Proposing a Framework for Mobile Applications in Disaster Health Learning

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ABSTRACT

Mobile applications, or apps, have gained widespread use with the advent of modern smartphone technologies. Previous research has been conducted in the use of mobile devices for learning. However, there is decidedly less research into the use of mobile apps for health learning (eg, patient self-monitoring, medical student learning). This deficiency in research on using apps in a learning context is especially severe in the disaster health field. The objectives of this article were to provide an overview of the current state of disaster health apps being used for learning, to situate the use of apps in a health learning context, and to adapt a learning framework for the use of mobile apps in the disaster health field. A systematic literature review was conducted by using the PRISMA checklist, and peer-reviewed articles found through the PubMed and CINAHL databases were examined. This resulted in 107 nonduplicative articles, which underwent a 3-phase review, culminating in a final selection of 17 articles. While several learning models were identified, none were sufficient as an app learning framework for the field. Therefore, we propose a learning framework to inform the use of mobile apps in disaster health learning. (*Disaster Med Public Health Preparedness*. 2017;11:487-495)

Key Words: mobile applications, learning, disaster health, framework, systematic review

A mobile application, or app, is defined as a self-contained program or piece of software that is designed to fulfill a particular purpose and can run on a variety of mobile devices, such as smartphones and tablets.[1,2] Mobile apps were first developed in the early 1990s, but did not gain widespread popularity until the early 2000s.[3] It is estimated that roughly one-fifth of US adults have used at least one health app; by 2017, half of mobile phone users are projected to have utilized at least one health app.[4] Mobile health apps are now available for clinical populations (eg, asthma patients) as well as for general health and preparedness (eg, cardiopulmonary resuscitation and first aid).[5-7] In 2012, it was estimated that 85% of US adults owned a mobile phone, of which roughly 53% were smartphones.[4] With such a large number of US adults having access to a mobile phone, a mobile disaster health learning app may be a useful platform to assist in US preparedness efforts in health and disaster health settings.

Notably, the fields of disaster health and medicine are still underrepresented in app usage and utilization.[8] In 2012 Case et al identified 5 types of apps used in disaster settings: disaster scene management, remote monitoring of casualties, medical image transmission (teleradiology), decision support, and field hospital information technology (IT) systems.[8] They noted that only teleradiology and field hospital IT mobile systems had been activated in real disasters.[8] Furthermore, equipment limitations and skills deterioration were cited as obstacles to end user effectiveness and compliance.[8] However, despite these issues, there is much potential in using mobile apps in general health preparedness and by health professionals as an extension of their toolkits. Mentler et al noted the development and need for an integrated mobile application system for managing mass casualty incidents for emergency medical services providers.[9]

While mobile apps have been utilized in a variety of public health settings, there are limited research investigations on the use of mobile apps as an educational or learning platform for health professionals. Previous research has examined the importance of online web-based technologies as a useful enhancement to learning. One example is the use of push technology, which is a means through which information is delivered automatically to all end users from a central location or server.[10] One study noted the importance of Twitter and Facebook (as push technology) to supplement a curriculum on ultrasound concepts.[11] Medical students who received curriculum tweets or Facebook posts voiced approval on the concise yield of information and ease of use.[11] Another study examined the usefulness of delivering

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prenatal health information via a text messaging app and found that users' health knowledge improved over time.[12]

Despite these studies, there is still a dearth of research on the utility of apps in health learning or training frameworks. Most of the research to date has been focused on the use of web tools (eg, podcasts, video blogs, and blogs) and online programs that use an app interface (eg, Facebook and Twitter). There has been a lack of research examining mobile apps as a self-contained program on a cellphone. As mobile apps continue to evolve, there is an opportunity to explore the use of apps in a disaster health learning context. This is of emerging importance, as mobile apps are becoming increasingly ubiquitous in the United States. With such prevalence comes the opportunity to deliver the latest information and curricula to health professionals who work in disaster settings.

