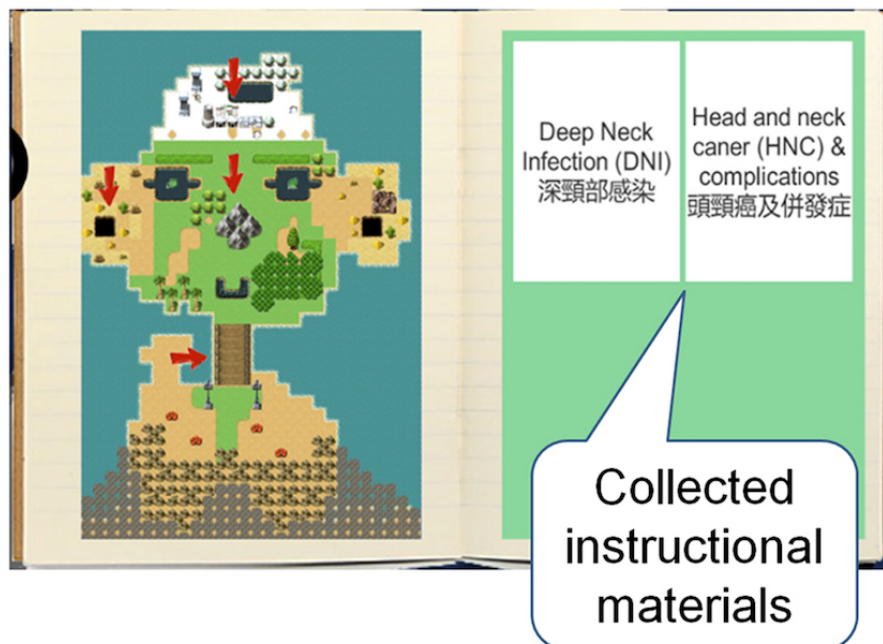
### Selection of Participants

The inclusion criteria were as follows: (1) age >20 years and (2) undergraduate medical students (defined as 3 or 4 years of medical school training [clerkship]). The exclusion criteria were (1) previous ORL-HNS training and (2) declining to participate.

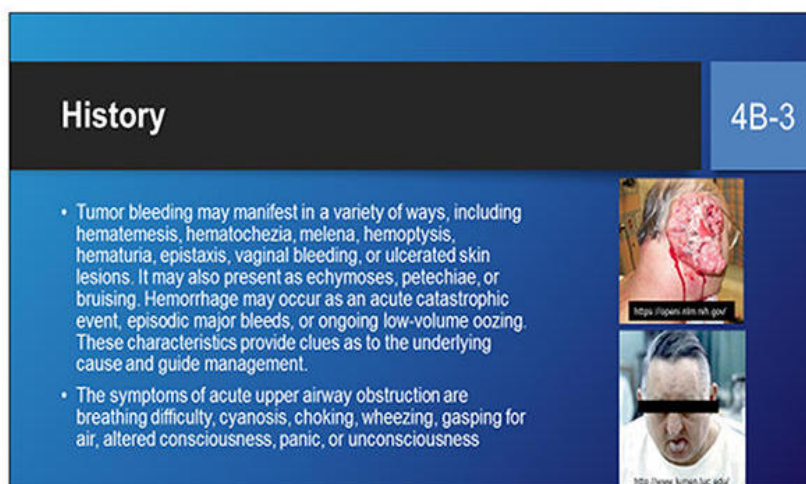
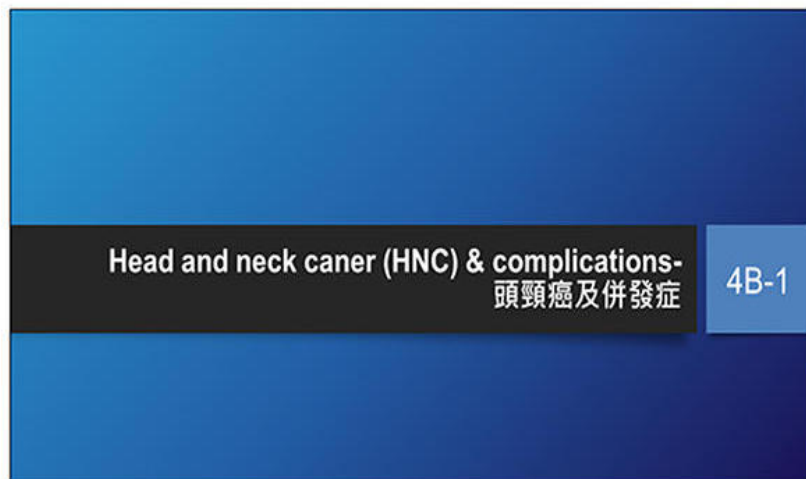
**Figure 2.** User interface of the start screen contained four instructional domains, an adventure story and a review center.



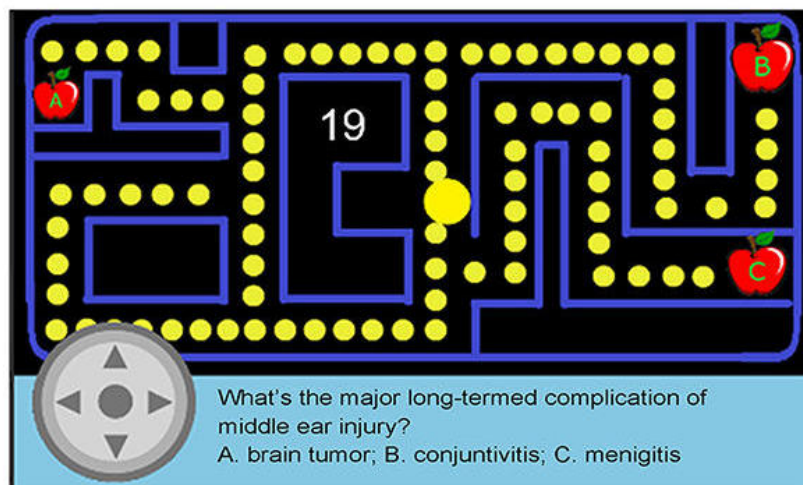
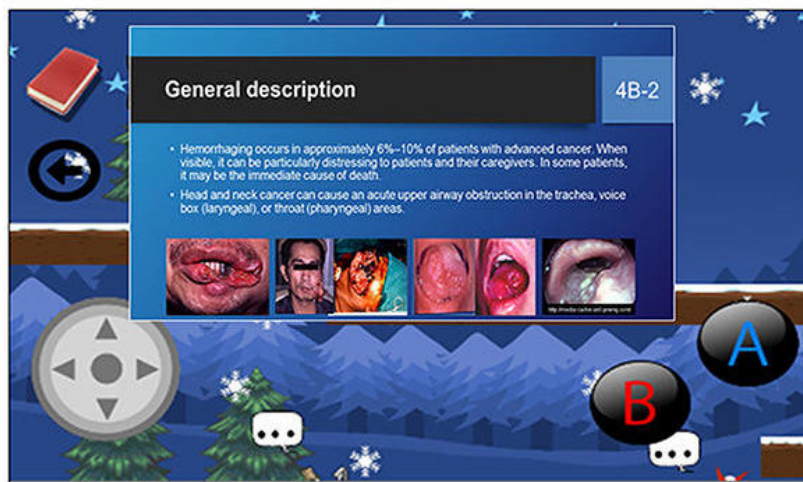
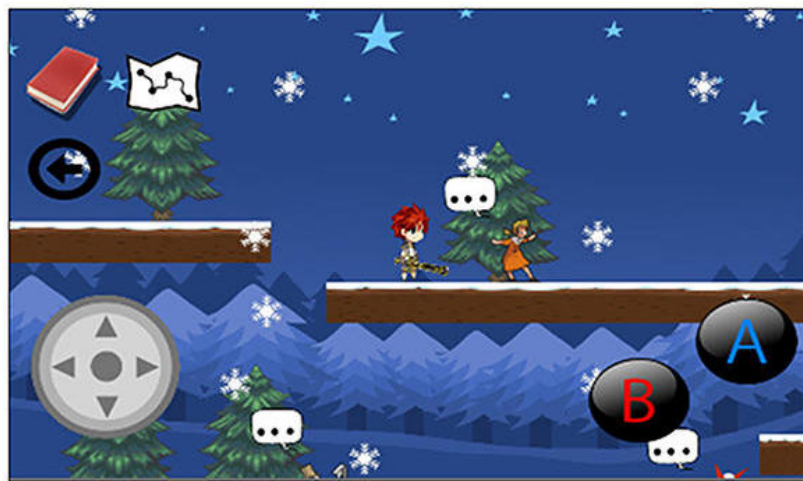
**Figure 3.** A screenshot of the review center allowing the learners to review the acquired instruction materials anytime.



**Figure 4.** Screenshots of the PowerPoint Show module. Learners in this group needed to watch visual-auditory text-image videos including linearly arranged instructional slides (top, middle, bottom).



**Figure 5.** Screenshots of the interactive multimedia module. Learners in this group operated a character to run, jump, and interact with other characters (top) to obtain instructional materials (middle) and complete small game-based quizzes (bottom).



**Table 1.** A general design of the multimedia situational tests.

Scenarios	Questions	Specifications of assessment
S1: Elicit history of acute otorhinolaryngology–head and neck surgery illness with an example picture.	Q1: Which is the most impossible diagnosis from four disorders?	Ability of remembering
S2: Additional symptoms and signs.	Q2: Which the less likely diagnosis from three disorders?	Ability of applying
S3: Seek critical physical findings.	Q3: Which is the most preferable diagnostic tool for further physical examination?	Ability of analyzing
S4: Interpret key physical findings of a video.	Q4: Which is the more possible diagnosis from two disorders?	Ability of analyzing
S5: Prescribe treatments according to the key features.	Q5: Which is the most effective solution?	Ability of evaluating

## Methods of Measurement

There were six different face-to-face assessments in this study.

### Group Embedded Figures Test

The 25-item Group Embedded Figures Test (GEFT) was given to the students after enrollment to assess their cognitive style [17]. The reliability of GEFT has been confirmed (Spearman-Brown reliability coefficient, .82) [18]. The cognitive style of the learners could be determined according to the number of correct answers given by the participants. We defined a GEFT score  $\leq 12$  as *FD* and  $> 12$  as *FI* in this study.

### Multiple-Choice Questionnaires (MCQ)

In this study, the participants were required to complete the same MCQ pretest and another different posttest immediately after the M-TEL. A 15-min 10-question standard MCQs were used to evaluate the students' knowledge (range, 0-100) with regard to *emergent ORL-HNS disorders*. Each textbook-based MCQ was designed to be answered within 90 seconds. We established a pool of 100 MCQs and performed empirical analysis according to previous test results to determine the test difficulty and item discrimination. Before this study, the instructional content was reviewed by 2 members of staff to determine whether it was sufficient to answer all of the questions. They also used a table of specifications to ensure that there was a match between teaching and testing. Moreover, they performed judgmental analysis of the items and subsequently revised the poorly constructed items or removed the questions with an inappropriate (too easy or extremely difficult) level of difficulty. Accordingly, we constructed two different 10-question MCQ tests with the same levels of difficulty (moderate difficulty) and discrimination (good discrimination).

### Multimedia Situational Test (MST)

The participants were required to complete the same MST pretest and another different posttest immediately after the M-TEL. The MST was a variation of the key feature test for assessments of clinical reasoning ability involving knowledge and intellectual skills (range, 0-100) [19]. A key feature was defined as a significant step in the resolution of a problem. Key feature tests were different from knowledge-based tests and can successfully predict future physician performance [20]. In this study, the MST included a set of five scenarios (a written description of a scenario with or without an image/video) for one emergent ORL-HNS disorder and five corresponding MCQs (Table 1). The MST was designed to be completed in 15 min.

The two MSTs were approved by a senior member of staff to ensure the validity of the content. Evaluation of the MSTs by other students showed that internal consistency reliability was acceptable (Cronbach alpha=.76). Two members of staff confirmed that these questions could be sufficiently answered after reviewing the instructional content of the M-TEL.

### Global Satisfaction Score

We used the global satisfaction score (GSS; range, 0-100) to measure *learner satisfaction* after the M-TEL. GSS was measured using a visual analogue scale from 0 (very dissatisfied) to 10 (very satisfied).

### AttrakDiff2 Questionnaire

We used the AttrakDiff2 questionnaire to compare *user learning experience*. The AttrakDiff2 questionnaire was developed to evaluate the acceptance of technical innovations focusing on *user experience* [21]. The central idea behind the AttrakDiff2 is that interactive products fulfill both the pragmatic and hedonic needs of their users. It uses four qualities (attractive, identifiable, stimulating, pragmatic) with seven anchor scales (semantic differential design with a 7-point Likert-like scale) for a total of 28 questions. The mean value of an item group creates a scale value for pragmatic quality (PQ), hedonic stimulation (HQ-S), hedonic identification (HQ-I), and attractiveness (ATT). This questionnaire has been optimized to differentiate these subqualities.

