Study of challenges to utilise mobile-based health care monitoring systems: A descriptive literature review

Tayebeh Baniasadi1, Sharareh R Niakan Kalhori2, Seyed Mohammad Ayyoubzadeh1,3, Somayyeh Zakerabasali1 and Marjan Pourmohamadkhan1

Abstract
Mobile health encompasses remote and wireless applications to provide health services. Despite the advantages of applying mobile-based monitoring systems, there are challenges and limitations; understanding the challenges may assist in identifying available solutions and optimising decision-making to apply mHealth technologies more practically. This study aimed to investigate the main challenges related to mHealth-based systems for health monitoring purposes. This review was carried out through investigation of English evidence from four databases, including Scopus, PubMed, Embase, and Web of Science, using a defined search strategy from 2013 to 2017. Two independent researchers reviewed the results based on PRISMA guidelines, and data was categorised using a bottom-up approach to reach a framework for the most general challenges. Among the 105 papers obtained, eight works were selected. The revealed challenges were categorised into six main branches across a tree (with 55 nodes, four levels) including user-related, infrastructure, process, management, resource and training challenges. Identifying the resolvable and preventable challenges, such as those related to training, design might play a crucial role in preventing loss of resources and in growing the success rate of a project, particularly if considered in national level projects.

Keywords
mHealth, patient monitoring, remote monitoring, challenges

Introduction
Nowadays, e-Health is used both for patients and the care providers, and promotes health and disease management using newly developed tools and systems. These tools are used for many applications, including personal electronic records, disease management applications, clinical alerts and reminders, and electronic monitoring systems.1 One of the potential uses of information technology in the healthcare system is in applications for patient monitoring and follow up, which can include wearable sensors, mobile apps and other technologies and devices.2–4

Patient monitoring can be defined as the continuous measurement and observation of vital and/or physiological functions, to support decisions for treatment interventions. Remote monitoring is also one of the remote healthcare subgroups that seek clinical information about a patient at home, or in other places, and can transfer data to collecting and analysis centres.5

Mobile health (mHealth) is a subset of eHealth and refers to the use of portable wireless devices capable of transmitting, storing, processing and retrieving
real-time and non-real-time data between patients and medical personnel. mHealth describes services supported by mobile communication devices such as patient monitoring wireless devices, smartphones, personal digital assistants (PDAs) and tablet PCs. Digital mobile devices have greatly improved communication between patients and healthcare providers, self-care management and remote monitoring in order to achieve health goals.

The chronic and progressive nature of many diseases, often characterised by symptoms that can vary from day to day or over long periods, offering an ideal opportunity for the greater application of wearable patient monitoring (WPM) systems.

Wearable systems or sensors and medical devices are widely used to measure key health indicators such as electrocardiogram (ECG) readings, heart rate (HR), blood pressure (BP), oxygen saturation, body temperature and physical activity. These systems are designed to collect a variety of disease data sets. This can be achieved by collecting small, inexpensive, convenient and wearable sensors that can be connected to the internet through data collectors such as smartphones.

There are potential benefits of using health information technology, including improvements in patient care quality, faster response to patient needs, better communication between patients and clinical professionals, higher quality information for clinical decision making and more comprehensive and timely data processing. It also has the potential for patient empowerment, playing an active role supporting patients as individuals with the right to choose and that are involved in the decision-making process.

Despite the benefits of using technology and its capabilities, there are shortcomings associated with the emerging information and communication technology (ICT) sector in healthcare. There is also evidence indicating that the technology itself can also be part of the problem. Neglecting the complications and challenges of the use of emerging technology in the healthcare field may be dangerous and have irreparable results.

According to several studies in the field of patient monitoring technology, despite their benefits, there are challenges that must be addressed. Understanding the different dimensions of existing or potential challenges and threats may help strategic decision-making by professionals to implement and develop such technologies in the healthcare sector. In general, the identification of specific individual challenges will also help identify existing solutions.

Most studies have addressed specific aspects of such challenges (from a largely technical, regional, or managerial point of view), and fewer studies have examined aspects of the problem from different views. Therefore, the present study aimed to systematically determine the challenges of mobile health monitoring systems from different perspectives.

