

# A recommended guideline for the development of mHealth Apps

Ioannis A. Chatzipavlou, Sofia A. Christoforidou, Maro Vlachopoulou

Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece

*Contributions:* (I) Conception and design: SA Christoforidou, IA Chatzipavlou; (II) Administrative support: All authors; (III) Provision of study materials or patients: SA Christoforidou, IA Chatzipavlou; (IV) Collection and assembly of data: SA Christoforidou, IA Chatzipavlou; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*Correspondence to:* Ioannis A. Chatzipavlou, PhD Candidate. Department of Applied Informatics, University of Macedonia, 156 Egnatia Street, GR-546 36 Thessaloniki, Greece. Email: gcha@uom.edu.gr.

**Background:** Mobile Health or mHealth applications cope with medical or health issues supported by smartphones. Being a part of great importance in healthcare, mHealth apps are able to improve both the quality of medical services and the safety of the patients. It is regarded to be a new field with great prospect that attracts the interest of the stakeholders and the developers, above all. Of all the entities involved, developers have to face many challenges classified in four pillars: the regulation framework, the market, the technical issues and society. This paper aims to describe the role of the developers in the mHealth apps' market, the barriers they deal with and also, the impact of their work in the mobile healthcare domain. In our viewpoint, we propose a guideline with all of the developers' requirements for the buildup of mHealth apps.

**Methods:** The methodology followed includes a Boolean search strategy used in academic libraries (PubMed, IEEE Xplore, JMIR, The Cochrane Library) and search engines additionally (Google and Google Scholar), aiming to identify the developers' perspective.

**Results:** Our research from October until December of 2014 led us to academic papers referring to the various demands that developers have to confront. The major outcome of our research is the general acknowledgement of the dominant role that developers own in the mHealth apps' process.

**Conclusions:** Mobile technology allies multiple groups such as users, patients, providers of medical services, software developers, governments and even, non-governmental organizations. In particular, the developers' perspective involves the legal boundaries, the side of the market, the technological requirements (programming, devices, designing) and the moral aspects, as well. Developers should define the purposes of their apps—either diagnostic or therapeutic—and gain the confidence of the users in order to dominate the market, yet comply with the regulations.

**Keywords:** mHealth; developers; applications; apps

Received: 19 March 2016; Accepted: 04 May 2016; Published: 18 May 2016.

doi: 10.21037/mhealth.2016.05.01

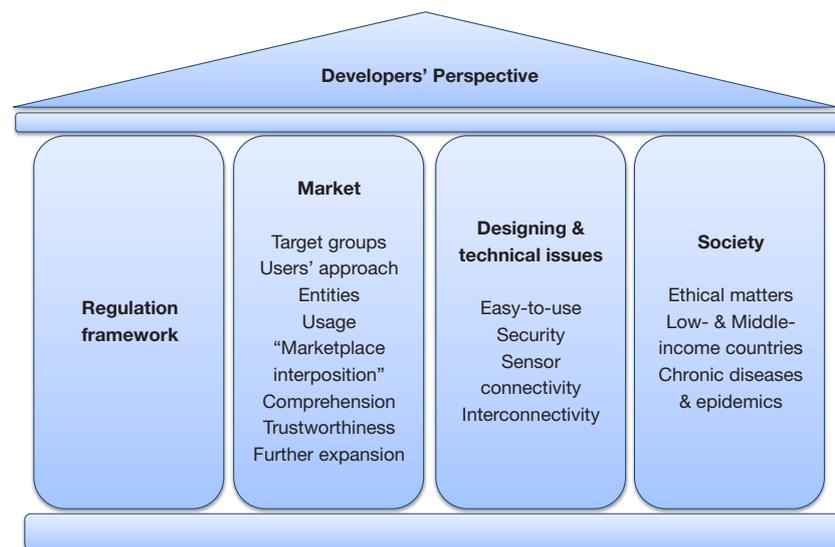
**View this article at:** <http://dx.doi.org/10.21037/mhealth.2016.05.01>