### Anonymous Feedback

We used anonymous feedback to assess *quality of learning*. Each participant in this pilot study also provided anonymous feedback about the quality of the module used after the M-TEL.

### Randomization

Figure 1 demonstrates the study flowchart. A balanced design with regard to age, sex, and cognitive style was assured by the randomization procedure. Using the Random Number Generator in IBM SPSS software (version 23; IBM, Armonk, NY, USA), computer-generated lists of random numbers were created for the allocation of the students, who were stratified by center with a 1:1 allocation using a fixed block size of 6 in both parallel subgroups. We concealed the allocation sequence from those assigning participants to intervention groups until the moment of assignment and adhered to our computer-generated randomization protocol.

## Intervention

The students were unblinded after randomization. The students in the PPS group used an app on a 7-inch tablet to watch video lectures in 10 linear-designed sessions and review the instructional materials in an ordinary office environment for 100 min. Meanwhile, the IM group played a parkour-like game to find and read the instructional materials, completed small game-based quizzes, and reviewed the instructional materials.

## Outcome Measures

The percentage change in MCQ score (ie, “knowledge gain”) after the M-TEL was the primary outcome measure. The percentage changes in MST (ie, “competence gain”), GSS, and AttrakDiff2 questionnaire scores were the secondary outcomes.

## Sample Size

There were 6 students who helped to establish and evaluate the M-TEL system for emergent ORL-HNS disorders (percentage change in MCQ: mean=31, standard deviation [SD]=16, effect size=1.94; percentage change in MST: mean=45, SD=52, effect size=0.87). In this pilot feasibility study, we needed to confirm that the students could gain knowledge and competence significantly. We estimated the sample sizes by a priori calculation (one-sample Wilcoxon signed-rank test, two-tailed, normal parent distribution, alpha=.05, power=0.95) and found that we needed at least 7 subjects for knowledge gain and at least 21 subjects for competence gain. Due to a fixed block size of 6, we determined that the sample size of the pilot study was 24.

## Statistical Analysis

Due to the relatively small sample size in the pilot study, we analyzed all variables using a nonparametric approach. Descriptive statistics were expressed as median and 95% CI. Percentage (%) changes ([after value-before value]/[before value] × 100) in the MCQ and MST were calculated. Differences between groups were analyzed using the Wilcoxon signed-rank test or the Mann-Whitney *U* test as appropriate. Categorical variables were analyzed using Fisher exact test. Effect size and 95% CI were estimated using the Hodges-Lehmann method for Mann-Whitney *U* test and Wilcoxon signed rank test and odds ratio calculation Fisher exact test to improve the quality of the reporting of our results. Statistical analyses were performed using G\*Power 3.1.9.2 software (Heinrich-Heine University, Dusseldorf, Germany), Graph Pad Prism 7.00 for Windows (Graph Pad Software Inc., San Diego, CA, USA), and IBM SPSS Statistics 23.0 (IBM Corporation, Armonk, NY, USA).

## Results

### Study Participants

Twenty-four volunteers (15 males, 63%, and 9 females, 37%; median age 23 years, range 22-25 years; 21 FI, 87% and 3 FD, 13%) were recruited in the pilot study. Table 2 summarizes the variables of interest for the overall study cohort. There were no significant differences in age, sex, cognitive style, MCQ score, or MST score between the IM and PPS groups at baseline. After

randomization, all participants (100%) received the intended intervention. There was no protocol deviation in the prestudy.

### Primary and Secondary Outcomes

Overall, all participants showed a significant improvement in MCQ score (ie, “knowledge gain”; median of percentage change 71, 95% CI 14-100;  $P<.001$ ; compared with the neutral value of 0) and a significant improvement in MST score (ie, “competence gain”; median of percentage change 25, 95% CI 0-33;  $P=.007$ ; compared with the neutral value of 0) after 100 min of learning.

The M-TEL positively impacted the GSS (median of difference 2.5, 95% CI 1.0-4.0;  $P=.002$ ; compared with the neutral value of 5), PQ (median of difference 1.7, 95% CI 0-2.0;  $P=.003$ ; compared with the neutral value of 0), HQ-S (median of difference 1.1; 95% CI 0.3-1.9;  $P=.04$ ; compared with the neutral value of 0), HQ-I (median of difference 1.7, 95% CI 1.1-2.0;  $P<.001$ ; compared with the neutral value of 0), and ATT (median of difference 1.4, 95% CI 0.9-2.1;  $P<.001$ ; compared with the neutral value of 0).

### Differences in Outcomes Between the Interactive Multimedia (IM) and PowerPoint Show (PPS) Modules

Figure 6 illustrates comparisons of the IM and PPS modules with regard to knowledge and competence gains. The PPS group had significant improvements in knowledge (median of difference of percentage change 25, 95% CI 0-40;  $P=.007$ ) and competence (median of difference of percentage change 20, 95% CI 20-40;  $P=.005$ ), whereas the IM group had a significant improvement in knowledge (median of difference of percentage change 25, 95% CI 0-40;  $P=.01$ ) but not competence (median of difference of percentage change 0, 95% CI -20 to 20;  $P=.78$ ).

Although the percentage change in MCQ was not significantly different between the two groups (median of difference -24, 95% CI -75 to 36;  $P=.55$ ), the percentage change in MST in the IM group was significantly lower than that in the PSS group (median of difference -41, 95% CI -67 to -20;  $P=.008$ ). Figure 7 illustrates comparisons of the IM and PPS modules with regard to satisfaction and learning experience. However, the IM group had significantly higher GSS (median of difference 2, 95% CI 0-4;  $P=.01$ ), PQ (median of difference 1.7, 95% CI 0.1-2.7;  $P=.03$ ), and HQ-S scores (median of difference 1.9, 95% CI 0.3-3.1;  $P=.01$ ) compared with the PPS group.

### Qualitative Feedback

The qualitative feedback from the PPS group emphasized that they found the PPS module “easy to use and follow,” “clear layout,” “enhanced knowledge,” “suitable small sessions,” and “simulated lectures.” However, they also reported that the module was “tedious,” “hypnogenetic,” and “difficult to play back.” The IM group reported that the IM module was “fun learning (attractive),” contained “enjoyable small game-based quizzes,” and was an “amazing learning experience.” However, they also considered it “difficult to use and follow,” that it contained “nonlinear instructional materials” and “some tough games.”

**Table 2.** Demographic data, cognitive style, learning outcomes, and satisfaction.

Variables	Overall, N=24	Interactive multi-media group, N=12	PowerPoint show group, N=12	Effect size, median of difference (95% CI) or odds ratio (95% CI) <sup>a</sup>	<i>P</i> value <sup>b</sup>
<b>Demographics</b>					
Age in years, median (95% CI)	23 (22-23)	23 (22-23)	23 (22-24)	0 (-1 to 0)	.32
Male sex, n (%)	15 (63)	7 (58)	8 (67)	-0.09 (-0.49 to 0.32)	>.99
<b>Cognitive style</b>					
Group Embedded Figures Test score, median (95% CI)	18 (17-18)	18 (15-18)	17 (17-18)	0 (-1 to 1)	.80
Field-dependence, n (%)	3 (13)	2 (17)	1 (8)	-0.13 (-0.54 to 10.28)	>.99
<b>Learning outcomes</b>					
Multiple-choice question_before, median (95% CI)	40 (40-50) <sup>c</sup>	40 (40-50) <sup>c</sup>	40 (30-60) <sup>c</sup>	5 (-10 to 10)	.52
Multiple-choice question_after, median (95% CI)	70 (60-80) <sup>c</sup>	70 (50-80) <sup>c</sup>	70 (60-80) <sup>c</sup>	0 (-10 to 10)	.71
Percentage change in multiple-choice question, median (95% CI)	71 (14-100) <sup>d</sup>	63 (0-100)	84 (0-125)	-24 (-75 to 36)	.55
Multimedia situational test_before, median (95% CI)	80 (60-80) <sup>c</sup>	80 (60-100)	70 (40-80) <sup>c</sup>	20 (0-20)	.13
Multimedia situational test_after, median (95% CI)	80 (80-100) <sup>c</sup>	80 (60-80)	90 (80-100) <sup>c</sup>	-20 (-20 to 0)	.02
Percentage change in multimedia situational test, median (95% CI)	25 (0-33) <sup>d</sup>	0 (-20 to 33)	29 (25-75)	-41 (-67 to -20)	.008
<b>Learning satisfaction</b>					
Global satisfaction score, median (95% CI)	8 (6-9) <sup>d</sup>	8 (7-9) <sup>d</sup>	6 (3-8)	2 (0-4)	.01
<b>Learning experience (AttrakDiff2 questionnaire)</b>					
Pragmatic quality, median (95% CI)	1.7 (0-2.0) <sup>d</sup>	1.8 (1.4-2.4) <sup>d</sup>	0 (-1.0 to 2.0)	1.7 (0.1-2.7)	.03
Hedonic stimulation, median (95% CI)	1.1 (0.3-1.9) <sup>d</sup>	1.7 (0.9-2.3) <sup>d</sup>	-0.2 (-1.7 to 1.6)	1.9 (0.3-3.1)	.01
Hedonic identification, median (95% CI)	1.7 (1.1-2.0) <sup>d</sup>	2.0 (1.4-2.0) <sup>d</sup>	1.1 (-0.6 to 2.3)	0.8 (-0.3 to 2.3)	.18
Attractiveness, median (95% CI)	1.4 (0.9-2.1) <sup>d</sup>	1.7 (0.9-2.1) <sup>d</sup>	1.2 (0.4-2.1) <sup>d</sup>	0.2 (-0.5 to 1.0)	.59

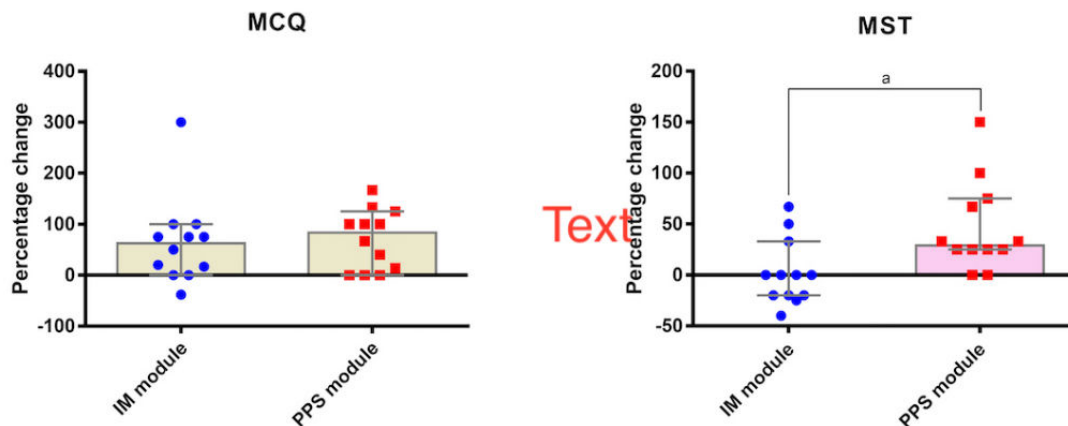
<sup>a</sup>Effect sizes were calculated with the use of Hodges-Lehmann method for Mann-Whiney *U* test and Wilcoxon signed-rank test, or odds ratio calculation for Fisher exact test.

<sup>b</sup>Mann-Whiney *U* test (continuous variables) or Fisher exact test (categorical variables).

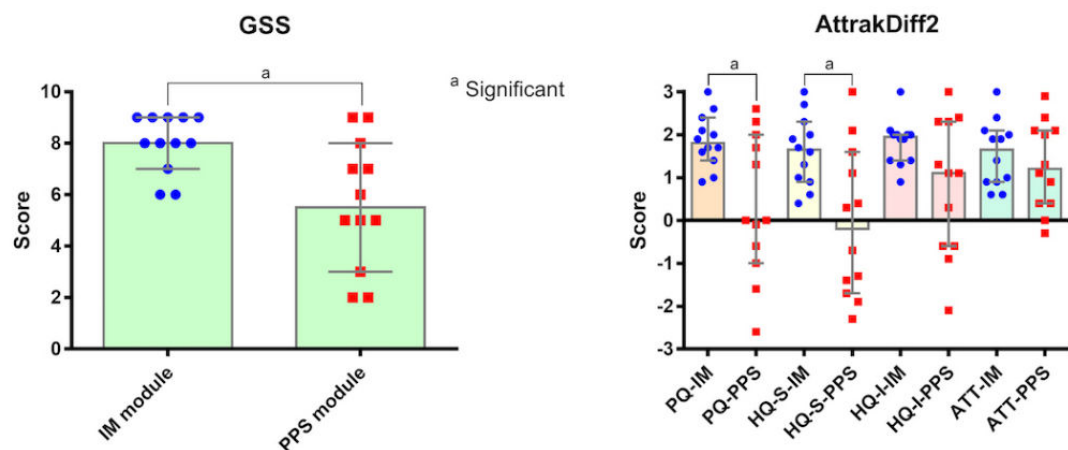
<sup>c</sup>*P*<.05, before versus after, Wilcoxon signed-rank test (two-tailed).