The objectives of this article were to identify the current state of disaster health apps being utilized in an educational, learning, and training perspective; to describe and place apps in a health learning context; and to adapt an app learning framework for the disaster health workforce. In this article, a *framework* consists of concepts and existing theory that provides an organizing structure for the phenomenon under study.[13,14] We seek to enhance this definition by structuring our framework to enhance learning outcomes by using mobile apps in the disaster health field. This work seeks to add to the small but growing literature describing apps for health learning and training settings.

METHODS

Study Design

This systematic literature review was conducted by using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[15] The review examined articles written or translated into English, with no necessary date or geographic restrictions, using the PubMed (US National Library of Medicine, Bethesda, MD) and the Cumulative Index to Nursing and Allied Health Literature (CINAHL; EBSCO, Ipswich, MA) databases. Gray literature searches were not conducted. For the purposes of this study, the term *app* was defined as "a self-contained program or piece of software designed to fulfill a particular purpose; an application, especially as downloaded by a user to a mobile device."[2]

Data Collection

Combinations of the following key words were used: mobile applications, mobile apps, learning, disaster, and health.

Inclusion Criteria

These were as follows:

- Articles that included 2 critical elements: "mobile apps" and "learning."
- Articles that had a strong focus on the health professional audience.

Exclusion Criteria

These were as follows:

- Articles that did not include both critical elements.
- Articles with exclusive focus on web 2.0 tools (eg, podcasts, video blogs, blogs).
- Articles with exclusive focus on personal digital assistants (PDAs).
- Articles examining apps that were outside of this article's definition of *app*.
- Articles on learning from a general population or patient population perspective (eg, apps for diabetes self-management).
- Articles that did not deal with apps or with the use of apps in mobile settings.
- Articles that did not have a component of learning or training.
- Articles that were not peer-reviewed.
- Articles that were not published in English.

Screening and Analysis Procedures

All references generated from article searches underwent an initial screen consisting of a title and abstract review. Articles selected for inclusion at this stage contained a "mobile apps" element and a "learning" component, per the inclusion criteria. The secondary screening consisted of a full article review, wherein each article was examined for how mobile apps were used and what learning models (if any) or elements of learning were applied. Last, a tertiary screening was conducted, which consisted of another full article review, with particular emphasis on what types of mobile technology were used, what elements of learning were utilized, and how mobile apps were used in specific target populations. The final list of articles generated from the tertiary screening was reviewed for useful learning models, elements of learning that could aid in development of an app learning framework, and use of mobile apps within the context of learning. All review phases were conducted by 3 of the authors, with agreement on article selection and exclusion. Results from these searches informed the proposed framework for mobile apps in disaster health learning.