## Introduction

Mobile Health or mHealth is regarded to be a sub-segment of eHealth and its domain is the medical or public health practice supported by mobile devices (1), mainly smartphones. As a matter of fact, the arrival of smartphones in the market in 2007 (2) brought the innovative emergence of the apps. MHealth applications appeared later and are related to healthcare systems in multiple ways; information,

diagnosis, treatment etc. mHealth's prospect is significant both for the improvement of the healthcare systems and for the economic interest around the field. Nowadays, is considered to be the biggest technological breakthrough and its potential is increasing.

As a result, the undeniable utility of mHealth apps continuously raises the interest in this sector. Developers are defined as Information and Communication Technology (ICT) professionals who “build/code



**Figure 1** Four pillars of developers' perspective.

ICT solutions and specify ICT products according to the customers' needs" (3). Specifically, mHealth app developers, recognizing the potentials of the field, are making an effort to understand the characteristics and the direction that mHealth apps' market is going to follow in order to intervene, having not a strategy which observes the changes, but a leading one.

The aim of this "umbrella review" paper (4) is to describe the executive role of developers in mHealth market from their own perspective and come up with a guideline for the development of mHealth apps. To our knowledge, no former research has been undertaken to refer to the developers' entity exclusively. In particular, the developers' perspective encloses the technological requirements (programming, devices, design), the financial aspect (characteristics and prospects of the market) and the legal barriers. The legal barriers include the regulations about mHealth apps market, but also the moral option of the issue; additionally, involve the relations and the interaction with the doctors and the patients under the target of the improvement of the healthcare systems, the common good of the societies and the interest of the developers.

## Methods

Our methodology constitutes of an extended research for articles in the following academic libraries: PubMed, JMIR,

The Cochrane Library, IEEE Xplore and additionally, in the search engines Google and Google Scholar from October until December of 2014. We selected the following Boolean search strategy: mhealth OR "mobile health" OR medical AND developer AND smartphone AND apps OR app and the criteria were the accessibility of the reviews (whether they are available without cost or not), the date (selecting the period from 01/01/2007 until 31/12/2014) and the language (English).

JMIR is supposed to be a limited and focused library. Thus, the Boolean search strategy did not return any results from this academic database. We, then, decided to just use the term Developer and search in the mHealth category.

Once the selection of academic papers was complete, we gathered so as to pick the articles finally used in our paper. We cited them by reading their titles, their abstracts as well as the whole paper, whenever it was required. The selection process brought forth a total of 15 articles.

## Results

We aimed for a variety of papers referring to all kinds of aspects about the development of mHealth apps. As a result, we decided to follow some work streams, in order to present the matters concerning the developers. Consensus was reached in four pillars, presented in *Figure 1*.

- (I) Regulation framework: in this section we mention the main legal instructions for the mHealth apps.

- (II) Market: the interaction of all entities (users, patients, medical professionals etc.) with the developers is examined in this part.
- (III) Designing and technical issues: this subdivision focuses on the developers' principal matter which is the technological area.
- (IV) Society: the last pillar covers some ethical and

social affairs related to mHealth apps.

Since the division of the selected papers wasn't distinct, based on their content, we settled a classification of them complying with the subjects of the pillars been set (Figure 2).

As mentioned above, we confronted the heterogeneity of the total papers picked by categorizing them in Table 1, according to the topics of the four pillars.

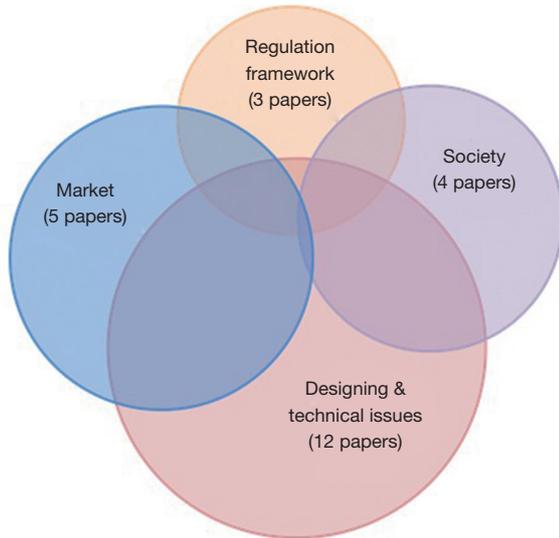


Figure 2 Classification of the papers examined in our paper.