Methods

Search strategy

An electronic search of four databases (Scopus, PubMed, Embase and ISI) was carried out. The search strategy was built on three core concepts: ‘challenge’, ‘mHealth’, and ‘monitoring’. The search was limited to a 5-year period (2013–2017). The steps for building the search query for the PubMed database are presented in Table 1. Equivalent searches were then conducted according to the instructions provided for each database.

Inclusion criteria

The search for challenges to utilise mobile-based healthcare monitoring systems was restricted to the English language and articles published as a journal paper or in conference proceedings. Articles were included if they reported the results of mHealth challenges in health monitoring. As technology advances quickly, and the challenges faced by these technologies differ over time, with the aim of investigating recent challenges and barriers this study contains only

<table>
<thead>
<tr>
<th>Table 1. PubMed search query.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search terms</strong></td>
</tr>
<tr>
<td>1. challenge[ti] or challenges[ti]</td>
</tr>
<tr>
<td>2. limitations[ti] or obstacles[ti]</td>
</tr>
<tr>
<td>3. barriers[ti] or barrier[ti]</td>
</tr>
<tr>
<td>4. problem[ti] or problems[ti]</td>
</tr>
<tr>
<td>5. issue[ti] or issues[ti]</td>
</tr>
<tr>
<td>6. 1 or 2 or 3 or 4 or 5</td>
</tr>
<tr>
<td>7. wearable[ti]</td>
</tr>
<tr>
<td>8. m*health[ti]</td>
</tr>
<tr>
<td>9. mobile[ti]</td>
</tr>
<tr>
<td>10. 7 or 8 or 9</td>
</tr>
<tr>
<td>11. follow*[ti]</td>
</tr>
<tr>
<td>12. monitor*[ti]</td>
</tr>
<tr>
<td>13. surveillance[ti]</td>
</tr>
<tr>
<td>14. care[ti]</td>
</tr>
<tr>
<td>15. tele[ti] or remote[ti]</td>
</tr>
<tr>
<td>16. metry[ti] or sensor[ti] or sensing[ti]</td>
</tr>
<tr>
<td>17. 15 and 16</td>
</tr>
<tr>
<td>18. tele<em>monitor</em>[ti]</td>
</tr>
<tr>
<td>19. tele*care[ti]</td>
</tr>
<tr>
<td>20. telemedicine[ti]</td>
</tr>
<tr>
<td>21. 10 or 11 or 12 or 13 or 14 or 17 or 18 or 19 or 20</td>
</tr>
<tr>
<td>22. 6 and 10 and 21</td>
</tr>
</tbody>
</table>
articles that were published in a recent 5-year period (2013–2017 inclusive).

**Exclusion criteria**

Because our aim was focused on reviewing mHealth challenges in health monitoring, papers that study non-human monitoring and for non-clinical purposes were excluded. Also, review and systematic review articles that were entered in the search result, and articles for which the abstract and full-text were not available to us were also excluded.

**Screening and article selection**

Articles were imported into Mendeley reference management software. After removal of duplicate records, articles were screened independently at the title and abstract level by two researchers (SMA, TB). Disagreements between reviewers were resolved by consensus, or by consulting the third reviewer (ShRNK). Records of potentially relevant articles were downloaded and imported into EndNote reference management software for eligibility assessment.

**Analysis**

Extracted information was tabulated, categorised, and presented graphically in a hierarchy structure. Data was categorised using a bottom-up approach to reach a framework of the most general challenges. This review was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

**Results**

The process of article selection is shown in Figure 1. Eight studies were included in this literature review. The indicated challenges in these eight papers were either investigated by the authors or extracted from previous works. Summarised results of extract information from these eight articles are presented in Table 2.

![Figure 1. The PRISMA-based article selection process flow chart.](image-url)
Table 2. Reviewed papers’ characteristics and addressed challenges of mHealth-based health monitoring systems.

