

A Systematic Literature Review of Content-Based Mobile Health

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Abstract—Mobile health (m-health) applications have recently attracted attention from both the manufacturing sector and research community. The evolution in the use of the smartphone has been aided by advanced communication and presents challenges in terms of the reliability and accuracy of applications. Awareness of these challenges could help industries and designers to develop better tools to enable patients and users to access effective apps. The aim of the study is to identify the critical features and content for m-health apps and the essential components for a salient m-health framework. In support of this aim, this article reviews 80 papers with more than 100 applications regarding m-health applications to gain a deep understanding of the critical content requirements for future improvements in m-health app features. Four prominent characteristics of the most important features emerged from the review of the literature: 1) reminder, 2) monitoring program, 3) training program, and 4) community network features. These features were then incorporated into the design of a m-health framework. It is our hope that m-health technology adoption will increase in the near future by improving patient engagement. The authors believe that by understanding m-health app critical content requirements and its classification, new solutions may be revealed with the potential to overcome the present challenges.

Keywords – m-health; m-health app; telemedicine applications; patient engagement; e-health; remote monitoring;

1. INTRODUCTION

The use of mobile computing has exploded and reached the commercial industry and mainstream consumers via smartphones, personal digital assistants (PDAs) [16], mobile phones and tablets. According to Gartner Inc, worldwide mobile connections will grow up to 7.4 billion by 2015, and mobile applications offer benefits that cannot be matched by desktop products [11]. In a recent example, Apple launched new mobile phone features on the iPhone 5S that could benefit mobile health developers through its movement sensor to detect a user's movement. A variety of sensors such as microphones and cameras [30] can be greatly employed by mobile health (m-health) apps. Moreover, mobile guide systems have become significantly advanced and offer context-based personalisation, user collaboration and social interaction [11]. These examples of the current advantages of mobile computing drive the healthcare community to seek ways to efficiently utilise the technology to better manage people's wellbeing. One of the solutions that has been proposed by healthcare providers is to make use of the available internet-based technologies, such as mobile phones, which offer tremendous access to information in order to help people manage their health. The technologies allow healthcare providers to upload medical records, lab results, images and drug information to handheld devices such as PDAs, tablets, push-to-talk devices, cell phones or smartphones. As a consequence, patients or users could easily know about their health diagnostics, easily exchange information and even can self-monitor and have full access to their record and freely communicate with physicians in a comfortable way. Patients are using these technologies to monitor specific aspects of their health, fill in gaps in their medical care, and take more responsibility for their wellbeing [1].

In the last decade, advances in wireless communications and network technologies have had a substantial impact on m-health [14]. M-health apps are receiving increased attention largely due to the global penetration of mobile technologies. A rapid growth in health technology is underway. With the growing use of mobile phones, m-health has evolved rapidly and its revolution demonstrates a tremendous impact particularly in developing countries. This is a positive development for physicians, patients, healthcare institutions and general m-health app users. Thus, healthcare practitioners are now progressively implementing m-health apps in their practices. It benefits patients and health practitioners by decreasing the

cost for both parties. Regarding the high cost of health care, m-health apps can offer real cost savings by utilising the high take-up of mobile applications, as well as provide a quality patient care and physician efficiency. For instance, patients can manage their own health and gain benefit from accessing the expertise of healthcare professionals at their fingertips when and where they need it.

M-health apps are a very useful tool especially when physicians or patients are stretched for time. The apps help physicians tremendously in delivering better care to patients while cutting costs, a goal which the healthcare community are striving towards. For instance, the online mode of m-health apps allows remote monitoring to be conducted in real-time which is an important aspect for critical patients [14]. This is one of the reasons why the healthcare community needs mobile applications rather than desktop products, especially for patients who cannot perform many movements.

The purpose of m-health apps is to distribute health care very quickly at any time and anywhere with less obstruction. For instance, using smartphones for health purposes can provide numerous advantages like continuous uninterrupted data stream, powerful computing power, portability, large memories, wide screens and the capability to support multimedia application software compared to other wireless communication technologies [1]. Lower costs and improvement in the quality of healthcare can be gained by mobile apps, and they can also help to prevent chronic diseases such as the human immunodeficiency virus (HIV), acquired immunodeficiency syndrome, heart disease, diabetes, cancer and others.