## Discussion

### Regulation framework

Firstly, we have to state that the area of regulation of mHealth market is currently on an ongoing state in order to be defined. The newborn character of the market and the significance of the field are responsible for the difficulties in regulations' arrangement. Also, a clear line does not exist between which mHealth apps appertain to the regulation and which do not; the basic criteria are the level of intervention in user's health and the level of sensitive patient information being handled by the app (5,6).

If some developers intend to release mobile apps for both diagnostic and therapeutic purposes, they should obtain either the Medical Devices Directives (MEDDEV) Guideline in the European Union or the FDA Guideline in the United States of America, before they put it in the market (6). Nevertheless, there is a definite amount of

Table 1 Classification of the articles based on the 4 pillars

Author(s), year	Regulation framework	Market	Designing & technical issues	Society
Batrick and Telemedicine Alliance, 2004	-	-	√	-
Lorenz <i>et al.</i> , 2007	-	-	√	-
Guerra <i>et al.</i> , 2009	-	-	√	-
Liu <i>et al.</i> , 2011	-	-	√	-
Garvin, 2012	√	-	-	√
Hebden <i>et al.</i> , 2012	-	√	√	-
Sundar <i>et al.</i> , 2012	-	√	-	-
Choi <i>et al.</i> , 2013	√	-	-	-
Craven and Selvarajah, 2013	-	√	√	√
Becker <i>et al.</i> , 2014	√	√	√	-
Dunsmuir <i>et al.</i> , 2014	-	-	√	√
Dunton <i>et al.</i> , 2014	-	-	√	-
Su Xing <i>et al.</i> , 2014	-	-	√	-
Wang <i>et al.</i> , 2014	-	√	√	√
White <i>et al.</i> , 2014	-	-	√	-

applications that actually adopt the regulations and the laws—or are at least certified (1).

A challenge that developers need to surpass by any means is to guarantee reliability and gain the confidence of all the entities involved. Trustworthiness has to be an issue of vital importance, when it comes to the medical field. There is a certain need for safety measures in order to ensure the patients' safety and privacy. MHealth apps have to satisfy a lot of necessary standards so as to be used both by healthcare professionals and non-professional patients (7). Developers have to take into consideration the applicable laws and regulations applied in the medical sector in the process of producing a new app (6).

### *Market*

#### **Target groups**

A challenge that developers have to confront is to understand the market generally but also the target group of their apps. They have to realize the demands of the target group so they have to locate the demographic characteristics of them (8). For example, younger adults pay attention in the procedure of signing in and in the speed of the session (the time that results are being displayed), while older adults care about the quality of the results (9).

#### **Users' approach**

A domain to be examined is the growth of mHealth applications from different perspectives. At first, there is the psychological perspective with the consumers' needs and expectations. Then, developers focus on the technological perspective of app development and finally, the legal and regulatory perspective. In general, the vital strategies to support sustain growth in the mHealth business need to be listed (1). Developers should not only encourage users towards all new and innovative mHealth apps, but also persuade them through the so called "motivational technologies". Navigability, interactivity and customization of the applications could be the keys for satisfied consumers (10).

#### **Entities**

Mobile technology allies multiple groups such as consumers, patients, providers of medical services, software developers, governments and even, non-governmental organizations (8). Therefore, developers should aim to improve access to health care and delivery, engagement of patients and clinical outcomes throughout mobile

communication novelties. The broad availability of mobile Web access allows developers to expand their clientele. However, the continuous and increasing offer of mHealth apps sets high hopes in the market (1).