<table>
<thead>
<tr>
<th>Article title</th>
<th>Author, year, country</th>
<th>Target area</th>
<th>Tools</th>
<th>Addressed challenges/limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone technology for improved mental health care in South Africa: possibilities and challenges</td>
<td>Norris et al.19 2013 South Africa</td>
<td>Mental health</td>
<td>Mobile phone</td>
<td>Ethical considerations, trained therapists in administering mobile therapy, communication between the therapist and client, lack of insurance coverage, reluctance of therapists to adopt this medium of therapy, digital illiteracy, languages, quality control (Inaccurate information without empirical evidence), security, privacy</td>
</tr>
<tr>
<td>Challenges and trade-offs involved in designing embedded algorithms for a low-power wearable wireless monitor</td>
<td>Hernandez-Silveira et al.20 2014 United Kingdom</td>
<td>Ambulatory monitoring/ Monitoring vital signs</td>
<td>Wearable wireless monitor</td>
<td>Motion artifacts, Negative impact of body movement On the quality of the physiological data &amp; ECG signal</td>
</tr>
<tr>
<td>Challenges in wearable personal health monitoring systems</td>
<td>Kim et al.21 2014 USA</td>
<td>Wrist-worn health monitoring</td>
<td>Wearable bio-signal sensing systems</td>
<td>Multi-Modality/Multi-functionality, power consumption, the electronics size, data transfer bandwidth, simultaneous electrochemical sensing, electrode DC offset, motion artifact Practical daily use: battery duration or autonomy related problems, obtrusiveness while wearing, hygiene and allergy issues, ruggedness of device in terms of water, shock, temperature or dust and dirt resistance Data and measurement procedures: robustness of data measurements(affected by proper placement of the wearable device, body hair, vibrations or external light sources), data accuracy and validity, connecting/pairing the wearable devices, and synchronisation with mobile phone or Internet, exporting of data, privacy and security User experience: unclear feedback, the design of user interfaces, interaction usability issues</td>
</tr>
<tr>
<td>Challenges in wearable devices based pervasive wellbeing monitoring</td>
<td>Rustie et al.22 2016 Spain and Slovenia</td>
<td>Pervasive wellbeing monitoring</td>
<td>Wearable monitoring device</td>
<td>Adherence and attrition Data artifacts, missing sensor data and misreports, technical problems (battery life, standard hardware, app design) Motion artifacts and other interferences Discomfort related to positioning of sensors Battery issues of sensors and smartphone, generation of false alarms, calibration The dependence of the proposed algorithm on specific hardware</td>
</tr>
<tr>
<td>Scalable passive sleep monitoring using mobile phones: opportunities and obstacles</td>
<td>Saeb et al.23 2017 United States</td>
<td>General population (sleep monitoring)</td>
<td>Mobile phones</td>
<td></td>
</tr>
<tr>
<td>A wearable patch to enable long-term monitoring of environmental, activity and haemodynamics variables</td>
<td>Etemadi et al.24 2016 USA</td>
<td>Chronic cardiovascular diseases and the general population</td>
<td>Wearable patch</td>
<td></td>
</tr>
<tr>
<td>A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors</td>
<td>Kakria et al.9 2015 Thailand</td>
<td>Heart patients</td>
<td>Wearable biosensors</td>
<td></td>
</tr>
<tr>
<td>Smart ECG monitoring patch with built-in R-peak detection for long-term HRV analysis</td>
<td>Lee et al.25 2016 Seoul, Republic of Korea</td>
<td>Long-term ECG (heart rate) monitoring</td>
<td>Smart electrocardiography (ECG) patch</td>
<td></td>
</tr>
</tbody>
</table>
We have presented all findings in a tree-like structure composed of six main branches, as shown in Figure 2, presenting the main categories of mHealth applications challenges in monitoring systems as follows:

1. **User-related challenges** correspond to users of the system, and comprised the different levels of users’ digital literacy, lack of technology acceptance, lack of enough commitment to use technology, and weak communication between caregivers and patients.

2. **Infrastructure challenges** are not under the control of the developer and are related to standards, regulations (e.g. insurance coverage), and communication technologies such as Bluetooth, Wi-Fi, cellular data connection and their technical features.

3. **Process challenges** are not related to a specific part of the system and must be considered in every component of it. In these challenges, several difficulties, including security (e.g. authentication and authorisation), confidentiality and ethical concerns, were identified.

4. **Management challenges** consist of difficulties related to weak quality control and legislation.

5. **Resource related challenges** are related to hardware, software, lack of specialised developers and cost.

6. **Training related challenges** are related to those issues that are due to the lack of user training and instruction.