However, although a number of studies have examined the emergence of the mobile phone and its effect on people's lives [2], research has yet to address the content and features issues in m-health apps. Designers of app in USA can not market their products. Only when their app are received 510(k) clearance from Food and Drug Administration. Therefore it has been published that only 75 apps total across the medical landscape in different diseases have met 510k clearance apps [10] due to some missing requirements which many m-health apps have not reached yet. In contrast, the use of m-health apps is a phenomenon that is expected to rapidly progress in many areas in the years to come. Therefore, there is a great opportunity to explore the potential of mobile applications particularly with a focus on the contents in order to improve the adoption of the m-health services. To avoid reluctance to use poorly designed m-health apps, empirical insight into the work practice should be taken into account [17]. This means that knowing the healthcare landscape is critical to determining a strategy of adoption. While penetration of mobile phone services is increasing, the high diversity of users also emerges which leads to a variation in requirements.

In this paper, the authors try to take advantage of mobile technology benefits to propose a generic framework for m-health that facilitates any kind of treatment and exercise. The research focuses on the mobile features and content that are required on the users' side in order to fill the gap in the previous research. Therefore, this paper aims to address the following questions:

RQ1. What are the critical features and content for m-health apps?

RQ2. What are the essential components for a salient m-health framework?

To answer the above questions, the authors provide an overview of their research background in the next section, followed by the research methods and literature findings. In the subsequent section, the m-health framework is proposed. The findings and limitations are discussed, and the contribution of the research is summarised at the end of this paper.

2. RESEARCH BACKGROUND

M-health can be defined as “the use of wireless communication devices to support public health and clinical practice” [20]. Others refer to m-health as “mobile computing, medical sensor and communications technologies for healthcare” [14, 18]. The purpose of m-health apps is to rapidly distribute healthcare at any time, anywhere with few barriers. Patients can self-monitor, have full access to their records and freely communicate with physicians [1].

Nowadays, there is a great variety of mobile technologies that can be utilised for m-health solutions such as smartphones, PDAs and tablets. M-health apps offer a range benefits to people in various aspects. The current generations of smartphones such as 3G and 4G connectivity have a significant effect on all aspects of life, and are used as handheld computers rather

than as phones [1]. The opportunity for innovative applications in healthcare and medical technologies has been opened by the invention of high data connectivity on mobile devices. More than three-quarters of the world's 5.3 billion mobile phones are located in the developing world, and some organisations are already setting trends in developing countries. For instance, the Vodafone Foundation co-founded the mHealth Alliance to facilitate the adoption of m-health, while Johnson & Johnson launched its Text4Baby program to provide education to pregnant women.

These devices are powerful lifelines for people who need access to healthcare services [6]. Although large numbers of physicians are using mobile phones, there is a notable lag in the incorporation of m-health within the traditional medical practice. For example, the use of health apps for health outcome measurement or mobile phone sensors as an outpatient diagnostic tool is not common. Even though the benefit of m-health apps seems profound, particularly in developing countries, there is a lack of evidence to support its widespread use [20]. To expect higher m-health adoption, evidence of its effectiveness, convenience, cost-efficiency and user acceptance is required.

In general, mobile apps should be intuitive and easy to use with simple interfaces to conserve the mobile device's battery power [28]. M-health apps can be simple but still have a tremendous impact on society not only in developed countries, but in developing countries. However, some apps still need enhancements such as clear content requirements in order to meet the needs of the healthcare community including physicians, patients and caregivers. The trend of using mobile phones for health represents an unmatched opportunity for improving public health. For instance, many current user interfaces such as icons and menus are inadequate and inappropriate for mobile applications [28]. Furthermore, computing standards and data format standards for mobile health do not exist, which leads to the complexities of interoperability between systems [14]. In addition, the phenomenal growth of mobile technologies has not been accompanied by an understanding of end-users [17] and does not properly address specific health problems.