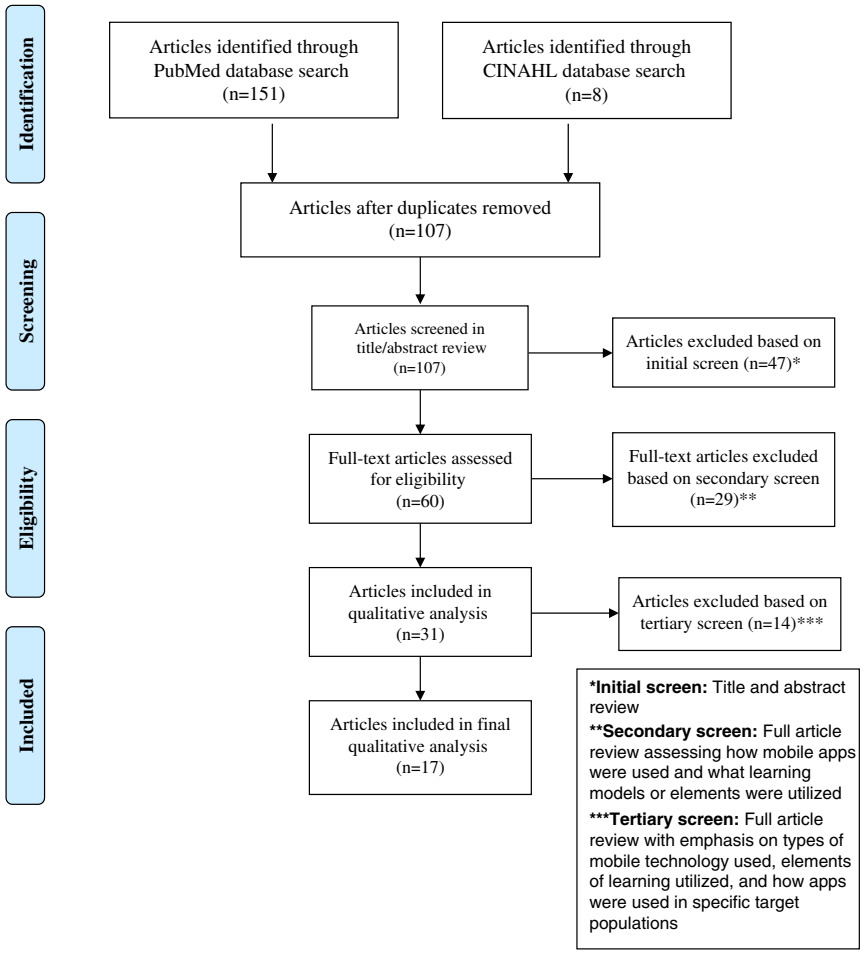
RESULTS

The search strategy generated a total of 159 references; of these citations, only 107 remained after removing duplicate entries. As described above, these 107 references underwent an initial screen, which resulted in 47 additional records being removed under the exclusion criteria. The secondary screen was conducted on the remaining 60 references; this secondary review excluded an additional 29 references. Finally, the remaining 31 articles were included in the qualitative analysis where they were reviewed again using our exclusion criteria. This tertiary screen removed 14 citations, which resulted in a final set of 17 articles for analysis (Figure 1).

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FIGURE 1

Flow Diagram for Selection of Articles for Qualitative Analysis.



Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist, 2009.

All references were peer-reviewed articles obtained through PubMed; all citations obtained from CINAHL were duplicates. Per the 3 main aims of this article, none of the 17 references adequately identified the current state of disaster health apps utilized in a learning or training context. Several learning models were identified, important learning concepts were gleaned, and these elements were deemed critical to a learning framework for use of apps in the disaster health field (Table 1). In analyzing the 17 articles, several prominent concepts contributed to our iterative understanding of considerations for the use of apps in disaster health learning and therefore informed the proposed framework. Eight articles focused on specific apps in a learning context.[16-23] Seven articles described the general attitude of health professionals and students in using mobile technologies and apps in learning.[18,20,24-28] Four articles examined the current status of apps for a number of different types of health professionals and how they are applied in a broad learning context.[28-31] Six references mentioned the lack of quality checks on app content.[25,27,29-32] Lastly, 3 references had some discussion of learning models, which will be examined in greater detail in the discussion section.[20,22,26]

DISCUSSION

In this literature review, 3 of the 17 articles that passed the tertiary screening had a preexisting, defined learning model discussed within the article.[20,22,26] Bullock utilized O'Leary's knowledge management classification as well as Sfard's acquisition and participation models to help further understand the use of technology for learning and sharing knowledge.[26] O'Leary's knowledge management framework is composed of 2 processes: conversion and connection.[26,33] Of these 2 processes, the "connection" pathways are the most relevant to technology and learning. Four connection pathways are identified: people to knowledge, knowledge to