<sup>d</sup>*P*<.05, compared with a neutral value ("0" for multiple-choice question and multimedia situational test, or "5" for "global satisfaction score" or "0" for "ArakDiff2"), Wilcoxon signed-rank test (two-tailed).

**Figure 6.** Gains of knowledge and competence. There was no significant difference in multiple choice (MCQ) test scores between the interactive multimedia (IM) and PowerPoint show (PPS) groups (left). The multimedia situational test (MST) score of the IM group was significantly lower than that of the PPS group (right). Data are expressed as median (95% CI). "a" indicates significance.



**Figure 7.** Satisfaction and learning experience. Global satisfaction score (GSS) of the IM group was significantly higher than that of the PowerPoint show (PPS) group (left). Using the AttrakDiff2 questionnaire, pragmatic quality (PQ) and hedonic stimulation (HQ-S) in the IM group were significantly higher than those of the PPS group. There were no significant differences in hedonic identification (HQ-I) and attractiveness (ATT) between the two groups (right). Data are expressed as median (95% CI). "a" indicates significance.



## Discussion

### Principal Findings

To the best of our knowledge, this is the first study to investigate the benefits of M-TEL to improve knowledge and competence of emergent ORL-HNS disorders. Our findings indicate that using well-designed M-TEL instructional materials can help undergraduate medical students to reinforce their existing knowledge (intermediate effect) and competence (small effect) of such a sensitive and important subject and provide an enjoyable learning experience (small-to-intermediate effect). In addition, our findings suggest that an IM module has the potential to provide an instructional approach to enhance knowledge as effectively as a PPS module. Although the PPS module was superior to the IM module with regard to competence gained (small effect), the students preferred the IM module to the PPS module because of it being more efficient and enjoyable to use (small-to-intermediate effect). However, qualitative feedback recommended that both modules needed to have better quality of design and function. Since the

development of the IM module was more time-consuming (3 months vs 1 months) and more expensive (US \$12,500 vs US \$2500) than that of the PPS module, the IM module needs to be further improved with regard to competence gain in the future. For example, we can modify the IM model according to the teaching strategies and principles of instructional design and pedagogy used in virtual patient cases to support the development of clinical reasoning skills [22].

### Limitations

Some caveats of our study merit comment. First, we included a convenience sample which may have led to exclusion bias. A more even distribution of the cognitive styles will provide more accurate data. However, FD volunteers are not frequently encountered in our undergraduate medical students (less than 10%). Moreover, it is very difficult to perform probability sampling at a regular medical school. Second, we did not investigate social interaction, self-motivation, and self-regulation (important elements of e-learning) in detail [23-25]. The effects of M-TEL on these factors during the learning process will be

closely monitored when the M-TEL app is made available to the students.

### Comparison With Prior Work

The role of M-TEL, especially as it pertains to the undergraduate medical student, is evolving. It is superior to classical learning in that it provides opportunities to learn outside of the classroom via the Internet and computer software [26]. A systematic review of the impact of e-learning for undergraduate medical students suggested that e-learning is equivalent and possibly superior to traditional learning regarding knowledge, skills, attitude, and satisfaction [27,28]. Our preliminary results are similar to previous studies, in that the interactive elements of M-TEL for medical education could facilitate learning complex topics with promising results in terms of knowledge gain and attitude [29-33]. However, M-TEL may not be an approach that is suitable for all [34].

Most previous studies have compared interactive e-learning with text-based learning or classroom lectures. Fundamental differences among these learning methods such as a learner-focused design [35] and unlimited learning place/time [36] may be confounding factors. The focus of an M-TEL course is the learner, since there is no instructor. Therefore, the developers need to understand the knowledge base (needs assessment) and learning preference of the learners when establishing the module [4,35]. Learning preferences are conscious and intentional strategies to achieve well-defined ends and include three layers: core (cognitive style), intermediate (information processing), and external (instructional preference) [37]. Since learning preferences are often observed to favor rewarded responses to high frequency or high likelihood questions [38], an M-TEL course needs to clearly explain the required information to the learner. E-learning has moved into a more student-centered model in a systematic review [9]. Therefore, it is better to take the learner's individual cognitive style and instructional preference into consideration in the development of the M-TEL. Moreover, significant differences in perceived ease of use, external control, behavioral intention, and use of e-learning between males and females have been reported when adopting an e-learning platform [39]. Although not statistically significantly different in this pilot study,

cognitive style and gender of the participants should be controlled in randomized controlled trials.

Unlike traditional classroom lectures, learners can start and stop M-TEL (or text-based learning) at any time or place of their choosing [36]. When M-TEL learners want to review instructional content, they can immediately do so and reduce the errors involved in teaching and learning. Of note, this may be unfair to students only receiving classroom instruction, because M-TEL learners can study when they are most receptive and spend more time to comprehend the learning materials. In this study, the PPS module was similar to the online learning and flipped classroom, and the learners could choose and review the content by themselves. Despite the relatively low reported level of satisfaction, the PPS module was more familiar to our students with a lower cognitive load, and this allowed a deeper understanding to facilitate superior competence gain compared with the IM module. Since the majority of our subjects had FI cognitive style, it could have an impact on the outcome of competence gain. In the past, Bertini et al [40] found that FI learners are more likely to be worse at "tests requiring learners to recall information in the form or structure that it was presented" than FD learners. In the study, MSTs have been designed for evaluating competence with regard to the clinical reasoning process. The nonlinear structure of presentation of the IM module might limit FI learners to recall information to answer a 5-question MST. However, interactive game-based learning seems to be a promising didactic tool to achieve higher long-term knowledge retention [41].

### Conclusions

The use of different learning strategies is one of the most important prerequisites of academic success among undergraduate medical students and can lead to a positive attitude toward learning [4]. M-TEL using an IM module seems to be an effective, enjoyable, and pragmatic way to instruct emergent ORL-HNS disorders in undergraduate medical students. However, results from this pilot study suggest that instructors may need to provide other learning methods to reinforce students' competency. While the small sample size reduces the statistical power of our results, especially with regard to cognitive style, its design seems to be appropriate to determine the effects of M-TEL using a larger group.

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### Authors' Contributions

LAL, SLW, YPC, HYL, and CKC participated in the conception and design of this work. LAL, YPC, MST, LJH, CJK, CHF, WCC, and HYL collected data. LAL, SLW, YPC, MST, HYL, and CKC analyzed and interpreted data. LAL, SLW, YPC, LJH, CJK, CHF, WCC, and HYL carried out the development of the project software. All authors participated in the writing of the manuscript and take public responsibility for it. LAL, SLW, YPC, CGH, HYL, and CKC revised it critically for important



intellectual content. All authors reviewed the final version of the manuscript and approve it for publication. All authors attested to the validity and legitimacy of the data in the manuscript and agree to be named as author of the manuscript.

### Conflicts of Interest

None declared.

### Multimedia Appendix 1

CONSORT-EHEALTH checklist (V 1.6.1).

[[PDF File \(Adobe PDF File\), 927KB - mededu\\_v4i1e8\\_app1.pdf](#)]

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## Abbreviations

**ATT:** attractiveness  
**CONSORT:** Consolidated Standards of Reporting Trials  
**FD:** field-dependent  
**FI:** field-independent  
**GEFT:** Group Embedded Figure Test  
**GSS:** global satisfaction score  
**HQ-I:** hedonic identification  
**HQ-S:** hedonic stimulation  
**IM:** interactive multimedia  
**MCQ:** multiple-choice questionnaire  
**MST:** multimedia situational test  
**M-TEL:** mobile technology in e-learning  
**ORL-HNS:** otorhinolaryngology–head and neck surgery  
**PPS:** PowerPoint show  
**PQ:** pragmatic quality  
**UME:** undergraduate medical education

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Original Paper

# Improving Internal Medicine Residents' Colorectal Cancer Screening Knowledge Using a Smartphone App: Pilot Study

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## Abstract

**Background:** Colorectal cancer (CRC) is the third most common type of cancer and the second leading cause of cancer death in the United States. About one in three adults in the United States is not getting the CRC screening as recommended. Internal medicine residents are deficient in CRC screening knowledge.

**Objective:** The objective of our study was to assess the improvement in internal medicine residents' CRC screening knowledge via a pilot approach using a smartphone app.

**Methods:** We designed a questionnaire based on the CRC screening guidelines of the American Cancer Society, American College of Gastroenterology, and US Preventive Services Task Force. We emailed the questionnaire via a SurveyMonkey link to all the residents of an internal medicine department to assess their knowledge of CRC screening guidelines. Then we designed an educational intervention in the form of a smartphone app containing all the knowledge about the CRC screening guidelines. The residents were introduced to the app and asked to download it onto their smartphones. We repeated the survey to test for changes in the residents' knowledge after publication of the smartphone app and compared the responses with the previous survey. We applied the Pearson chi-square test and the Fisher exact test to look for statistical significance.

**Results:** A total of 50 residents completed the first survey and 41 completed the second survey after publication of the app. Areas of CRC screening that showed statistically significant improvement ( $P < .05$ ) were age at which CRC screening was started in African Americans, preventive tests being ordered first, identification of CRC screening tests, identification of preventive and detection methods, following up positive tests with colonoscopy, follow-up after colonoscopy findings, and CRC surveillance in diseases.

**Conclusions:** In this modern era of smartphones and gadgets, developing a smartphone-based app or educational tool is a novel idea and can help improve residents' knowledge about CRC screening.

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**KEYWORDS**

colorectal cancer; cancer screening; early detection of cancer; residents' education; smartphone; mobile apps

## Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed cancer among both men and women in the United States. It is the second leading cause of cancer-related death overall. Incidence and mortality rates have been declining because of increased awareness of risk factors such as smoking and red meat consumption, and improvement in screening rates and treatment modalities [1-3]. According to the American Cancer Society (ACS), 135,430 new cases and 50,260 deaths from CRC were expected to occur in 2017, and the lifetime risk of developing CRC is about 1 in 21 (4.7%) for men and 1 in 23 (4.4%) for women [4]. The management of CRC is associated with substantial health care costs, with national expenditures exceeding US \$14 billion annually [5,6]. There are striking disparities by age, race, and tumor subsite despite a reduction in CRC incidence and mortality overall. The goal of further reducing CRC incidence and mortality can be achieved by ensuring access to high-quality health care, incentivizing healthy lifestyles, and increasing CRC screening. Meester and colleagues and others estimated that achieving the US National Colorectal Cancer Roundtable's goal of increasing screening prevalence to 80% by 2018 would prevent 277,000 CRC cases and 203,000 deaths by 2030 [7-10]. About one in three adults in the United States is not getting CRC screening as recommended. According to the US National Health Interview Survey, CRC screening in accordance with the guidelines among adults 50 years of age and older increased from 34% in 2000 to 63% in 2015 [11].

Generally, it is expected that as resident physicians advance in their training, CRC screening rates should improve with the expected improvement in knowledge of CRC screening. Wong measured performance outcomes in multiple screening categories over 3 years of training and found that actual patient screening rates were similar across all years [12]. One of the reasons for this lack of improvement in CRC screening could be residents' deficient knowledge about CRC screening, even though guidelines from the American College of Gastroenterology (ACG), ACS, and US Preventive Services Task Force (USPSTF) are mostly in agreement about screening modalities and age [13-15]. Akerman et al [16] assessed residents' CRC screening knowledge via a Web-based survey and concluded that there were many deficiencies. They concluded that fecal occult blood testing for screening purposes

remains undervalued, and confusion about administering the test persists. The distinction between screening and prevention needs further reinforcement [16].

Primary medical care of many underserved populations is dependent on resident outpatient practices. The physician-in-training role in health maintenance and screening has been assessed by various studies [17-21]. Other factors could be responsible for the compromise in effective health maintenance and screening in resident practice in addition to residents' knowledge deficiencies. One of these factors could be provider turnover every few years. Some studies even estimate that as many as 50% of patients are lost to follow-up of their chronic medical conditions and screenings when resident physicians graduate and pass their patients on to new providers [22].

Besides addressing other factors to improve health maintenance and screening in residents' practice, improving medical knowledge about preventive health and screening is the key. One of the reasons for residents' deficient knowledge about CRC screening is lack of training and educational tools. We conducted this comprehensive study to improve internal medicine residents' CRC screening knowledge via a pilot approach using a smartphone app.