3. RESEARCH METHOD

The research method conducted in this paper is based on a literature review to identify the critical requirements for m-health features and content.

A. Data Collection

In the first stage, the researchers reviewed numerous academic papers regarding m-health apps to gain a deep understanding of its critical features and content requirements for future improvements in the apps domain. To strengthen the foundation of the research, a thorough literature review was conducted of 80 academic papers in the context of m-health apps. The search period covered publications from 2004 to 2014. The electronic databases searched in this review included those identified as relevant to health and information technology in reputable journal databases such as Web of Science, Amcom Software, BioMedCentral, ACM Portal, ScienceDirect (www.sciencedirect.com), Google Scholar (scholar.google.com), SpringerLink, SAGE, IEEE, BJCP, PLOS, and BMG Public Health.

B. Search Terms

The search terms included the terms "mobile" and "health" in conjunction with terms for possible outcomes, content and features of m-health. The search terms helped to determine the scope of the study since many of the terms included mobile health such as: mobile healthcare, mobile health, e-health, telemedicine applications and mobile phone telemonitoring systems. The search results were filtered by reviewing the publication's titles, scanning the abstracts and finding the paper's keywords. The reference list in each selected paper was also scanned in order to gather more relevant papers. The papers were also screened using the following keywords: "mobile health application" or "mobile health" or "medical application" or "healthcare application AND mobile phone" or "patient monitoring" or "telemonitoring system".

4. LITERATURE FINDINGS

The search led to the identification of 80 academic papers with discussions of more than 100 apps in publications from 2004 to 2014. The authors compiled the data in a table comprising five columns with the following headings: the names of the

paper's author or authors; technological application discussed in the paper including the critical features; examples of the technology which present the types of application; the potential outcomes for healthcare; user group.

After the data was divided, a number of graphs were designed to derive the critical features, content and the essential components of m-health. The authors focused their analysis on m-health features and content. The top areas for m-health apps were identified in order to understand the current research field. The chart in Figure 1 presents the different areas of m-health apps.

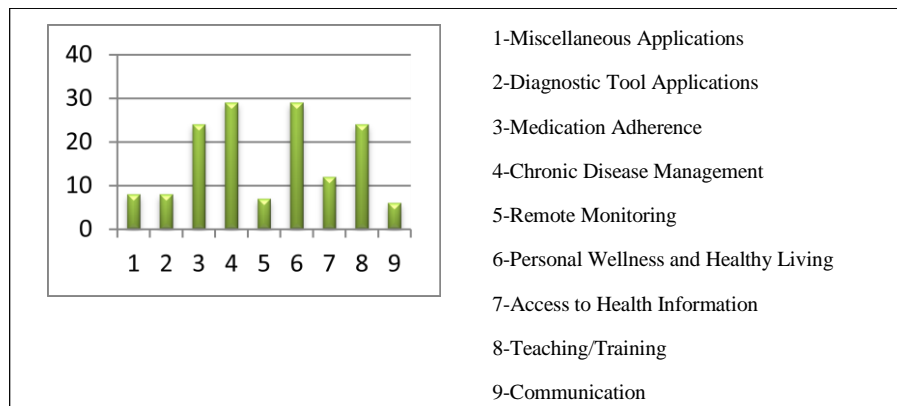


FIGURE 1: M-Health app areas

These areas are explained as follows [1]:

- **Miscellaneous Applications:** Reminders, appointment scheduling and communication among departments are covered in this type of app.
- **Diagnostic Tool Applications:** Patients can use the app to link their phone with other devices such as sensors, glucose meter and heart rate devices in order to get measurement data.
- **Medication Adherence:** Suitable knowledge and education is offered to patients and physicians in order to provide reminders and schedules for taking medication at the right time.
- **Chronic Disease Management:** This type of app aids the patient to monitor their situation without the need to visit a doctor.
- **Remote Monitoring:** This type of app provides safety and reduces the vulnerability of the users to injury; for example, it is used to monitor patients with disabilities and older adults.
- **Personal Wellness and Healthy Living:** This kind of app supplies news, data and educational materials about healthcare.
- **Access to Health Information:** This type of app assists patients to track their healthcare services. The patient can choose whether or not to share their information with family, caregivers and physicians.
- **Teaching/Training:** This type of app provides information and educational materials to help patients to understand some illnesses, such as animations or videos to increase patient understanding.
- **Communication:** This type of app provides actual services to patients and healthcare providers such as the provision of WiMAX technology for distribution video including streaming video. And also offers platform of networking for users like friend, patient and caregiver in order to share and support each other [6].