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TABLE 1

Learning Elements and Models Identified During the Review Process

Article No.	Authors	Content Topics	Description of Learning Model or Model Elements Identified
1[a]	Bullock[26]	- Examines how technology supports connections between doctors and knowledge - Discusses how mobile apps can enhance learning in the medical profession	- Utilizes O'Leary's knowledge management processes, which is composed of 2 parts: conversion and connection - The connection pathway is divided into 4 subcomponents: people to knowledge, people to people, knowledge to knowledge, and knowledge to people
2[a]	Renner et al[20]	- Examines the effect of self-reflection apps on hospital staff	- Describes self-reflection as a possible conduit for learning and improving job satisfaction
3[a]	Teri et al[22]	- Examines mobile learning in the context of a biochemistry app that was utilized for a health science course	- Describes the pedagogical process of selecting educational tools for learning and implications for mobile apps in education
4	Ortega et al[19]	- Examines a new mobile app designed for self-assessment	- Describes a hypothetical framework that integrates mobile technologies as part of traditional educational models - Additionally, describes a mixed education program ("blended learning") where mobile apps are combined with traditional attendance-based education
5	Albrecht et al[17]	- Examines a medical legal education app called "mARble," which allows students the ability to practice the necessary skills without causing any ethical dilemmas	- Describes a real-world complementary app that replicates medical scenarios - Additional benefits include integration of users into the learning process, thereby making them a key part of the learning process
6	Albrecht et al[16]	- Examines mobile Augmented Reality (mAR), which may increase the attractiveness of mobile learning apps in medical education[b]	- Describes a methodological approach and study design that measures and identifies factors that must be addressed when attempting to integrate AR-based mobile apps into medical teaching
7	Khatoon et al[30]	- Reviews the use of mobile technology, such as apps within dentistry	- Describes the use of apps in student learning and professional learning - Discusses the need to ensure that app content is up to minimum professional standards
8	Murfin[32]	- Offers insight and suggestions for critically evaluating a medical app	- Describes a framework for critically evaluating a medical app - Discusses elements of user engagement and user evaluation of app content
9	Szekely et al[28]	- Examines how smartphones and tablets can be used by diagnostic imaging professionals, radiographers, and residents	- Describes how radiology apps can support learning
10	Archibald et al[24]	- Examines how preceptors and residents use tablet computers in implementing a new family medicine curriculum	- Describes how apps can support learning by allowing easier information access
11	Bibault et al[25]	- Examines how physicians in training use social media and mobile technology in learning and practicing medicine	- Describes the impact of mobile technologies and apps on learning in a clinical context
12	Haffey et al[29]	- Assesses the contemporary range of smartphone apps with drug prescribing or related content	- Describes the current status of apps in medical prescribing and pharmacology education - Discusses how clinicians can benefit from medical apps, as well as quality control issues
13	Lewis et al[31]	- Identifies and assesses 3D model anatomy apps for students and educators	- Describes the Flemings VARK model which consists of 3 learning styles (visual, auditory, and kinesthetic)
14	Nuss et al[18]	- Examines how medical students used mobile technology in patient care, the mobile apps used, and how expertise and time spent with mobile technology changed over time	- Describes medical students using apps (on an iPad) for clinical reference in decision support, producing reports (productivity tools), and as a learning environment (eg, accessing question banks and other apps)
15	Sanchez-Rola and Zapirain[21]	- Examines the use of a mobile app that was designed to teach users how to identify various regions of the brain, share results, and test knowledge	- Describes how students and health professionals can learn how to define specific brain regions of interest via mobile app
16	O'Connor and Andrews[27]	- Summarizes and examines the available literature on mobile technologies used in undergraduate clinical nursing education	- Examines the benefits of using mobile platforms in nursing education and clinical education
17	Yoo and Lee[23]	- Examines whether a nursing simulation app is as effective as a simulator on nursing student learning	- Explores an integrated approach that combines mobile apps and high-fidelity patient simulators together

[a]The first 3 articles discuss learning models.

[b]Augmented reality is the integration of technology into learning that allows individuals to practice certain techniques in simulated scenarios without breaching ethical boundaries.[17]

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knowledge, people to people, and knowledge to people.[26,33] Technology can be used to support learning through all 4 of these pathways. Examples include search engines (people to knowledge), blogs and wikis (knowledge to knowledge), social media (people to people), and apps or electronic libraries (knowledge to people).[26] Mobile apps can help to facilitate these pathways through Sfard's acquisition of knowledge process.[26,34] In brief, Sfard's acquisition and participation models examine how individuals acquire knowledge and the bonds between individuals and others that aid in learning.[26,34] Bullock uses these models as part of a process through which mobile technology can assist in collaborative learning.[26] However, despite their usefulness, these models are being examined for general health learning. There is little discussion regarding the unique environment that disaster health professionals operate in and whether apps could be a useful supplement for learning in the disaster health field. These 2 learning models provide little insight into the types of learning that are helpful for disaster health.