## Methods

### Survey Design

This pilot study was completed in 3 parts. Initially, we designed a questionnaire based on the CRC screening guidelines of the ACS, ACG, and USPSTF; we then requested institutional review board approval. The institutional review board of the University of Toledo Medical Center then granted the request for approval after reviewing the app and the survey questionnaire (no. 201713). The survey contained 14 questions on 7 areas of CRC screening, [Textbox 1](#) outlines. We emailed the questionnaire via a SurveyMonkey (SurveyMonkey Inc, San Mateo, CA) link to all the residents of an internal medicine department. We analyzed the responses after 4 weeks. The first question simply asked for the year of training, to create a subset for analysis by year of training. Respondents had the ability to answer with multiple correct choices for some questions, reflecting the multiple options presented in the source guidelines. [Multimedia Appendix 1](#) shows the survey form.

**Textbox 1.** The 7 areas of colorectal cancer screening tested in the survey and covered in the app.

Screening in average risk and with positive family history of colorectal cancer
Identification of screening tests
Prevention methods
Detection methods
Following up positive tests with colonoscopy
Follow-up after colonoscopy findings
Surveillance in diseases

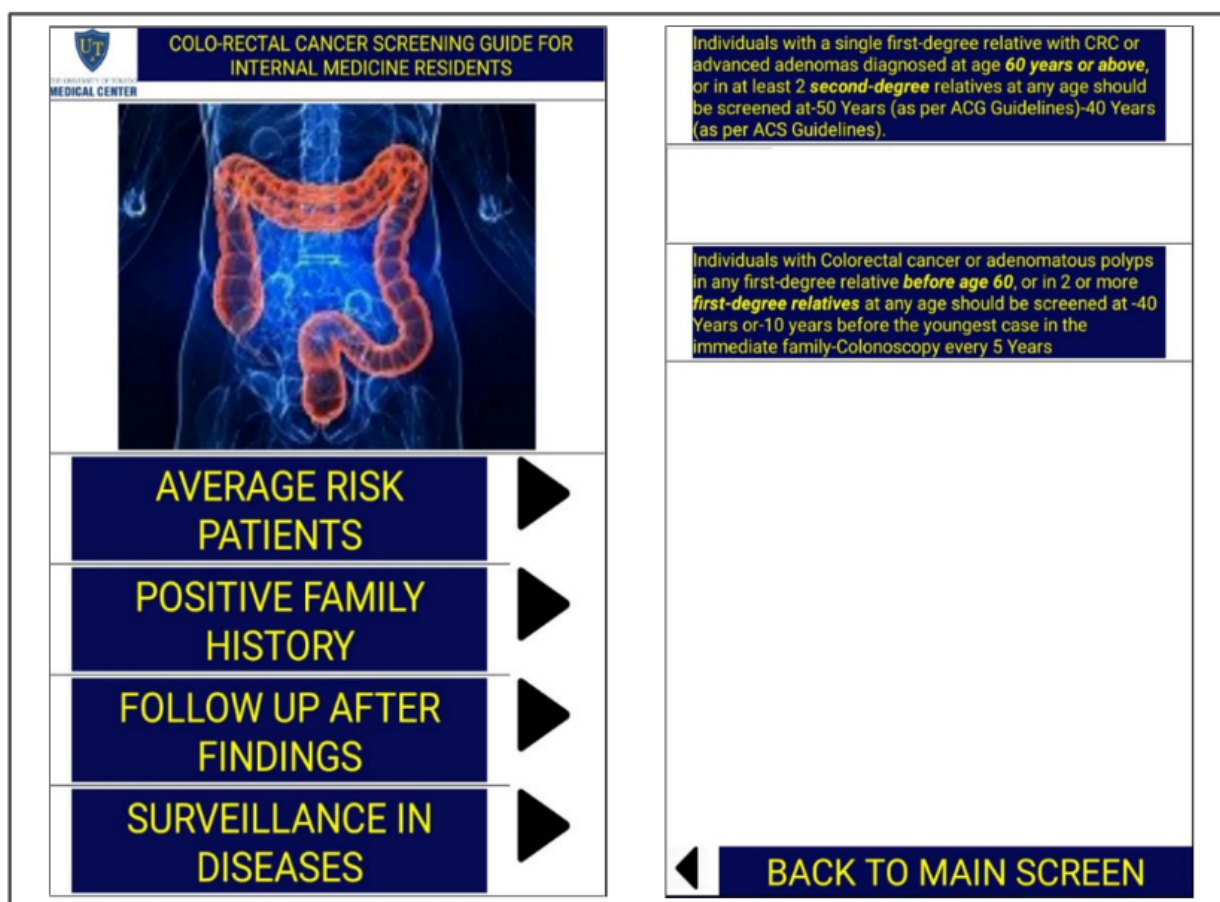
### App Design

In the second part, we designed a smartphone app. The decision to use a smartphone app for education was purely experimental and was based on the recent advancement in technology of smartphones and gadgets and the subsequent growth of the smartphone app industry. First, we collected information about CRC screening based on the ACG, ACS, and USPSTF guidelines, and then made a screen tree based on this information. The screen tree consisted of a total of 9 screens, including the main screen, as [Figures 1,2,3, and 4](#) show. The smartphone app was created on an online app creation portal (Mobincube, San Francisco, CA, USA). We designed the app keeping in mind simplicity yet ensuring good visibility of the information. The portal subscription we obtained for the app creation and publication was without advertisements to avoid any conflicts of interest. We tested the trial version of the app on a smartphone and a tablet before publication.

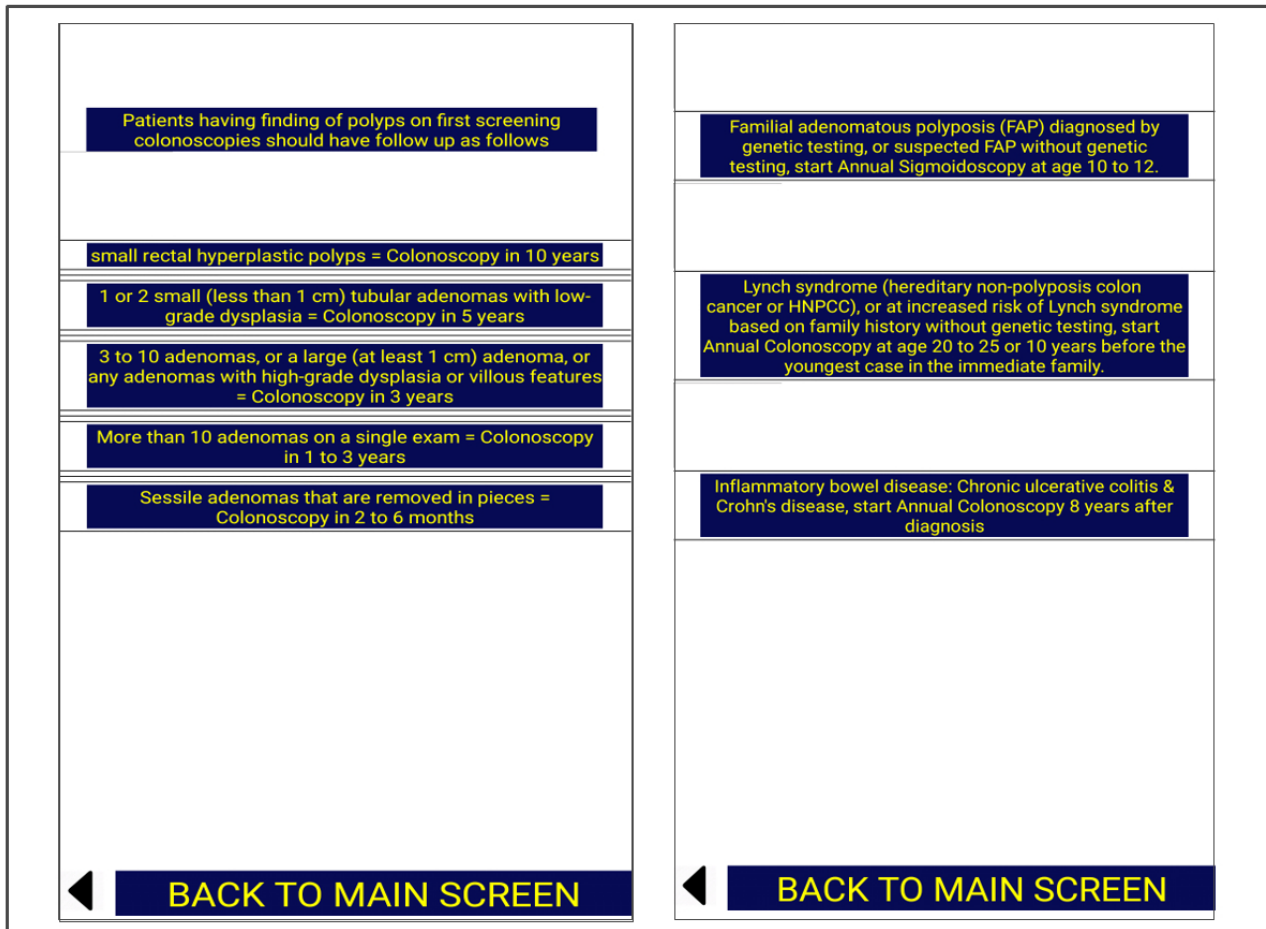
Then we uploaded the app onto the Google Developers Console (Google Inc, Mountain View, CA, USA) and published it the Google Play Store (Google Inc) for Android users. We also sent the app to Apple support for testing before publication in the App Store (Apple Inc, Cupertino, CA, USA). All the residents were introduced to the app via emails and flyers. We tracked the number of app downloads via a developer account in both the Play Store and the App Store. The app was purely educational and there were no interactive components in the app. The purpose of the app was to improve residents' knowledge about CRC screening.

In the third and final part, we repeated the survey after 4 weeks and compared the responses with those of the first survey. Weekly reminders were sent to residents to complete both the surveys. We gave residents no incentives to complete the surveys. We applied the Pearson chi-square test and the Fisher exact test to look for statistical significance.

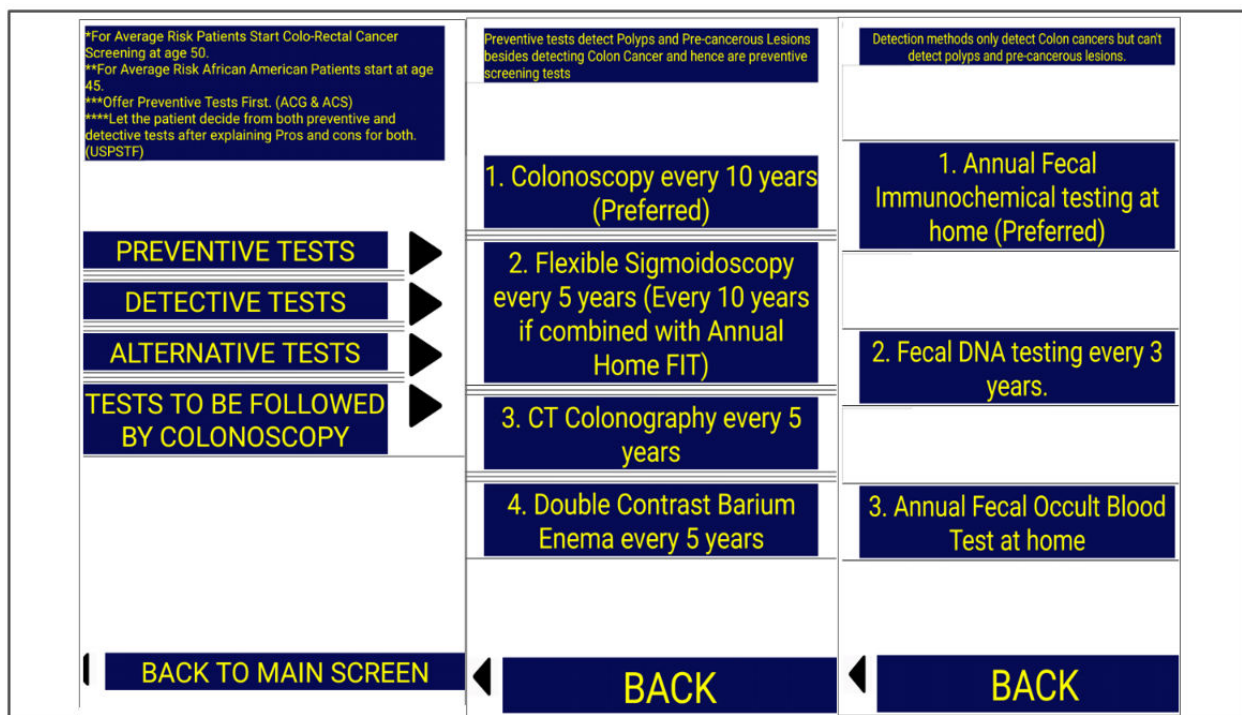
**Figure 1.** Screenshots of the main screen and family history screen. ACS: American Cancer Society; ACG: American College of Gastroenterology; CRC: colorectal cancer.