As shown in Figure 1, most of the papers concentrate on chronic disease management applications and personal wellness and healthy living. Medication adherence applications and teaching or training are also the most critical areas and receive more attention by healthcare market users. This is then followed by access to health information, whereas the other areas such as diagnostic tool, remote monitoring and communication slightly lag behind with less than 10 papers discussing those

particular aspects. However, in an agreement with [25], our analysis shows that there is a lack of apps concentrating on people with a physical disability even though the wellness and healthy living factor is being paid a great deal of attention by the mobile phone community.

A. Mobile Health Features and Contents

Mobile features play a crucial role in facilitating a pleasant and rich user experience [28], which makes the study of the content for m-health apps a top priority. The question of identifying appropriate design features is being actively researched worldwide [30] according to functionality [24, 21], complexity [32] and interface [19, 15, 9]. With regard to the literature review findings in this research, m-health apps must be designed into four broad aspects of features: reminders, monitoring programs, training programs and community networks, as shown in Table 1.

TABLE 1: Top features for m-health apps

Reminder	Monitoring Program	Training Program	Community Network
Text message (SMS)	Touch application	Video conference	Forum (patients, family, caregivers, friends)
Image message	Interactive voice response (IVR)	Video recording	
Automated voice call	Text message	Information display	
Email	Real-time self-monitoring tools	Game	
	Image and sensor	Video phone	
	Tracking tools include GPS	Simulated practice	
	Health journal/log	Catalog	
	Medical record	Article	
		Medical terms/translation	

From the 80 papers that were reviewed from publications from 2004 to 2014, 31 papers extensively discuss the essential use of reminder features where the patient can gain the benefit from an alarm reminding them to handle their health activities. One of the most popular reminder styles is the text message as well as the image message, automated voice call and email. Text messaging is one of the simplest channels to deliver public health messages. For instance, patients get a text message reminding them to take their medicine or to encourage their attendance of appointments [23, 12]. This push technology has been broadly adopted and allows messages to be delivered without any effort on the part of recipient [23]. Research has found that patients are fascinated with using alarm reminders to handle their healthcare activities [31]. Moreover, the reminder message is found to be effective in many ways especially to prevent chronic diseases. Thus, treatment adherence is improved. For example, the effectiveness of this reminder has been reported in the post-treatment review of children with uncomplicated malaria in Western Kenya and improving medication adherence for HIV care [3].

Monitoring program applications consist of touch applications, interactive voice responses, text messages, real-time self-monitoring tools such as monitoring video applications based on the patient's movement, image and sensor tracking tools including GPS, health logs or journals and medical records. It is essential for m-health apps to provide patients with support for treatment adherence. These monitoring apps are very useful tools with which physicians can communicate to their patients and monitor their health during recovery with no geographical boundary. All parties including physicians, patients and caregivers can use text messages to log their health-related activities [23] and flexibly exchange information among each other. For example, text messages sent by patients are processed by the Sweet Talk web application and the reported values are added to the patient's journal [13]. This text-based coaching had a meaningful clinical impact on the healthcare community [22]. The apps should have acceleration sensors that let users interact more closely with more realistic feel and better controls [28] which can enhance the m-health app enjoyment. For example, cardiologists have successfully replaced the use of the stethoscope in outpatient clinics by the mobile phone Vscan ultrasonic sensor. Built-in camera and personal organiser applications such as calendars, schedulers and notepads [28] that support multiple tasks have become increasingly important. These features are useful for collecting and storing health-related data [23]. Meanwhile, the independent living of patients with disabilities and long term chronic diseases could be assisted by using smartphones with GPS and location features [1]. The GPS is very essential for patients to track their information, to search for hospital locations, to automatically

track patients' with exercise routes or to calculate the calories burned during their workouts [23]. Like the related monitoring based applications, the information provided to physicians must be accurate and consistent for appropriate diagnosis and intervention. The monitoring apps could cause serious patient harm if they fail to function as intended.