#### **Usage**

As long as consumers are concerned, developers may examine the degree to which apps are not only downloaded but also used and the improvement of apps' effectiveness. So far, most attempts in app development have been in the general wellness category, with diet and exercise apps dominating in the market (9).

Despite the increasing availability of mHealth applications, the majority of them has only simple functionality and usually does little more than provide information. Patients seem to need a little support on quality issues, so as to manipulate an overwhelming amount of mHealth apps (1).

#### **"Marketplace interposition"**

In addition, developers are obliged with the responsibility of "marketplace interposition". This term refers to the encouragement of society to permit self-treatment and unauthorized practice of medicine, because of the technological advancement. There is special need to examine the way people actually handle their right to take care of their health by themselves. Thus, the technological advancement calls for new measure of regulation to ensure safety (1,10).

Another point of the limitation of the "marketplace interposition" is the assumption of responsibility by the consumers over their health issues. Unfortunately, the creation of effective and efficient health apps does not guarantee the improvement of health on its own. Consequently, application development needs to involve both public health and clinical professionals, who are able to address the health problems to the patients. The aim is that mHealth apps will be used by patients, as well as by patients who need them the most (1).

#### **Comprehension**

Programmers need to deal with a limitation related to the general human perception. Once medical information is presented, there is a chance that almost half the people who read it will not be able to understand what it means. The whole time the designing process lasts; developers should aim for optimum comprehension and effectiveness (8).

In order to accomplish that, they need to take into consideration the amount of information that the patient,

the consumer and the doctor have to read and access. In general, comprehension can be a key to the success of apps, but it is not necessarily sufficient in the mHealth app sector (1).

### **Trustworthiness**

A domain for further research might be the extent to which people trust their mHealth app and its recommendation (10). Moreover, apps that drive to health outcomes and are based more on a health belief model are more expensive. This fact affects the conquest of specific populations in the market. A suggestion for the future is that app developers should collaborate with behavior changes experts, so as to achieve better health outcomes (10).

### **Further expansion**

Besides the health outcomes, developers may need to expand to other fields, such as the change of health behaviors in disease management. The presence of follow-up and continuous checking up on patients arise the psychological aspect of mHealth apps. It would be interesting to see whether mHealth apps could facilitate chronic disease patients (11) or if they could even change the factors that attribute to chronic disease, such as busy lifestyle and unhealthy eating habits (1,9).

### ***Designing and technical issues***

Developers of mHealth apps are mainly concerned about the design process. They should take into consideration the specification of features and the user interface design choices, made during developing process. They should also pay attention to the details of implementation, the dynamic visit protocol and the synchronization of data across study devices (12).

### **Easy-to-use**

As far as the user interface design is concerned, developers should consider the users' technical abilities, the type of data being collected and the size of the mobile device display. Aiming the development of an easy-to-use application, developers could conduct design and usability studies, referring to the users (13).

Another demanding task, that developers need to deal with it, is to improve the usability of mHealth apps. Examples of medical fields in which mHealth apps are promoted could be an epilepsy patient monitoring system (14) or an app for low back disorders (15).

The mobile platform selected by the developers allows fundamental technologies, database and networking support to be provided throughout the apps. Specifically referring to iOS (16) the operating system is qualified with various libraries regarding graphics and animation. Mobile software architecture in general and mainly 2D/3D visualization technology may ameliorate mHealth apps' accessibility (16).

### **Security**

Also, security is supposed to be a challenge when data are collected on mobile devices. Developing a strategy to ensure data are only accessible to those authorized to access the data is essential in any clinical study. Developers are expected to overcome the numerous technical challenges of conflicting data and data loss (11,13). As a result, developers have to satisfy the need for the automatic detection of data loss episodes by using all software and hardware means available (8).