Renner et al describe a system of reflective learning, wherein participants could learn in their environment by reflecting on work situations that have occurred.[20] Reflection is defined as a process "in which people recapture their experience, think about it, mull it over, and evaluate it"; this can be seen as a type of informal learning.[20,35] While reflection is a normal, everyday process, it is not generally used intentionally as a mechanism to improve learning or performance.[20] Mobile apps can be used to assist reflective and collaborative learning by allowing participants to document and reflect on daily experiences, as well as collaboratively reflect on difficult situations for learning purposes.[20] Reflective learning (via mobile app) may be a useful tool in disaster health learning by contributing to experiential learning after exposure to an event. However, using only reflective learning is not sufficient for an app learning framework for disaster health, as it excludes other important components related to use of apps in disaster health settings.

Teri et al defined and examined the pedagogical impact of a mobile app in a health/science learning environment.[22] Mobile apps in a pedagogically sound learning context are defined as "the digital support of adaptive, investigative, communicative, collaborative, and productive learning activities in remote locations which offer a variety" of environments for teachers and learners to function and learn in.[22] Literature searches on mobile learning yield common themes such as a flexible learning environment, performance support, and user-centered environments.[22] These components are crucial to any app learning framework but, similar to reflective learning, represent only a partial framework for examining mobile apps in a disaster health learning context.

It is important to place the previously described learning models within the environment of disaster health learning. In this perspective, individually, none of the 3 models reviewed earlier in this discussion are sufficient to fully describe an app learning framework for disaster health. However, each model has important elements that should be adapted into a new proposed framework that is helpful for disaster health learning, as well as mobile app development. In particular, the O'Leary framework's "connection pathways" are important mechanisms in considering how technology can facilitate the transfer of knowledge to people.[26] Additionally, Renner's reflective learning model can facilitate a positive effect on user learning and user engagement.

Just-in-Time Learning and Training

An important aspect of disasters is their unpredictable nature. Disaster health professionals are often deployed during or shortly after an incident has occurred. As such, a recurring theme in the literature is a concept known as just-in-time (JIT) learning, which should play a key role in any disaster learning framework.[18,24,25] JIT learning spans the range of providing point-of-use clinical reference information to short, focused lessons that health workers can first use and then apply in the field. In disaster health settings, having timely and accurate information is critical to the success of any disaster response and therefore is an important element in developing a mobile app for disaster health professionals. JIT learning has roots in O'Leary's knowledge management processes. In particular, the connection paths from O'Leary's 4 pathways can help facilitate and link knowledge to individuals.[26,33] Mobile apps are thought to be most effective in the knowledge to people pathway; this makes intuitive sense, as mobile apps (by their nature) are connecting individuals to some type of information or knowledge. Medical residents in one study by Archibald et al noted that using mobile apps during residency eliminated the need to carry large textbooks around because all the information was available by using the app.[24] Especially relevant to medical training were mobile apps containing drug interaction information, which can be critical information to have in an emergency situation.[24] The study by Bibault et al of French medical residents noted that residents used their smartphones to access a variety of apps, including drug dosage, radiation dose calculators, and literature searches. These described uses have implications for JIT learning.[25] In fact, there is some concern regarding the use of such apps, with the implication being that medical residents may slowly forget how to conduct proper drug or radiation dose calculations without such apps.[25] However, in the field of disaster health, there is less concern regarding loss of skills due to disuse and more concern for accuracy due to the variety of emergency scenarios a disaster health professional could potentially face. In emergency settings, JIT learning could prove vitally important. A radiation or drug dose calculator in disaster settings could mean the difference between administering a proper dose and a fatal one. JIT learning in disaster health is also not restricted to drug or radiation information. Mobile apps that supply information on a variety of disaster scenarios could be used to

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provide critical information at the right time during an actual emergency. As discussed by Nuss et al, medical students noted that the use of apps allowed streamlined access to information, which connected knowledge to real-world needs.[18] Lastly, JIT learning and training is important in allowing health professionals to access information when and where they need it; this ease of access may prove vital during a disaster or emergency incident (assuming intact networks and stable power supply).