Training program applications involve video conferencing and recording, teaching or exercise games that may be enhanced by sensor and touch-screen interfaces, video phone, information displays that can facilitate powerful graphics and visual effects, catalogues and articles for reference guides, simulated health practice, and medical term definitions or translations. Training or education programs are an essential part of the m-health apps that provide information about health promotion and disease prevention. As an example, the Johnson & Johnson Text4Baby program provides education to pregnant women and new parents. Such information can fall into two categories, namely, tips and educational content [23], and has a positive impact on the target condition [29].

Community network apps engage with the patient's social environment via forum interactions. It is important to note that, besides peers, all of the patients have family members or close friends with whom they communicate regularly [27]. The apps should be integrated into the social network in order to allow patients, family members and friends to share their experience or ideas about particular diseases. Integrating patients or users into social network forums enables them to share their personal experiences with a particular disease to other people and learn from one another. This feature is useful in order to establish collaboration among users in terms of socialising. For instance, the Houston app uses peer-to-peer social support to share the user's daily progress with a group of friends (known as fitness buddies) and send messages of encouragement to each other [23,7]. Research reports that support from the community has been associated with lower hospital re-admission rates [27], longer survival times in patients with heart failure [8] and the adoption of health-promoting behaviours [4, 5].

Having reviewed the above features and content requirements, the authors argue that m-health apps should integrate these four aspects. Taking these four facets into consideration should enable the integrated use of the apps, and support the interoperability among the different apps. Despite the potential benefits, one of the reasons that m-health app usage has not taken off among physicians is that they are providing a divergent solution, due to the fact that the four features have not been integrated yet. Even though the apps offer tremendous help in delivering better care to patients while cutting costs, the convergence issue still occurs.

B. M-Health User Classification

It is very important to deliver health data to the right person on the right device at the right time. Even physician should be involved and specify the correct medication in order to prevent the occurrence of any mistakes in the use of m-health apps. In order to provide an accurate m-health framework, all the key user groups in m-health apps are identified. The pie chart in Figure 2 illustrates the key user group classification according to our literature review findings. The patient group is the first target user group for m-health apps investigated in the literature, with the high proportion of 44%. This is followed by the physician group (physicians including health specialists, doctors or nurses) comprising 37%. General users and caregivers comprise 12% and 7%, respectively. Thus the patient and physician groups are identified as the major focus user groups for most academic papers.

From the review, it was possible to identify the four top critical features regarding content requirements and user classifications for m-health apps. From the literature it is clear that the accuracy and reliability of content are crucial factors. Designing and producing quality content for apps has become critical due to the users' tastes and preferences according to their different categories.

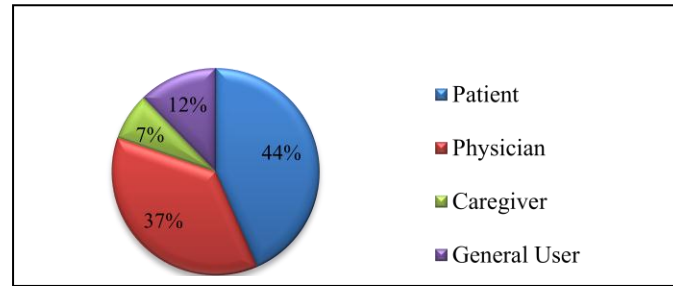


FIGURE 2: Classification of users in m-health apps (2004-2014)

Thus, it is a challenge for developers to satisfy the different user needs which requires serious research in order to facilitate the effective usage of m-health apps. Given that, in the near future, m-health apps must seriously address the need for quality content including the level of content detail and presentation, and users' special needs based on the user categories.