### **Sensor connectivity**

The use of mobile sensors, in order to select data, could contribute to the encouragement of a healthier lifestyle, too. Sensors are categorized in video sensors, environmental-based sensors and wearable sensors (17). Most mobile devices nowadays are equipped with, at least, accelerometers or compasses. Taking advantage of the technical means available and the trend of users to healthy fitness habits or caring of the elderly, developers could aim to specific parts of the population in the market (9,17).

A design principle usually is the sensor fusion, according to (18). Developers are able to benefit from the different sensors that mobile devices come up with and end up with more punctual measurements, consolidating the input collected by all the sensors of a mobile device. In consequence, manufacturers manage to balance the disadvantages of one sensor with the advantages of another one (9,18).

### **Interconnectivity**

From a technological point of view, an app cannot be an "independent piece". Hardware and software components increase the complexity. There are at least 4 large operating systems for smart devices, drivers that are not standard and protocols that differ between mobile phone producers (1). There is also a variety of programming and design techniques leading to a heterogeneous configuration of the mHealth app development (19). Consequently, the

consolidation of all different systems remains a challenge in the developers' field (9).

### *Society*

#### **Ethical matters**

Apart from the regulation tasks, developers may need to confront ethical issues as well. The connection of smartphones to sensors able to measure physiological functions and the transmission of sensitive personal data are part of the ethical aspect (6). The reporting of health information may include evidence about health states, mood or behaviors. Thus, an emerging consideration for developers could be the construction of mHealth apps in which self-reporting of patients includes physiological measurement or not (8).

#### **Low- and middle- income countries (LMICs)**

Even before smartphones, personal digital assistants (PDAs) were used as the first electronic mHealth tools. Nowadays, developers are challenged to combine application devices (smartphones, tablets, etc.), medical devices and using clinical studies to develop mobile health applications. The growth of mobile use in many LMICs, where health management is also in great need of improvement, could guide the future development of mHealth tools (13).

#### **Chronic diseases and epidemics**

Furthermore, a developers' goal to be achieved could be the development of apps focusing on chronic diseases that are epidemic in the world. The developers' challenge is to achieve an approach that will focus on its person separately, facilitate the accessibility and the clinical effectiveness, even under so demanding circumstances (11).

### *Limitations*

Despite our systematic search for academic papers as far as developers' perspective is concerned, we have unavoidably faced some limitations, concerning the whole search procedure. Our aim was to define the broad role of developers in the development of mHealth apps. Yet, we recognize, that the continuous development of mHealth sector arises new elements every day. In particular, we did not refer to the cost or the time scheduling of the designing of mHealth apps. Moreover, we did not mention any specific element that developers should take into consideration, according to precise health issues. As a result,

a general presentation of the developers' perspective in the mHealth area was achieved.

### *Future research*

Since the role of developers remains executive in the mHealth sector, a field for further research could be the development of innovative applications according to the medical (diagnostic, therapeutic etc.) and humanitarian (psychological, social etc.) needs. Therefore, there are various potentials for further research in the continuously demanding field of health, as far as mobile applications are related to.

### **Conclusions**

In this paper, we present many aspects of great importance that developers need to take into consideration in the mobile health market. These requirements have been selected according to the articles included and have been categorized into the regulation framework, the market field, the designing process and the social aspects. Developers should obey the rules and keep to the regulation of privacy, in order to gain the trust of the users. As far as the market is concerned, there are several factors for attention, such as the entities involved in the mHealth field, the usage, the comprehension and the trustworthiness of mHealth apps. In the designing process, the dominant role of developers has to ensure the usability of apps, the security of data collected and the interconnectivity of all hardware and software means available. Finally, in the social and humanitarian domain, developers could take into consideration the moral issues for the amelioration of health management in LMICs.

In conclusion, mHealth apps could improve both the quality of healthcare and the safety of the patients. Eventually, mobile health applications are becoming a significant part of healthcare. The potentials of developers have yet to be exploited in this particular field. We believe that this paper has managed to cover the principal points of developers' perspective about the mobile health applications.