Content Quality and Transparency/Reliability of Information

Two important and related components of a mobile app are the content quality and transparency of information sources. Multiple studies have noted the lack of content quality checks and the opaque nature of information sources on mobile health apps.[25,27,29,30] Information in an app should clearly state "current as of." Haffey et al reviewed over 300 medical apps and found only 6 apps that provided medical references for the app information.[29] Other studies noted the lack of peer-reviewed articles or other evidence-based metrics as references in app content; therefore, the accuracy of information is very much on the end user of an app and not on the developer.[30] This has particular salience for medical professionals. If the quality of a medical learning app's content is not verified and the original sources of information are not available, any information an app provides could be erroneous or outdated, potentially putting lives at risk.[25] Transparency and consistency of content quality are all the more important given the lax regulatory environment and relatively weak oversight of app stores.[25,27,29-32] These conditions are especially true for disaster health workers, who may be working in high-risk areas where there is little time for content quality checks or tracking down original sources of information. Currently, informal word of mouth, professional recommendations, and institutional development of apps appear to be the more common ways of assessing content quality.[24]

User Engagement and Motivation

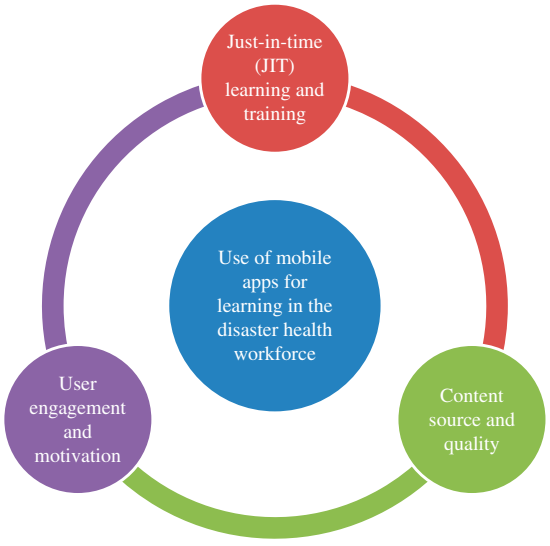
Another component for consideration in an app learning framework should be user engagement and motivation to use a mobile app for learning purposes. Studies have explored the importance of user engagement and comfort in using apps in health learning contexts.[17,18,22,31] One study examining the use of apps in a health science curriculum noted that mobile apps in higher education often feature interactive components such as games and quizzes to engage users, as well as to assist in the learning process.[22] Importantly, a user's environment can affect how likely they are to use a mobile app. In one study, a medical student noted their comfort level around using medical apps grew with increased exposure to apps while in training; other positive feedback included using apps to meet specific needs on medical student caseloads.[18] From a pedagogical perspective, it is necessary for mobile apps to be designed to promote active engagement in the learning process, which can lead to increased understanding and confidence of knowledge.[22] Additionally, mobile apps can support reflective learning, which is an informal learning pathway.[20] Apps that cue individuals to reflect on their knowledge, surroundings, and current experiences can compensate for low awareness or motivation.[20] Therefore, apps with a reflective learning component could help facilitate users into building connections between knowledge and environmental context, as well as increase motivation to continue using the app. In addition, reflection can be used to continue and enhance professional development.[20] This may play an important role in motivating an individual to use an app and to continue engaging with it. These implications extend into the disaster health arena; mobile apps are only effective as long as users continue to trust and utilize them in their normal activities. This is all the more relevant for disaster health apps, which can help promote both JIT learning and training, as well as learning on a regular basis through consistent engagement, motivation, and possibly self-reflection by the user.

Proposed Framework Based on Systematic Review

Based on this literature review, the generation of a new learning framework for disaster health professionals is warranted since none of the sources describe a model of app use in disaster health learning. The proposed framework describes the use of mobile apps in learning by incorporating elements of adult learning, as well as components of learning models discussed above. A proposed framework for using mobile apps in a learning context for the disaster health workforce is presented in Figure 2. Based on our qualitative analysis,

FIGURE 2

Proposed Framework for Mobile Apps in Disaster Health Learning.