5. PRELIMINARY MOBILE HEALTH FRAMEWORK

In this paper, the authors propose a m-health framework for m-health apps using the following techniques: 1) identifying the critical m-health app features and their content requirements, and 2) determining essential m-health app user group classifications. These techniques are used to ensure sufficient and salient information is gathered, while minimising the amount of data to be transferred to and stored on the m-health app devices by identifying only the features and content that are required by the targeted users. Moreover, most existing frameworks look from the architecture perspective. Thereby, researchers need to develop a new framework based on content. This is a good step that is focusing on critical features and content requirements of m-health. That could help to ensure the delivery of effective, reliable and efficient m-health. Applying the principle of 'less is better' to the features is necessary for m-health apps and any mobile apps that are supposed to be simple and only provide exact and 'just nice' content and functionalities. This is due the mismatch between the mobile app design and the needs of the end-user [26] where the obvious solution is to match the design of the features to the actual needs of the person who will be using it. It is believed that this approach has not been considered adequately in prior research. The preliminary m-health framework is shown in Figure 3, using mobile physiotherapy as an example.

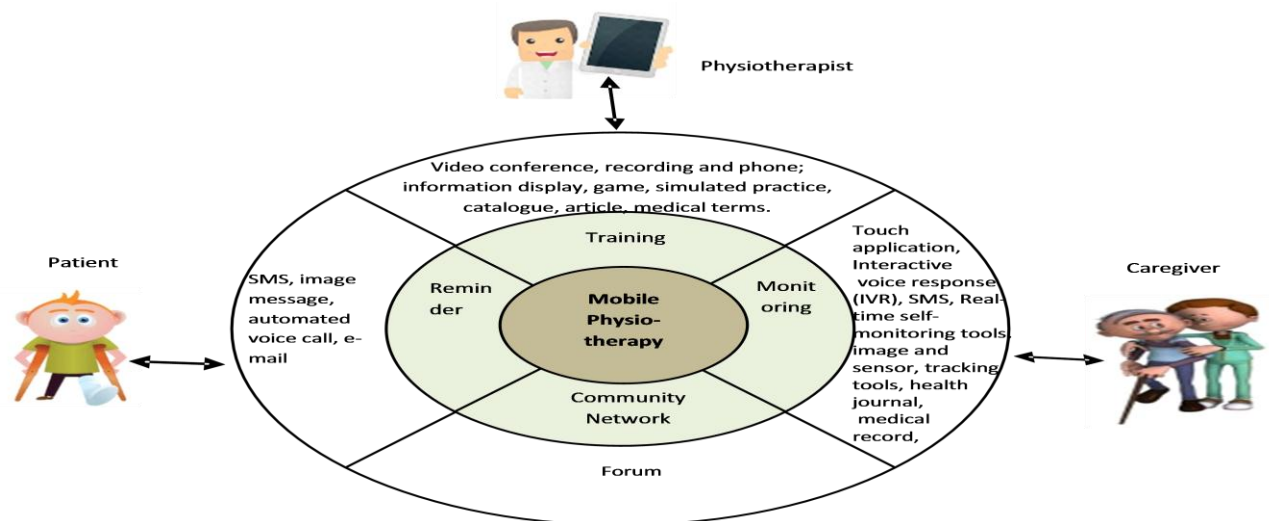


FIGURE 3: Pre-liminary m-health framework

6. DISCUSSION

The mobile phone is becoming an essential part of healthcare and healthy living. Its usage offers sophisticated journaling applications close at hand, using photos, measuring devices and sensors to automate the logging of personal health states [23]. In line with this trend, mobile physiotherapy adoption will change the traditional delivery of healthcare by providing an opportunity to patients, caregivers and physiotherapists to continuously monitor the patient's treatment and health condition outside the clinic and the patient's home [6]. In addition, the technology can provide caregivers with tools to better monitor and care for their loved ones. It can help physicians in making appointments, increase their lifestyle change instructions, types of monitoring and connect to ancillary services such as rehabilitation, home nursing and patient's electronic health record portals. Healing takes more than information: it involves complex problem solving and care coordination that requires medical experience. Therefore the m-health apps require the integrated involvement of the users, namely, the physicians, patients and caregivers, to ensure efficient patient care.