### **Acknowledgements**

Special thanks to Vasileios Pavlou and Kyriakos Andriotis.

### **Footnote**

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

## References

1. Becker S, Miron-Shatz T, Schumacher N, et al. mHealth 2.0: experiences, possibilities, and perspectives. *JMIR Mhealth Uhealth* 2014;2:e24.
2. Rollins M. The Android Application Business. In: Rollins M. *The business of Android Apps Development*. New York: Apress; 2011;1-21.
3. CEN. European ICT Professional Profiles. CEN Work Agreem 2012;(CWA 16548):1-46. Available online: <ftp://ftp.cen.eu/CEN/Sectors/List/ICT/CWAs/CWA%2016458.pdf>
4. Paré G, Trudel MC, Jaana M, et al. Synthesizing information systems knowledge: a typology of literature reviews. *Inf Manag* 2015;52:183-99.
5. Veijalainen J, Hara V, Bisong B. Architectural Choices for mHealth Services in Finland and Cameroon. Lulea: 2011 IEEE 12th International Conference on Mobile Data Management *IEEE*;2011:46-51.
6. Garvin W. The Legal Perspective of mHealth in the United States. *J Mob Technol Med* 2012;1:42-5.
7. Choi W, Park MA, Hong E, et al. Development of mobile electronic health records application in a secondary general hospital in Korea. *Healthc Inform Res* 2013;19:307-13.
8. Craven MP, Selvarajah K, Miles R, et al. User requirements for the development of smartphone self-reporting applications in healthcare. In: Kurosu M, editor. *Human-Computer Interaction. Applications and Services*. Berlin: Springer-Verlag Berlin Heidelberg; 2013.
9. Hebden L, Cook A, van der Ploeg HP, et al. Development of smartphone applications for nutrition and physical activity behavior change. *JMIR Res Protoc* 2012;1:e9.
10. Sundar SS, Bellur S, Jia H. Motivational Technologies: A Theoretical Framework for designing preventive health applications. In: Berlin: Proceedings of the 7th International Conference on Persuasive Technology (PERSUASIVE 2012), LNCS 2012;112-22.
11. Wang W, Chan S, He HG. Developing and testing a mobile application programme to support self-management in patients with stable angina: a feasibility study protocol. *Stud Health Technol Inform* 2014;201:241-8.
12. Lorenz A, Mielke D, Oppermann R, et al. Personalized mobile health monitoring for elderly. In: New York: *MobileHCI '07 Proceedings of the 9th international conference on Human computer interaction with mobile devices and services*; 2007:297-304.
13. Dunsmuir DT, Payne BA, Cloete G, et al. Development of mHealth applications for pre-eclampsia triage. *IEEE J Biomed Health Inform* 2014;18:1857-64.
14. Battrick B, editors. *Telemedicine 2010: visions for a personal medical network*. Noordwijk: ESA Publications Division; 2004:42.
15. Guerri JC, Antón AB, Pajares A, et al. A mobile device application applied to low back disorders. *Multimed Tools Appl* 2009;42:317-40.
16. Liu C, Zhu Q, Holroyd KA, et al. Status and trends of mobile-health applications for iOS devices: A developer's perspective. *J Syst Softw* 2011;84:2022-33.
17. Su X, Tong H, Ji P, et al. Activity recognition with smartphone sensors. *Tsinghua Sci Technol* 2014;19:235-49.
18. White PJ, Podaima BW, Friesen MR. Algorithms for Smartphone and Tablet Image Analysis for Healthcare Applications. *IEEE Access* 2014;2:831-40.
19. Dunton GF, Dzibur E, Kawabata K, et al. Development of a smartphone application to measure physical activity using sensor-assisted self-report. *Front Public Health* 2014;2:12.

doi: 10.21037/mhealth.2016.05.01

**Cite this article as:** Chatzipavlou IA, Christoforidou SA, Vlachopoulou M. A recommended guideline for the development of mHealth Apps. *mHealth* 2016;2:21.