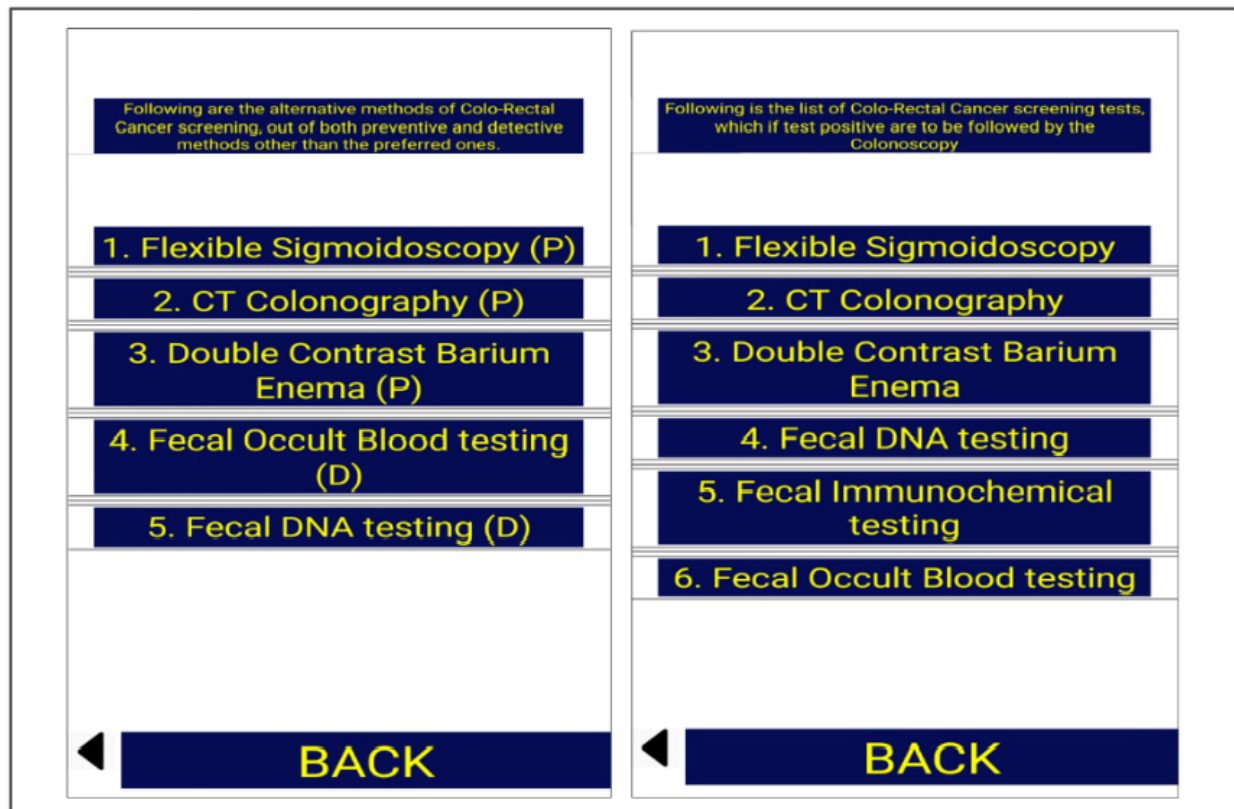
**Figure 2.** Screens showing follow-up after findings and surveillance in diseases.



**Figure 3.** Screens giving information about preventive and detection tests in average-risk patients. ACS: American Cancer Society; ACG: American College of Gastroenterology; FIT: fecal immunochemical test; USPSTF: US Preventive Services Task Force.



**Figure 4.** Screens showing alternative methods of colon cancer screening and screening tests to be followed by colonoscopy if positive. CT: computed tomography.



## Results

### Survey Response Rates

We analyzed and compared the data in 3 subsets. In the first subset, we compared responses to the survey questions from respondents in the same training year to determine improvement in knowledge in each training year individually after publication of the smartphone app. In the second subset analysis, we compared responses between each of the 3 resident training years (ie, postgraduate year [PGY]-1, PGY-2, and PGY-3) to look for differences in knowledge between different training levels at baseline and differences in knowledge improvement after publication of the smartphone app. In the third and final analysis, we analyzed responses in aggregate to look for overall improvement in knowledge.

We emailed the survey link to 59 residents during the first phase and allowed 4 weeks for completion of the survey, with weekly reminders sent via email. A total of 50 residents completed the survey, for response rate of 85%. Of the 50 respondents, there were 22 PGY-1 residents, 15 PGY-2 residents, and 13 PGY-3 residents. After publication of the app, we emailed the survey link again. A total of 41 residents responded to the second survey, for a response rate of 69%; of the respondents, there were 20 PGY-1 residents, 11 PGY-2 residents, and 10 PGY-3 residents.

### Assessment of Residents' Knowledge

The first few survey questions assessed the resident's knowledge about CRC screening in average-risk patients and with a family

history of CRC ([Multimedia Appendix 2](#)). Most of the residents correctly identified the screening age in such patients. The residents were lacking knowledge about the ACG recommendation to start screening for CRC in African Americans at age 45 years. But after using the smartphone app, their knowledge improved significantly, from only 4 residents (8%) responding correctly before using the app to 29 residents (71%) responding correctly after using the app ( $P<.001$ ). Although not statistically significant, knowledge about offering preventive tests first ( $P=.01$ ) and offering colonoscopy every 5 years to patients with family history of CRC in a first-degree relative at age less than 60 years ( $P=.17$ ) all improved.

When asked to identify screening modalities for CRC screening, many residents were lacking the knowledge about the various tests that can be offered. The number of correct responses indicating their knowledge about computed tomography (CT) colonography every 5 years, double-contrast barium enema every 5 years, sigmoidoscopy every 10 years with annual fecal immunochemical testing at home, and fecal DNA testing every 1 to 3 years increased with statistical significance after intervention ([Multimedia Appendix 3](#)). The residents were also tested on their ability to identify preventive tests, which can detect precancerous polypoid lesions. Most residents could identify only colonoscopy every 10 years as a preventive test at baseline, but after the intervention, more of them, at all training levels, correctly identified flexible sigmoidoscopy every 5 years, CT colonography every 5 years, and double-contrast barium enema every 5 years as preventive tests ([Multimedia Appendix 4](#)).



Detection methods only can detect CRC; they can't prevent it as prevention methods do by detecting precancerous polypoid lesions. Stool-based CRC screening tests are the detection methods. Residents' knowledge for correctly identifying detection methods was not satisfactory at baseline but improved significantly after education with the app, and they were able to identify annual fecal immunochemical testing, fecal occult blood testing at home, and fecal DNA testing every 1 to 3 years as CRC detection methods ([Multimedia Appendix 5](#)). Most residents could identify sigmoidoscopy and fecal occult blood testing as the tests that are to be followed by colonoscopy if the test result is positive. At baseline, they did not all know that positive results on CT colonography, double-contrast barium enema, fecal immunochemical testing, and fecal DNA testing should also be followed by colonoscopy. After using the smartphone app, however, more of the residents identified these tests as needing to be followed by colonoscopy ([Multimedia Appendix 6](#)).

The residents were also tested on the recommended follow-up after colonoscopy screening. Overall, the residents' knowledge was not satisfactory on the follow-up periods of 10 years in the case of small hyperplastic rectal polyps being found, 5 years for 1 or 2 small tubular adenomas, 3 years for 3 to 10 adenomas, 1 to 3 years for more than 10 adenomas, and 2 to 6 months for sessile adenomas. Knowledge improved, but this was statistically significant only in the case of knowledge about the follow-up of sessile adenomas and of more than 10 adenomas ([Multimedia Appendix 7](#)). Finally, residents were asked about surveillance for CRC in familial adenomatous polyposis, Lynch syndrome, and inflammatory bowel disease. Residents' knowledge about CRC surveillance in familial adenomatous polyposis was lacking before using the smartphone app but improved significantly after the educational intervention ([Multimedia Appendix 8](#)).

## Discussion

### Principal Findings

Most of the recommendations for CRC screening from the ACG, ACS, and USPSTF are similar. For our study, we extracted commonalities and only tested recommendations that were similar between all of these guidelines. Apart from these organizations, others also publish guidelines, most of which reinforce the already-stated recommendations, but they also make some new recommendations, adding to the confusion for residents and other health care professionals. Recently, the US Multi-Society Task Force on Colorectal Cancer made new recommendations, in which they divided the screening tests into three tiers based on performance features, costs, and practical considerations [23]. In our study, we tested the knowledge of residents to identify these screening tests but didn't test for division of these tests into three tiers.

Our study showed that, regardless of the levels of training, residents in one internal medicine department were lacking knowledge about CRC screening. This finding agrees with that of Sharma et al [24,25], who investigated the understanding of CRC screening among primary care physicians and internists. There was no difference in residents' knowledge between baseline and after the educational intervention in the form of a

smartphone app: knowledge improved equally among all 3 PGY levels. This finding is consistent with a study in 2005 [26], which showed no statistically significant difference in CRC screening rates between different years of training.

Our study was different from previously reported ones in that, first, ours was very comprehensive and covered all aspects of CRC screening and, second, it used the novel approach of a smartphone app for education of the residents. Previously reported studies, such as that of Akerman et al [16], only tested for identification of CRC screening tests. Beyond testing for knowledge of CRC screening in average-risk patients and with a family history of CRC, we also tested the important concept of differentiation between prevention and detection tests, which is acknowledged in the ACG and ACS guidelines. Residents were lacking knowledge in other areas of CRC screening, such as identifying tests other than colonoscopy, screening in African American patients, following up positive tests with colonoscopy, follow-up after colonoscopy findings, and surveillance for CRC in various diseases such as familial adenomatous polyposis, Lynch syndrome, and inflammatory bowel disease.

Our study showed that residents were knowledgeable about screening of average-risk patients with colonoscopy at age 50 years and those with a family history of CRC. Because ACS guidelines state that colonoscopy should be offered at age 40 years to patients with a family history of CRC in a first-degree relative at or over age 60 years and ACG guidelines state that screening in these patients should be the same as for average-risk patients, we considered both responses correct in our survey analysis. The areas that showed improved knowledge after use of the smartphone app were correctly identifying all of the CRC screening tests, differentiating between prevention and detection tests, and correctly identifying these tests. Also, the postsurvey results showed improved knowledge of screening tests that need to be followed by colonoscopy if the test result is positive. The areas that didn't improve much were the follow-up of a screening colonoscopy in case of findings, as well as surveillance for CRC in various diseases.

Residents' knowledge about alternative CRC screening methods is important, as some patients do not wish to have colonoscopies because of the invasive nature of the test. Residents can only offer alternative, less-invasive methods if they have knowledge about them. Although the use of screening colonoscopies has increased over the last few years, it is still far from the National Colorectal Cancer Roundtables' goal of achieving 80% by 2018, and awareness of alternative methods is important in achieving this target. It is important for residents to know about follow-up after colonoscopy findings and surveillance for CRC in various diseases, as residents ultimately take care of the primary needs of these patients in the clinic.

Various educational strategies have been employed in the past for improving knowledge of CRC screening, ranging from didactic lectures, as shown by Lane et al [27], to an interactive case-based model, as shown by Schroy et al [28]. These educational methods showed variable improvement in knowledge, and additional interventions may be needed to improve screening performance. In this modern era of smartphones and gadgets, developing a smartphone-based app

or educational tool can work very well for residents' education, as shown by Shaw and Tan [29]. Using a smartphone app to improve internal medicine residents' knowledge of CRC screening is a novel idea and worked very well in our study.

### Study Limitations

Our response rate was good, but our study was limited by being a single-center study with a small sample size. This intervention can be expanded to other institutions to determine the validity of our results in a multicenter setting. In addition, this study did not check whether the residents' improved knowledge translated into their clinical practice in terms of an improved CRC screening rate. A multi-institutional study is being planned, and the original study will be expanded to determine the app's effect on the screening rate. Here it is important to mention that,

although this study was not intended to observe a change in practice, a few residents reported that the app was a readily available tool on their smartphone and was helpful to them when they encountered the issue of CRC screening of their patients in an outpatient setting.