Physiotherapist involvement is often a crucial part of making m-health successful in improving patients' lives. Remote coaching and symptom monitoring, for example, can keep the physiotherapist informed of the patient's condition and facilitate coaching interactions [23] among the physiotherapist, patient and caregiver. Some key benefits for physiotherapists include improving access to real-time patient information and providing patient health education and information during treatment appointments. This is very useful for patients who have physically disabling conditions or mobility problems as the patient can fully interact with the portable device. In a simple example, the diagnosis or treatment of a teenager would not be approached in the same manner as a 90 year-old; likewise, children with cerebral palsy need much higher attention than someone who has a knee injury. Even the prescription should not be standardised. People with the same diagnosis or symptoms require individualised assessments based on the severity of the illness, concomitant medications, extent of caregiver support and the patient's wishes. Although they can have the best physician, if the patient does not follow the treatment or follow up with a physician then it is worthless. With the use of mobile phones, there is a new opportunity to interact with patients because the m-health apps can break down communication barriers.

As the number of built-in devices and applications expands on mobile devices, the provision of appropriate content such as user interfaces becomes increasingly important [28]. For example, acceleration sensors will let patients or physicians interact more closely with better control and realistic feel which enhances their enjoyment of m-health app usage. Therefore, in the near future, mobile apps should produce considerable amounts of content with a view to make effective and efficient m-health app and of course to address two distinct goals of content, namely, production and adoption.

7. LIMITATIONS

Even though the authors believe that their work is sufficient to provide guidelines for m-health app requirements, the study is not without its limitations. For instance, the number of papers that are relevant to this study's context is small which limits the ability to generalise our findings. Further, our review was widened to include different health areas and diseases but future research may focus solely on one area or disease. However, this limitation offered an opportunity for our research as healthcare providers have yet to fully address the m-health app requirements for mobile phones. In this regard, our work can help the healthcare providers to focus their attention on the key features and content of m-health apps.

8. CONTRIBUTION AND CONCLUSION

This paper has proposed an m-health framework by identifying the m-health app critical features and content related to m-health to ensure that the needs of the targeted user groups (physiotherapist, patient and caregiver) are met. It is the authors aim that m-health technology adoption will increase in the near future by improving patient engagement. We believe the findings discussed in this paper can leverage the problem of integration cooperative users into the design of systems to support mobile healthcare work.

By answering the following questions, our findings can be summarised into some key points, and future studies might take these factors into consideration to ensure the development of effective m-health apps.

- Firstly, what are the critical features and content for m-health apps?

To answer the above question, 80 papers from notable publication databases were reviewed. Our findings show that the critical features for m-health apps can be categorised into four aspects, namely, reminder applications, monitoring, training, and community engagement. By classifying these features, the essential content is identified. The reminder feature includes SMS, image message, automated voice call and email. Monitoring consists of touch applications, interactive voice responses, SMS, real-time self-monitoring tools, images and sensors, tracking tools including GPS, health journals/logs and medical records. Training includes video conferencing, video recording, information displays, games, video phone, simulated practice, catalogues, articles and medical term definitions and translations. Community network feature includes, forums (patients, family, caregivers, friends) (as summarised above in Table 1).

- Secondly, what are the essential components of a salient m-health framework?

This study found that m-health apps consist of a few layers of features and content that should consider the user groups' roles regarding its function. The essential components are the reminder application, monitoring, training, and community network with its content and user groups such as physiotherapists, patients and caregivers. The features, content and user groups were then mapped to form the proposed framework. By doing this, we argue that their framework offers the best way to explain the function of the content-based m-health framework. Technology is moving towards wireless solutions, and our proposed m-health framework greatly contributes to this trend. Thus, we argue that our approach offers a viable solution that merits further m-health app innovation development and support.

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