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3 central elements are suggested for enhancing the learning value of apps in a disaster health environment. These elements are user engagement and motivation, content source and quality, and JIT learning and training. This framework is most useful from the learning and educational perspective; however, it is vitally important that mobile app developers also be aware of these concepts. This may allow the development of a "common language" that both disaster health professionals and mobile app developers can communicate in, which may lead to more effective development of learning apps specifically for the disaster health workforce. In the framework, each of the elements takes equal precedence; no one element is preeminent among the three. Each element is a necessary base component of the other elements, and the summative qualities of the combined elements are used to influence the overall use of mobile apps for learning purposes.

These elements also integrate a number of concepts that have been elaborated on in the literature but that have not been resolved in the field. Multiple studies have examined the issue of user engagement and continued motivation to use an app. In addition, a number of studies have noted the need for transparency in content source and a thorough examination of content quality. Finally, JIT learning and training are of particular importance because disaster health professionals need to call upon particular skills that may not be required absent an emergency. This concept is similar to O'Leary's connection pathways, one of which is the transfer of knowledge to people.[26,33] In such a context, health workers in disaster settings may need to refresh or also synthesize information that is not readily familiar to them, and this supports a JIT approach to learning.

These 3 principles are not unique to disaster health but are of utmost importance given the contextual environment that disaster health professionals operate in. In a disaster incident, there is often little time to start the user engagement process; however, the motivation to learn is high. Additionally, disaster health professionals must have already made the determination that an app is useful well before an incident occurs. This leads to the second element, which is content quality and source. In a disaster scenario, should a disaster health worker find an app useful (user engagement), they are counting on receiving accurate information and do not have the time nor the resources to ensure the information provided is correct and from reputable sources. This is where ensuring the content quality and transparency of content source is critical to achieving a successful outcome. There is also a potential opportunity to utilize reflective learning in user engagement, which may have important learning applications.[20]

This proposed framework provides conceptual constructs considered vital to enhancing learning via mobile apps by the disaster health workforce. The main concepts established in the literature as being of particular importance are engaging users, ensuring the content is of high quality and from reputable sources, and ensuring that health care professionals can utilize the apps to achieve timely and critical learning in preparation for, response to, and recovery from disasters or emergency situations in their environment.

Limitations

Limitations include restricting this literature search to peer-reviewed publications written in English. Additionally, given the rapidly evolving field, other references may have come online since March 2015, which was when this literature search was last updated. Furthermore, gray literature searches were not conducted for this study.

Strengths

Some of the strengths of this work include analysis of the literature in a relatively novel area, as well as the proposal of a new app learning framework for use in the disaster health field. Another asset of this work includes using a clear app definition. Restricting the definition of *app* allowed us to standardize the results of the literature search and specifically hone in on certain elements unique to mobile apps.

Future Implications for Research and Practice

Future research should continue examining the use of mobile apps in disaster settings utilizing a conceptual learning framework like the one proposed. Mobile apps in general continue to generate high interest in the education and medical training fields. However, the onus will be on researchers to demonstrate that mobile apps are valued in the disaster health field, that apps will be an accepted tool for disaster health learning and training, and that the use of apps will contribute to better outcomes in disaster and emergency settings.

Future practice should examine the use of this framework for developing mobile learning apps tailored to the disaster health field and to examine their effectiveness in a learning context. In particular, mobile app developers may find this framework relevant for creating a learning app specific to the disaster health workforce. Additional areas of practice can include piloting an actual app through the 3 main elements of the framework seeking insight from end users to examine the practical implications of using apps in the field. There is much potential to expand and refine this framework as more research is conducted and more experience is gained.

CONCLUSIONS

This article examined the current state of mobile apps in disaster health settings, sought to understand and situate apps in a health learning context, and proposed an app learning framework built from prior learning models but attuned to the disaster context and the perceived needs of the disaster health workforce. Despite the limited number of publications, this article identified several learning models that were utilized in routine medical and

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health environments. As described, none were sufficient as a model of app use in disaster health learning. Therefore, an app learning framework was proposed that encapsulates important elements from these prior models and adds additional components and concepts. Future research should examine the usefulness of this framework in a simulated exercise or real-world disaster health environment. Additional research should continue examining the health and disaster health literature as other mobile learning concepts are introduced or clarified.

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Disclaimer

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