### Conclusion

While residents seem knowledgeable about colonoscopic CRC screening in average-risk patients, we found significant deficiencies in other areas of the comprehensive evaluation. A smartphone-based app or educational tool is a novel idea and can help improve residents' knowledge about CRC screening. A smartphone-based educational tool can be a part of residents' orientation before the start of their residency to reinforce their knowledge about age-appropriate and specific screenings.

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### Authors' Contributions

ZK designed the study, developed the smartphone app, collected data, conducted statistical analysis, drafted the manuscript, did critical revision, and approved the final manuscript. UD, MN, BK, YAA, and YA collected data and drafted the manuscript. MAK designed the study, collected data, and critically revised the study. WB did statistical analysis and drafted the manuscript. TS and AN did a critical revision for intellectual content and gave final approval of the manuscript.

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### Conflicts of Interest

None declared.

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### Multimedia Appendix 1

Survey form emailed via SurveyMonkey to residents.

[PDF File (Adobe PDF File), 33KB - [mededu\\_v4i1e10\\_app1.pdf](#) ]

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### Multimedia Appendix 2

Screening in average-risk patients and with a positive family history of colorectal cancer.

[PDF File (Adobe PDF File), 24KB - [mededu\\_v4i1e10\\_app2.pdf](#) ]

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### Multimedia Appendix 3

Identification of colorectal cancer screening tests.

[PDF File (Adobe PDF File), 32KB - [mededu\\_v4i1e10\\_app3.pdf](#) ]

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### Multimedia Appendix 4

Identification of colorectal cancer prevention methods.

[PDF File (Adobe PDF File), 31KB - [mededu\\_v4i1e10\\_app4.pdf](#) ]

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### Multimedia Appendix 5

Identification of colorectal cancer detection methods.

[PDF File (Adobe PDF File), 29KB - [mededu\\_v4i1e10\\_app5.pdf](#) ]

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### Multimedia Appendix 6

Identification of positive tests to be followed by colonoscopy.

[PDF File (Adobe PDF File), 33KB - [mededu\\_v4i1e10\\_app6.pdf](#) ]

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## Multimedia Appendix 7

Identification of follow-up after colonoscopy.

[[PDF File \(Adobe PDF File\), 32KB - mededu\\_v4i1e10\\_app7.pdf](#)]

## Multimedia Appendix 8

Identification of surveillance for colorectal cancer in various diseases.

[[PDF File \(Adobe PDF File\), 30KB - mededu\\_v4i1e10\\_app8.pdf](#)]

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## Abbreviations

**ACS:** American Cancer Society  
**ACG:** American College of Gastroenterology  
**CRC:** colorectal cancer  
**CT:** computed tomography  
**FIT:** fecal immunochemical test  
**PGY:** postgraduate year  
**USPSTF:** US Preventive Services Task Force

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Original Paper

# Consensus on Quality Indicators of Postgraduate Medical E-Learning: Delphi Study

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## Abstract

**Background:** The progressive use of e-learning in postgraduate medical education calls for useful quality indicators. Many evaluation tools exist. However, these are diversely used and their empirical foundation is often lacking.

**Objective:** We aimed to identify an empirically founded set of quality indicators to set the bar for “good enough” e-learning.

**Methods:** We performed a Delphi procedure with a group of 13 international education experts and 10 experienced users of e-learning. The questionnaire started with 57 items. These items were the result of a previous literature review and focus group study performed with experts and users. Consensus was met when a rate of agreement of more than two-thirds was achieved.

**Results:** In the first round, the participants accepted 37 items of the 57 as important, reached no consensus on 20, and added 15 new items. In the second round, we added the comments from the first round to the items on which there was no consensus and added the 15 new items. After this round, a total of 72 items were addressed and, of these, 37 items were accepted and 34 were rejected due to lack of consensus.

**Conclusions:** This study produced a list of 37 items that can form the basis of an evaluation tool to evaluate postgraduate medical e-learning. This is, to our knowledge, the first time that quality indicators for postgraduate medical e-learning have been defined and validated. The next step is to create and validate an e-learning evaluation tool from these items.

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**KEYWORDS**

postgraduate medical education; continuing medical education; e-learning; distance education; quality tool; quality indicators; education, medical; education, medical, continuing; education, distance

## Introduction

E-learning, which also goes by many other names, is taking up a strong position in medical curricula because of its flexibility, richness, and potential for resource sharing and for high value in light of its cost [1]. E-learning is suggested as an eligible instrument for interprofessional learning [2], and Goh described e-learning not as just hype, but as a core aspect of medical education in the future [3].

However, the debate on what denotes good-quality e-learning is ongoing. More explicitly, the lack of knowledge on what constitutes good-quality e-learning has been identified as one of the main inhibitors of its usefulness [4]. Cook postulated that e-learning is not always cheaper or more efficient than traditional forms of medical education. However, he also stated that e-learning can be a very important innovation when it becomes “low-cost, low-tech, but instructionally sound ‘good enough’ online learning” [5]. The problem is that there is no useful model for “just good enough” postgraduate medical

e-learning. The literature shows that there are no specific working models for this target audience [6] and that the models and tools that are used are diverse. We have previously provided a list of quality indicators [6] and tried to find the underlying constructs of which items are important and meet the needs of learners [7]. In this way, we tried to provide the categories necessary to evaluate postgraduate e-learning. Both for educators involved in postgraduate e-learning and for users themselves, it is crucial to know that e-learning is worth their investment in it. Previous research showed that users are less motivated and less eager to undertake an e-learning module when they are in doubt about its quality [7]. Furthermore, experts believe that it is necessary to know what quality features are required and expected of an e-learning course before it is created [7].

In response to this debate on what constitutes good-quality medical e-learning, we set out to provide an empirically based set of quality indicators. Thus, we performed a Delphi procedure to evaluate suggested quality indicators from the literature. To our knowledge, this study is the first international consensus by both educational experts and experienced users on quality indicators in postgraduate medical e-learning.

## Methods

In this study, we performed a Delphi procedure to determine consensus on the possible quality indicators for e-learning in postgraduate medical education.

### Study Design

Escaron et al describe the Delphi method as being well suited to informing health education [8]. It is based on the concept of pooled intelligence and should enhance the individual judgments and capture the collective opinion of experts [9]. We performed the Delphi digitally, facilitated by RAD, because online Delphi studies reduce costs, time, and effort [9] and are not limited by geographical boundaries. The downside is that participants have a consultative role and disagreements are hard to explore. This is even more the case when using a digital medium to communicate. To maximize the effectiveness of the Delphi, we followed the guidelines of de Villiers et al [9]. We first provided a definition of e-learning to the expert panel, then started with a questionnaire of items. After analyzing the results, we removed items without consensus, added comments on the remaining items, and, if applicable, added new items.

### E-Learning Definition

For this Delphi we chose the following, slightly adapted definition from Sangrà et al: “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 ways of understanding and developing learning” [10]. To simplify the discussion, we chose to talk about stand-alone, asynchronous, and distant e-learning (and not learning management systems). We provided all participants with this definition and an explanation in the introduction of the Delphi.

### Expert Panel Selection

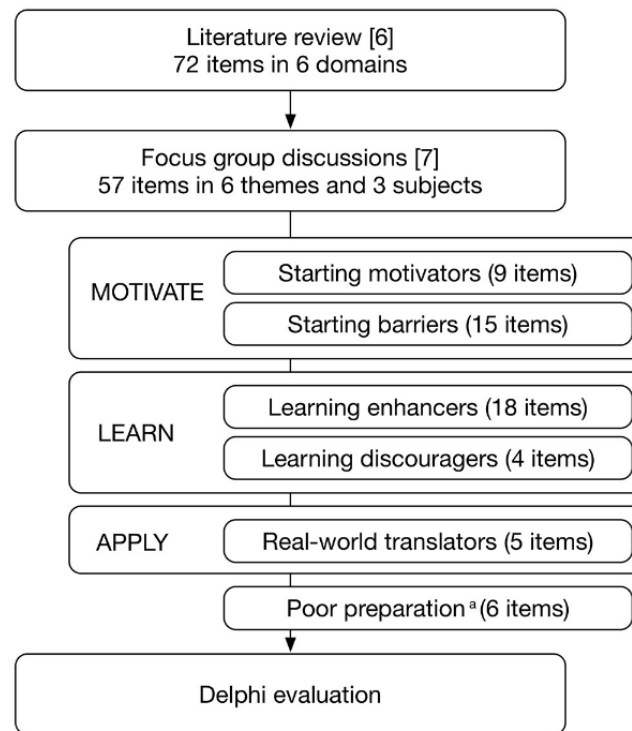
For this study, we used 2 expert groups: medical educators and end users. Medical educators are experts in the theory and practice of creating e-learning and end users know what it's like to use the e-learning in their daily practice. A suitable expert is defined in the literature as someone who possesses the relevant knowledge and experience and whose opinions are respected by fellow workers in their field [9]. For this study, we defined an educational expert as a member of a national medical education platform (usually a university- or government-led foundation aimed at improving and validating medical education) or someone who has been published in peer-reviewed international journals on the subject of medical e-learning, and who has had at least 3 years' experience with medical education and e-learning development. We defined experienced postgraduate users as postgraduate residents who graduated at least 2 years ago and who have had exposure to e-learning throughout their postgraduate training.

We selected experts by means of an inquiry to the National Education Board in the Netherlands and from author contacts. We invited experienced users in the Netherlands and Great Britain because we had local contacts there. An expert panel usually consists of 15 to 30 participants, with 5 to 10 participants per category [9]. Our aim was to have 10 experts and 10 experienced users but, as we believe that educational experts have a better background in the theoretical grounding of education, we preferred to have a few more educational experts on the panel. We thus aimed for 13 experts and 10 users [9].

### Questionnaire Development

The initial set of indicators was based on 2 previous studies and contained quality characteristics from the literature [6] (72 items) and from focus group discussions (resulting in 57 items) with both experts and end users [7] (see Figure 1). These previous studies gave a total of 57 items in 6 themes on 3 subjects: motivate, learn, and apply. The subject *motivate* consisted of indicators that increase the learner's level of motivation in the theme, called starting motivators, and indicators that form a barrier to starting or finishing the e-learning, called starting barriers. The next step was the subject *learn*, which consisted of all pedagogical indicators that either facilitate (learning enhancers) or limit (learning discouragers) the learning experience. The subject *apply* was made up of indicators that help the learner to translate and apply the e-learning into their daily practice (real world translators). Finally, the theme poor preparation (6 items) consisted of indicators that help an author prepare for the creation of an e-learning resource. Items such as “Plan a feasible budget to prevent incompleteness of the e-learning due to lack of funds” were not originally aimed at the end user and therefore evaluated only by the experts.

The questionnaire started with introductory text explaining the subjects, providing a definition of e-learning, and asking the experts and users to imagine e-learning that was “just good enough” and targeted at medical postgraduates. After that, the experts and end users evaluated the individual items on a 5-point Likert scale and were able to add comments [9].

**Figure 1.** Subjects and themes of postgraduate medical e-learning quality indicators.<sup>a</sup>The preparation theme is aimed at e-learning authors only.

After we agreed on the content of the questionnaire, we performed a pilot round with 5 participants (2 educators and 3 end users). After incorporating their feedback on the items, we invited the experts to fill out the questionnaire digitally. We started the first round with 57 items.

### Statistical Analysis

After each round, we worked out consensus by calculating the rate of agreement:  $(\text{agreement} - \text{disagreement} / \text{agreement} + \text{disagreement} + \text{indifferent}) \times 100\%$ . We used a rate of agreement of two-thirds to accept an item. An item was rejected when there was no consensus after 2 rounds, or when an item was rejected by a rate of agreement lower than  $-66\%$  in the first round (the rate of agreement scale ranges from  $-100$  to  $100$ ). There is no consensus in the literature regarding the best rate of agreement to be used; the range used has been between  $51\%$  and  $80\%$  [11]. We chose to use two-thirds as proposed by de Villiers et al [9].

The Ethical Review Board of the Association for Medical Education gave ethical consent (file number 475), after which all participants gave their written informed consent.

## Results

We sent the first invitation emails out on March 19, 2017, and received the final response on July 20, 2017. We invited 23 experts, of whom 13 replied and participated, 9 did not reply to the invitation, and 1 did not consider himself an expert on postgraduate medical e-learning. We invited 17 experienced users, of whom 5 did not reply, 2 could not participate due to other obligations, and 10 were able to participate. In total, we had 23 participants, of whom 23 responded in both rounds. Of the participants, 13 (57%) were male. The average age of the experts was 49 years and that of the users was 31 years. The

experts came from the Netherlands ( $n=7$ ), Great Britain ( $n=3$ ), Canada ( $n=2$ ), and South Africa ( $n=1$ ). They had an average of at least 3 years' experience creating or evaluating medical e-learning and together had published 29 articles. A total of 4 were members of the Dutch Association for Medical Education expert group on e-learning. The users were Dutch ( $n=7$ ) and British ( $n=3$ ), and had more than 3 years' experience as residents, and had attended on average more than 2 e-learning during their residency.