**Discussion**

To investigate the challenges involved in applying mHealth-based monitoring systems, a review was conducted. Generally, it was revealed that various barriers, such as not considering system users, weak design to achieve a good communication with the system, low level of technology acceptance and commitment, not meeting standardised requirements in system design, creation and implementation phases along with poor interoperability may decrease the chance of system success. Furthermore, technical issues, including hardware and software considerations, can also be problematic. Lack of developer knowledge about system requirements, sustainable financial support and proper infrastructure also might be important. Furthermore, mHealth-based systems that are equipped with sensors might encounter different challenges and difficulties. Other review studies were conducted from different viewpoints, for example, Baig and colleagues addressed WPM system challenges in four domains including sensors and signals, connectivity, data processing, integrity and clinical decision support, patient engagement and interaction. Moreover, according to the World Health Organisation’s report, there are other challenges for applying and developing mHealth systems such as security, cost, interoperability, scalability issues and knowledge level of local developers. In another study, Mohamadzadeh and Safdari raised other challenges such as system confidentiality and acceptance as well as interoperability with electronic health records. In addition, a low level of face-to-face relationship and technical difficulties with communication were mentioned. Moreover, Ali revealed other challenges regarding mHealth applications for infectious disease surveillance, including technical, financial, political, social, ethical and cultural barriers. Gurupur and Wan revealed five major areas of challenges, focusing only on the technical aspects required to implement mHealth-based systems comprising usability, system integration, data security and privacy, network access and reliability.

In this study, we have reviewed literature and evidence including research articles and review works to gather and organise all the challenges into six categories. To overcome these challenges in each section, we suggest:

For **User-related challenges**: user friendly design and an active role for users in every step of system development, according to the age group and level of user literacy, their taste and experience, should be considered; otherwise, tools may be designed based only on technical views and engineering aspects, resulting in systems that might either be used inappropriately or avoided in routine practice.

For **Infrastructure challenges**: infrastructure barriers are sometimes due to lack of specific standards and a low level of awareness of available standards; as these systems are used for patient monitoring, they are required to be evaluated based on standards approved by officials on a regular basis. Communication-related challenges in the case of cellular data connection and Bluetooth need to be checked in terms of sustainable connectivity and pairing, respectively, particularly in emergency and sensitive situations. It is necessary to ensure that, in cases where these limitations cannot be resolved, the use of the system is stopped due to patient safety.

For **Process challenges**: available solutions should be studied, and technical difficulties resolved by experts, in addition to providing sufficient training and advice about the problems observed by users, including health care providers, patients and others.

For **Management challenges**: efficient system control is required on a regular basis; also, comprehensive legislation for effective management is necessary.

For **Resource-related challenges**: applied hardware for interventions such as patient monitoring tools need to be considered according to standards principals. factors such as size, weight, energy consumption, potential risk and threat for patient safety.
Figure 2. The tree-like structure of mHealth Monitoring Systems Challenges.
should be tested in a pilot survey by a specialised team. From the viewpoint of software-related challenges, proper attention to the theoretical concepts in the design process is crucial. Also, it is important that user-related problems be considered through user-centred design. It is also necessary that usability factors and appropriate user interfaces be considered. Obviously, sufficient and sustainable financial resources need to be available before and during project implementation.

For Training-related challenges: it is highly advised that the consequences of poor education of users, especially of patients, is considered. To increase the chance of success of an mHealth project, the user training process needs to be personalised based on age, literacy, understanding and knowledge level.

Generally, the categorisation of challenges can be depicted as a tree-like structure with two main branches, including technical and nontechnical aspects, or a tree with wearable and non-wearable systems branches. The relationships between challenges could also be presented graphically in future work. Furthermore, mHealth-based monitoring system challenges could be studied at a broader level including national and international investigations such as legal barriers and the digital divide issue.

The challenges in mHealth-based monitoring systems identified here may cause the systems to be either refused or used improperly. Understanding these barriers may lead to the creation of a valid evaluation and appraisal framework to check available mHealth systems and develop solutions that are useful for project developers and managers to prevent problems in further works; furthermore, they might be useful for policymakers at a national level to apply information technologies for health purposes more effectively through the establishment of useful policies, regulations and guidelines.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Seyed Mohammad Ayyoubzadeh http://orcid.org/0000-0001-8450-7818

References

16. Gleason AW. mHealth—Opportunities for transforming global health care and barriers to adoption. Journal