In the first round, 37 items were accepted as important, with a rate of agreement of above two-thirds. No items were rejected, there was no consensus on 20 items, and 15 new items were added by the participants (Figure 2). In the second round, we added the comments from the first round on the items without consensus and added the 15 new items (35 items in total). We also added 3 explorative questions based on comments from the first round, exploring the usefulness of a list of indicators. Multimedia Appendix 1 shows all items, rate of agreement, and consensus.

The first explorative question was "Do you think it is possible to define a minimum and general set of criteria that can be generalized for all types of medical e-learning?" A total of 17 participants thought this was possible, 5 were not sure, and 1 thought it was too complicated. Worries about such a list of indicators included the following:

*But I would be concerned that to be applicable for all types of medical e-learning it might be too general and therefore not practically useful [Medical educator 1]*

*Yes, but it's like evidence-based medicine: you must be able to deviate with motivation. [Medical educator 4]*



The experts also raise the concern of a fast-changing definition of e-learning:

*the term e-learning is in a fast-changing technological world with different needs and skills for makers (and for users) and is difficult to define—without maker- or user-focused definition and context [Medical educator 1]*

*e-learning doesn't mean anything in particular, tech can be used in every aspect of med-ed, and lots of different tech can be used for different purposes.... [Medical educator 5]*

Participants mentioned that which form of e-learning these indicators are about is very important to explain.

The second explorative question was “Do you think a 10-question survey, like the one mentioned in the introduction, would be of added value to the current evaluation tools?” It was thought by 14 (64%) to be of added value, 7 (32%) were not sure, and 1 (4%) thought it was not of added value. Arguments were

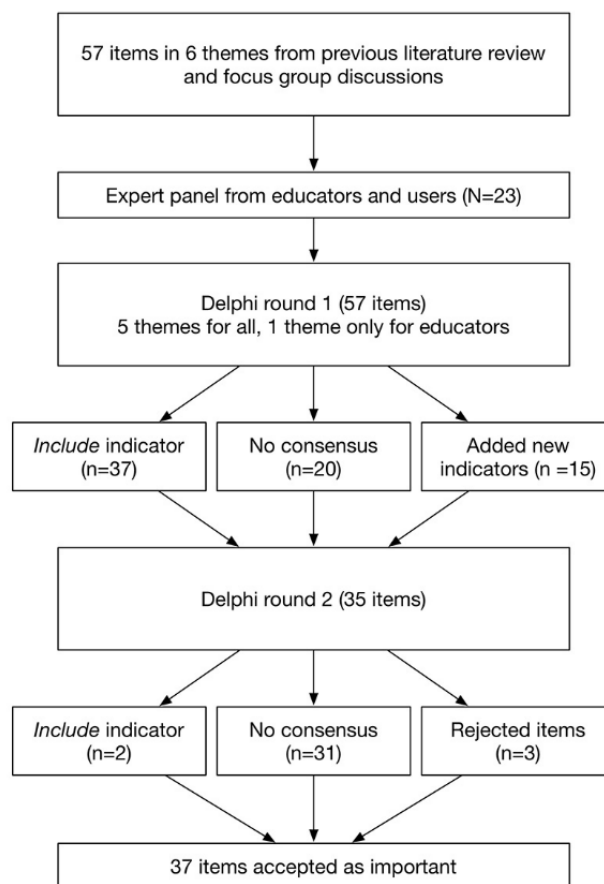
*...it would help setting priorities [Medical educator 8]*

*...general design principles probably will apply to e-learning as well. So why the need of a specific tool? I think there may be added value in evaluating the specific additive value of technology. But I am not sure. That's why I am participating in this Delphi. [Medical educator 3]*

The third explorative question was to explore how many items participants considered to be workable. The general opinion was “the less the better, but as much as needed”. When asked for a number, participants responded with a range of numbers from 10 to 20.

We then evaluated the remaining 35 items (see [Multimedia Appendix 1](#)). There was consensus that just 2 items should be included, 3 were rejected, and there was no consensus on the rest. After this round, a total of 72 items were addressed and, of these, 37 were accepted and 34 rejected (see [Table 1](#)).

**Figure 2.** Flowchart of the Delphi results.



**Table 1.** The final quality indicators. Items 32-37 are expert theme preparation items.

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Subject and item
<b>Motivate</b>
1. Create a feeling of importance within the learner
2. Create a feeling of responsibility within the learner
3. Provide enough time to complete the e-learning
4. Define the purpose of the e-learning (knowledge, skills, and behavior or attitude)
5. Formulate the learning objectives and preferably visualize them
6. Provide an overview of all content
7. Prevent concerns about the quality of the content
8. Do not force, although obligation might be possible
9. Create the feeling that the learner is being taken seriously
10. Use a flexible platform, so that the content can be modified by the educator
11. Provide easy accessibility from all locations and devices
12. Use easy and clear navigation
13. Use a simple layout with a sitemap
14. Software should be safe and secure
15. Access should be fast
16. Make clear which device is needed and advise the learner about the skills needed
<b>Learn</b>
17. Enable the learner to personalize the module
18. Allow nonlinear learning
19. Show what has already been achieved and what has not yet been done (progress bar)
20. Provide technical support
21. Add summaries
22. Give feedback
23. Add exercises and assignments
24. Create interaction with the content
25. Do not stress or frustrate the learner
26. Avoid nonadaptive content
27. Do not create too distractive a design or learning activities
<b>Apply</b>
28. Make the content translatable to the real world
29. Update and maintain the e-learning
30. Provide sources of information and keep access available after the course is finished
31. Evaluate the e-learning after the course and collect feedback
32. Know your target audience and adapt learning objectives accordingly
33. Identify the authors at the beginning of the e-learning
34. Create a timeline with objectives and expectations of the production stage
35. Form a development team with at least 1 content expert, 1 educational expert, and 1 information technology expert, and let them all commit a certain amount of time before starting the development
36. Plan a feasible budget to prevent incompleteness of the e-learning due to lack of funds
37. Consider an appropriate learning environment and learning management system

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## Discussion

### Principal Findings

We performed an international Delphi study with educational experts and experienced users that led to 37 quality indicators for postgraduate medical education. To our knowledge, this is the first list of quality indicators for postgraduate medical e-learning with an evidence-based foundation: first selecting all the indicators mentioned in the literature, then adding to this list by focus group discussions, and finally selecting the items using a Delphi.

Cook et al wrote in 2009 that internet-based learning is associated with a positive effect, but that future research should directly compare different internet-based interventions [12]. Developing peer-reviewed training and guidelines for e-learning should also be the foundation of academic e-learning [13]. However, to compare e-learning or e-education methods and to guide authors, we need to provide them with a tool. These indicators should form the basis for such an e-learning evaluation tool that can help to compare different types of education with e-learning. To evaluate the effect of e-learning in postgraduate medical education, we need a list of indicators. We believe that these indicators should be supported by experts in the field and the final end users of the e-learning resources. This study produced such a list.

After the first round of the Delphi, the experts expressed the challenges of an evaluation of this type. The term *e-learning* can be confusing, the *added value* to a landscape of many other evaluation tools might be limited, and the indicators may be *too general*. The term e-learning, as discussed in the introduction, is broad. However, when it is well defined, we believe it can still be a workable term. There are many quality models in the literature [14], and e-learning has been evaluated many times [15]. But these models are aimed at different target audiences, the origin of the indicators is ill defined, and the validation is

limited, when present at all. The final indicators from our study are quite generic and are difficult to translate back to postgraduate learning. It could very well be that the items identified in this study are applicable to graduates or other groups of learners.

### Limitations and Strengths

Potential pitfalls in Delphi studies are the imposition of preconceptions on respondents and poor techniques for summarizing and presenting the group response. We tried to limit these pitfalls by producing a simple and straightforward questionnaire. Participant selection was limited to those who responded and, by choice, from the countries of the authors' residence. Therefore, our study lacked a certain cultural diversity, making the results possibly less generalizable.

The strength of the final indicators lies in the balance of general aspects of evaluation and the specifics added when needed. We believe that the 6 themes (motivation, barriers, learning enhancers, learning discouragers, real-life translation, and poor preparation) are general enough to be applied to all kinds of e-learning.

### Conclusion

Creating e-learning for postgraduates is not enough; evaluation and improvement should not be additional but mandatory to ensure maximum effect. E-learning quality indicators can be sorted into 3 groups (motivate, learn, and apply) with 5 general themes (motivators, barriers, learning enhancers, learning discouragers, and real-life translators) and a list of items that can be used in preparing e-learning resources.

This study provided a list of quality indicators for postgraduate medical e-learning. This list is unique in its evidence-based foundation and in the way that it applies broad themes with specific indicators. The most logical next step is to create and validate an evaluation tool based on these indicators.

### Acknowledgments

We wish to express our greatest gratitude to the participants of the Delphi. Without their feedback, patience, and time, we could not have completed this study.

### Authors' Contributions

All authors contributed equally in the preparation of the study protocol. Experts were supplied mainly by RAD and KW, and users were mainly suggested by RAD, FS, and KW. RAD carried out Delphi facilitation, data collection, and analysis. All authors wrote and corrected the final manuscript.

### Conflicts of Interest

None declared.

### Multimedia Appendix 1

Delphi results per question and per round.

[[PDF File \(Adobe PDF File\), 76KB - mededu\\_v4i1e13\\_app1.pdf](#)]

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Original Paper

# Instructional Video and Medical Student Surgical Knot-Tying Proficiency: Randomized Controlled Trial

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## Abstract

**Background:** Many senior medical students lack simple surgical and procedural skills such as knot tying.

**Objective:** The aim of this study was to determine whether viewing a Web-based expert knot-tying training video, in addition to the standard third-year medical student curriculum, will result in more proficient surgical knot tying.

**Methods:** At the start of their obstetrics and gynecology clerkship, 45 students were videotaped tying surgical knots for 2 minutes using a board model. Two blinded female pelvic medicine and reconstructive surgery physicians evaluated proficiency with a standard checklist (score range 0-16) and anchored scoring scale (range 0-20); higher numbers represent better skill. Students were then randomized to either (1) expert video (n=26) or (2) nonvideo (n=24) groups. The video group was provided unlimited access to an expert knot-tying instructional video. At the completion of the clerkship, students were again videotaped and evaluated.

**Results:** At initial evaluation, preclerkship cumulative scores (range 0-36) on the standard checklist and anchored scale were not significantly different between the nonvideo and video groups (mean 20.3, SD 7.1 vs mean 20.2, SD 9.2,  $P=.90$ , respectively). Postclerkship scores improved in both the nonvideo and video groups (mean 28.4, SD 5.4,  $P<.001$  and mean 28.7, SD 6.5,  $P=.004$ , respectively). Increased knot board practice was significantly correlated with higher postclerkship scores on the knot-tying task, but only in the video group ( $r=.47$ ,  $P<.05$ ).

**Conclusions:** The addition of a Web-based expert instructional video to a standard curriculum, coupled with knot board practice, appears to have a positive impact on medical student knot-tying proficiency.

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**KEYWORDS**

knot tying; video; proficiency; medical student

## Introduction

Many senior medical students lack simple surgical and procedural skills such as knot tying [1]. Initiatives including first and second year medical school electives have been proposed to provide early instruction in surgical skills and operating room etiquette [2-4]. The transition from a primarily didactic to a clinically based curriculum between the second and third year of medical school can also be anxiety provoking. In a study performed by Stewart et al [5], medical students entering their clinical years had low levels of confidence and high anxiety related to performing common procedural skills such as knot tying. Following a 4-hour preclinical training course, the students reported increased confidence and proficiency and lowered levels of anxiety. Focused surgical skills electives have also been implemented to help prepare senior medical students for entering residency [6-8].

There is no standardized method of teaching medical students knot-tying skills and several curricula have been proposed [9-11]. Gershuni et al [12] suggested a proficiency-based suturing and knot-tying program early in the fourth year of medical school and Naylor et al [13] demonstrated the benefits of a simulator-based curriculum with third-year medical students. Computer-based video instruction (CBVI) has also been used to teach medical students suturing and knot tying [14-16]. Xeroulis et al [17] demonstrated that medical students taught suturing and knot tying with CBVI showed greater retention of skills at 1 month than controls and students taught by instructors with concurrent or summary feedback. The authors concluded that CBVI could be an efficient and useful adjunct for basic skills training. Similarly, Yeung et al [18] performed a prospective randomized controlled trial comparing the use of text versus video as an education tool for laparoscopic intracorporeal knot tying with medical students. The authors found that the video group achieved superior conceptual understanding of the task compared to the text group.

Additionally, if medical students cannot tie surgical knots, they are often marginalized in the operating room. DiMaggio et al [19] demonstrated the importance of simulation practice in a study evaluating medical students who participated in a 2-day surgical skills laboratory session before starting their surgery clerkship. Students who completed this session expressed that participation in the cadaver laboratory allowed them a greater opportunity to suture in the operating or emergency room during their clerkship.

Overall, in our practice, we have noted that third-year medical students participating in their obstetrics and gynecology clerkship have a dearth of knot-tying experience. Using a prospective, randomized controlled study design, we sought to determine whether having access to an expert knot-tying training video would result in more proficient surgical knot tying.

## Methods

Between November 2015 and March 2016, 55 third-year medical students were approached at the start of their obstetrics and gynecology clerkships for inclusion in this Institutional Review

Board-exempt study. As this was an educational intervention, the trial did not require prospective registration.

As part of the standard curriculum at Northwestern University's Feinberg School of Medicine in Chicago, IL, all medical students underwent a 1-hour knot-tying education session on the first day of their clerkship. This session involved both didactics and a hands-on knot-tying workshop led by an attending physician. Participating medical students were then randomized to either the standard curriculum ("no video" group) or to the "video" group. Students in the video group received unlimited access to a Web-based expert instructional video on surgical knot tying (courtesy of Dr John OL DeLancey). Students in both groups received access to a knot-tying board for home practice for the duration of their clerkship. At the conclusion of their clerkship, all students received access to the expert knot-tying video.

On the second day of their clerkship, students in both groups were videotaped tying as many square, two-handed knots as they could on a knot-tying board in 2 minutes. Students in both groups also provided demographic (sex, age, race) and prior experience information (number of prior surgical rotations, comfort level with knot tying with range 0-10 and higher numbers indicating more comfort), family members in medicine, and if they were anticipating entering a surgical career. At the conclusion of their 4-week clerkship, students were again videotaped completing the knot-tying task and a satisfaction survey was administered (range 0-10 on nine measures, higher values indicating higher satisfaction with how knot tying was taught during the rotation). Students also self-reported the number of times they had viewed the expert video and practiced knot tying outside of the clinical setting using their knot board.

Videos of students performing the knot-tying tasks were viewed by two blinded female pelvic medicine and reconstructive surgery physicians who evaluated medical student proficiency using a standard knot-tying checklist (score range 0-16) and an anchored scale (range 0-20). The standard knot-tying checklist responses were 1=yes and 2=no on eight knot-tying metrics, including the following: sutures start crossed, index finger lifts suture to form loop, fingers pinch together, push suture through and grasp/tighten, hook thumb under suture, form loop, fingers pinch together, and push suture through and grasp/tighten. The anchored scale was based on a modified objective structured assessment of technical skill scale, which assigned scores from 1 to 5 on four separate procedure domains: respect for tissue, time and motion, instrument handling, and flow of operation and forward planning [20]. Higher scores represented better skills on both metrics. At the completion of the 4-week rotation, all students were again videotaped and evaluated. Statistical analysis was carried out using SPSS version 20 (Chicago, IL, USA). Paired *t* tests, Student *t* tests, Fisher exact, and Pearson correlations were calculated.

## Results

Of the initial 55 medical students approached for the study, 3 students declined to participate and 2 transferred from the clerkship. Of the remaining 50 students, 26 students were randomized to the video group and 24 to the nonvideo group.

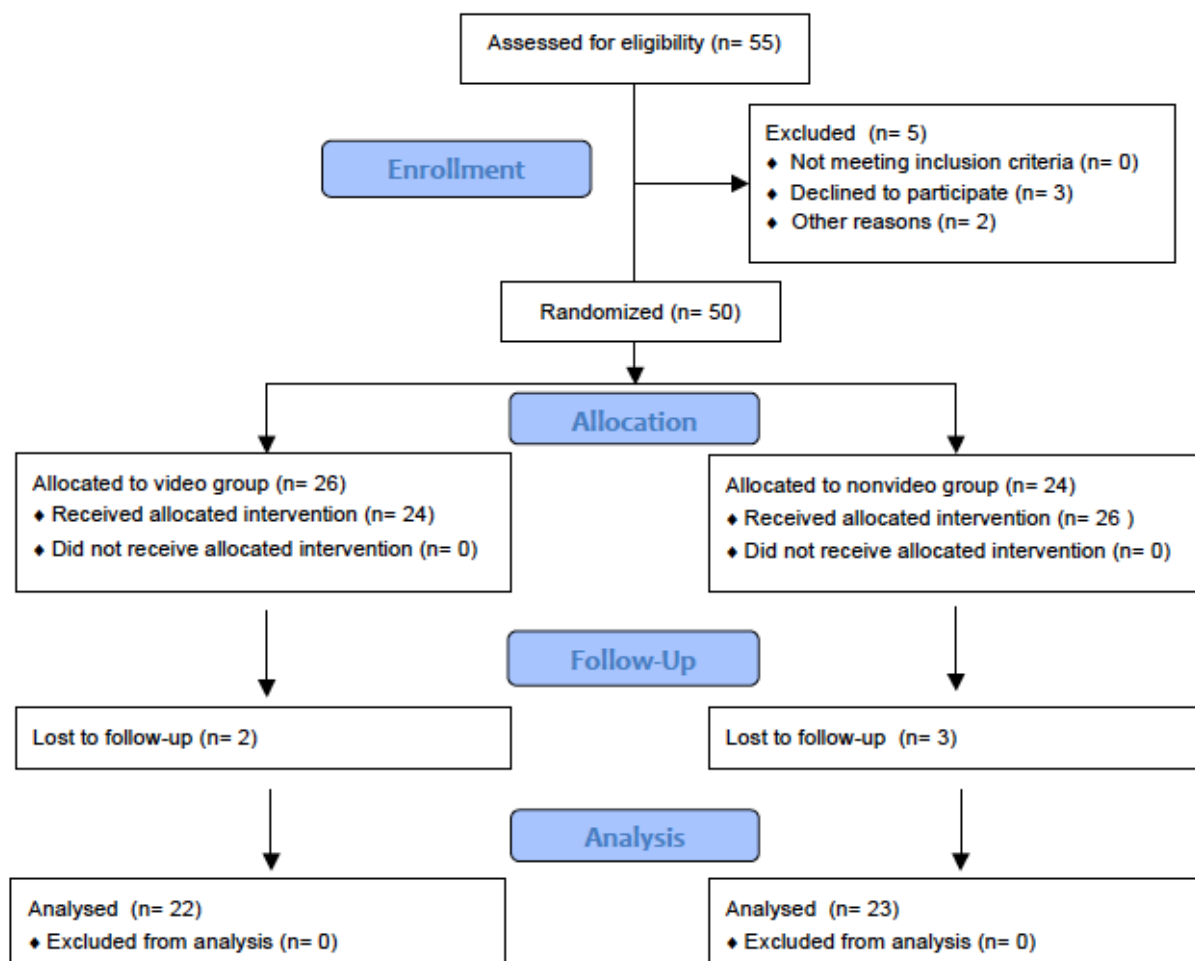
In total, 5 students were lost to follow up and did not complete either of the videotaped tasks. Ultimately, a total of 45 medical students completed both preclerkship and postclerkship knot-tying videotaped tasks and were included in the final analysis: 22 students in the video and 23 students in the nonvideo group (Figure 1).

Participants in the nonvideo and video groups did not differ in age (mean 25.4, SD 1.8 years vs mean 25.0, SD 2.4 years;  $P=.46$ ) or gender (52%, 13/24 female vs 43%, 9/24 female;  $P=.46$ ; Table 1). Students also did not differ in their number of

prior surgical rotations ( $P=.52$ ) or median comfort level with knot tying at the start of the rotation ( $P=.55$ ).

Thirteen of 45 students (29%) in the entire cohort reported having family members who were physicians and 10 students (22%) reported planning on entering surgical fields; this did not differ between groups ( $P=.53$  and  $P=.72$ , respectively). Additionally, preclerkship standard checklist and anchored scale scores on the knot-tying task were not significantly different ( $P=.90$ ) between the two groups.

**Figure 1.** Study enrollment.



**Table 1.** Demographics and student-reported measures (N=45).

Variables	Nonvideo group (n=24)	Video group (n=21)	P value
Age (years), mean (SD)	25.4 (1.8)	25.0 (2.4)	.46
Sex (female), n (%)	13 (54)	9 (43)	.46
Prior surgical rotations, median (range)	1 (0-4)	1 (0-4)	.52
Comfort level (IQ), median (range)	3 (2-5)	4 (1-5)	.55
Have family members who are physicians, n (%)	8 (33)	5 (24)	.53
Plan to enter surgical field, n (%)	6 (25)	4 (19)	.72

**Table 2.** Knot-tying metrics (N=45).

Scores by group	Prerotation, mean (SD)	Postrotation, mean (SD)	P value
<b>Nonvideo group</b>			
Standard checklist	9.7 (3.8)	12.5 (3.1)	.001
Anchored scale	10.5 (3.7)	15.9 (2.9)	<.001
Total score	20.3 (7.1)	28.4 (5.4)	<.001
<b>Video group</b>			
Standard checklist	9.0 (4.9)	12.9 (0.7)	.002
Anchored scale	11.5 (4.8)	15.8 (3.7)	.002
Total score	20.2 (9.2)	28.7 (6.5)	.001

The median number of self-reported board practice times did not vary significantly between groups ( $P=.66$ ); it was median 5 (range 0-20) in the nonvideo group and median 3 (range 0-20) in the video group. Student performance on the knot-tying tasks as evaluated by the standard checklist and anchored scale improved significantly through the course of the rotation in both groups (Table 2).

For the entire cohort, increased knot board practice was not correlated with higher postclerkship scores on the knot-tying task ( $r=.19$ ,  $P=.23$ ). When stratified by access to the knot-tying video, increased knot board practice was significantly correlated with higher postclerkship scores on the knot-tying task, but only in the video group ( $r=.47$ ,  $P<.05$ ) compared to the nonvideo group ( $r=.11$ ,  $P=.62$ ). Interrater scoring reliability was high (intraclass correlation coefficient 0.98, 95% CI 0.95-0.97). Both the nonvideo and video groups reported high rates of satisfaction with their knot-tying educational experiences (mean 39.0, SD 4.5 vs mean 40.7, SD 3.4,  $P=.17$ ).

## Discussion

In this prospective, randomized controlled study, addition of an expert instructional video to a standard curriculum, coupled with knot board practice, appears to have a positive impact on medical student knot-tying proficiency. These findings suggest that self-directed learning is more effective when augmented with an instructional video. The basic tenants of self-directed medical student learning include diagnosing needs, formulating goals, identifying resources, implementing appropriate activities, and evaluating outcomes [21]. In this study, appropriate activities in learning knot tying included knot board practice outside of the clinical setting, which was augmented with instructional video viewing for half of the study participants.

Self-directed learning is a critical component of modern medical student education. Technical skills, such as knot tying, are increasingly being taught in a simulated environment but additional practice, usually at home, is necessary to achieve

task competency. Green et al [8] recently published data suggesting the benefit of home video exercises in teaching technical skills. Additionally, as the costs of operating room time have increased, simulation is becoming an increasingly important adjunct to medical student education [22]. Learning basic skills in a simulation center or practice at home with availability of an educational video, can serve to foster a strong surgical skills' foundation in medical students. All medical students enrolled in this study were given access to knot-tying boards, which they could use at home. Availability of these resources likely facilitated knot-tying practice outside of the clinical setting.

Our study has several strengths and limitations. We performed a randomized controlled trial to evaluate the role of an expert educational video in medical student knot-tying proficiency. Our study population included medical students who had completed variable amounts of surgical clerkships. Additionally, knot-tying proficiency was evaluated by blinded trained gynecologists in a structured fashion with excellent interrater reliability. Limitations of our study include a relatively small sample size and its focus on a single institution. Because students were asked to record how many times they both viewed the expert video and practiced using the knot board at the conclusion of the rotation, recall bias may be a factor in students' responses. Future studies may benefit from implementing a logging methodology in which medical students can report their knot board and video use in an ongoing fashion. Additionally, although medical students were advised to not view the video if they were randomized to the nonvideo group, inadvertent crossover may have occurred between the groups.

Based on our analysis, Web-based video instruction appears to be a valuable adjunct to a standard knot-tying medical student curriculum. Additional prospective studies are necessary with focus on addressing the role of knot-tying practice outside of the clinical setting and the availability of practice materials, such as knot-tying boards and instructional videos.

## Conflicts of Interest

None declared.



## Multimedia Appendix 1

CONSORT - EHEALTH checklist (V 1.6.1).

[[PDF File \(Adobe PDF File\), 108KB - mededu\\_v4i1e9\\_app1.pdf](#)]

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## Abbreviations

**CBVI:** computer-based video instruction

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