A Survey on Trend, Opportunities and Challenges of mHealth Apps

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Abstract—Advancement of mobile technologies such as smartphones and PC tablets has given a great impact on healthcare systems. The mobile technology offers innovative approaches to addressing complex health concerns. Many mobile health applications (mHealth apps) are currently available on marketplaces. These apps are designed to facilitate various health issues and problems, and are intended to be used outside clinics. However, very little research has been conducted to address trend, opportunities, and challenging issues of the apps. The purpose of this study is to investigate the current state of mHealth. A literature survey was conducted. Major findings of this study include, smartphones will be the major platform for mHealth apps, the number of published software is much higher than published scientific research, current mHealth apps lacking in grounded based theory and evaluation, and security and usability issues are still vulnerable. The findings suggest that involvement of all healthcare stakeholders is critical to the success of mHealth apps.

Keywords—mHealth apps; mobile computing; smartphoness

1 Introduction

Mobile technology has changed and will continue to change the life of millions of people around the globe. It is a technology which allows a computing device not to be connected to any fixed physical link. Examples of mobile computing devices are smartphones, laptops, tablets, e-book readers, cameras, and so on; the most powerful and attractive one is smartphones. It incorporates all aspects of computing application and wireless communications.

Nearly 85% of the world population will have access to 3G wireless coverage, with the half of the population living in areas with 4G networks in year 2017 [1]. The growth of smartphones has far-reaching implications for eHealth [2]. The word eHealth was defined in [3] as "a relation to health services delivery such as healthcare, health system, health sector or health industry which suggests that eHealth refer more to services and systems rather than to the health of people". Smartphones have become a common device in healthcare settings; leading to rapid growth in the development of mHealth apps [4].

In this paper, the term 'mHealth' is used to refer to clinical and public health activities involving mobile devices such as smartphones. mHealth apps offer health-related services which are accessible to patients both at home and on-the-go [2]. mHealth apps also allow patients and health provider to be connected to services which include information on demand, health record management, real-time monitoring of chronic conditions such as diabetes, asthma, stress management, nutrient management, and so on [5]. mHealth has attracted researchers from various fields, and the number of research publications has increased. However, to the best of our knowledge, very few literatures have reported on trend, opportunities and challenges in developing and deploying mHealth apps.

The aim of this study is to get an overview of the current state of mHealth apps by addressing its progression, opportunities, and challenges. This paper is organized as follows. Section 2 presents methods of how this study is carried out, section 3 presents result analysis and discussion, and section 4 presents a conclusion of the study.

2 Materials and Methods

This study has been conducted using two methods; a survey of published academic literature and a survey of existing mHealth applications on Google Play. A literature survey was conducted by searching, retrieving, and analyzing documents from three scientific databases: Web of Science, Scopus, and IEEE. The search has been made using 3 search keywords: *mHealth applications*, *opportunities of mHealth applications*, and *challenging issues in mHealth applications*, in January – February 2017.

With the keyword `mHealth applications', 1075 documents had been retrieved from Scopus database. Fig. 1 shows the numbers of literature from year 2013 till 2017. Only 586 documents were retrieved from Web of Science and 216 articles were retrieved from IEEE database, using the same keyword. Some of the documents appeared in both, Scopus and Web of Science databases. However, when a search keyword "opportunities and challenging issues of mHealth ", was used only 100 documents had been retrieved (Fig. 2) from the Scopus database.

The number of retrieved articles in the year of 2017 does not reflect the real situation as the search was made at the beginning of the year. Besides those databases, Google and google scholar search engines had been used also. Google was used because it is the most widely used search engine and it has the capability of retrieving scholarly literature from any open access databases regardless publishing formats and disciplines. With a search keyword "mHealth application" on Google scholar, about 22,900 results have been retrieved within 0.28 seconds (as of 16 March 2017).

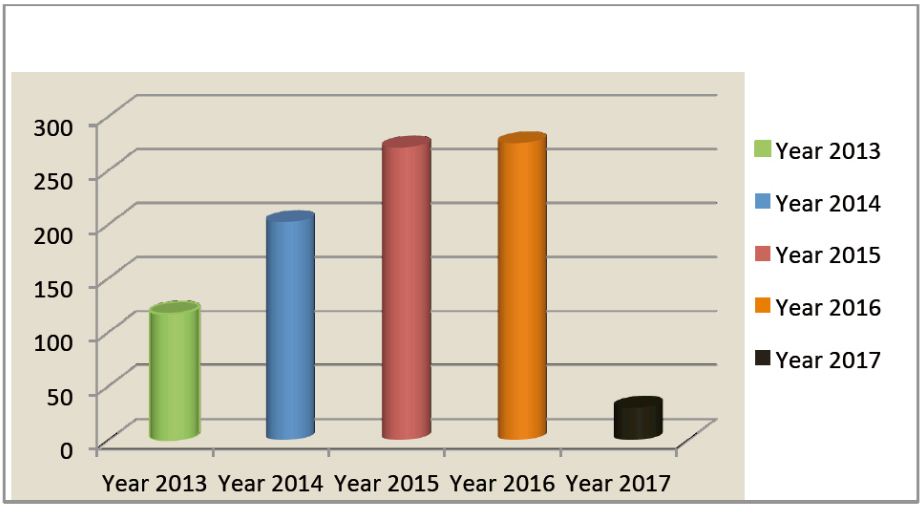

Fig. 1. Number of retrieved documents from Scopus database for a search keyword, mHealth applications

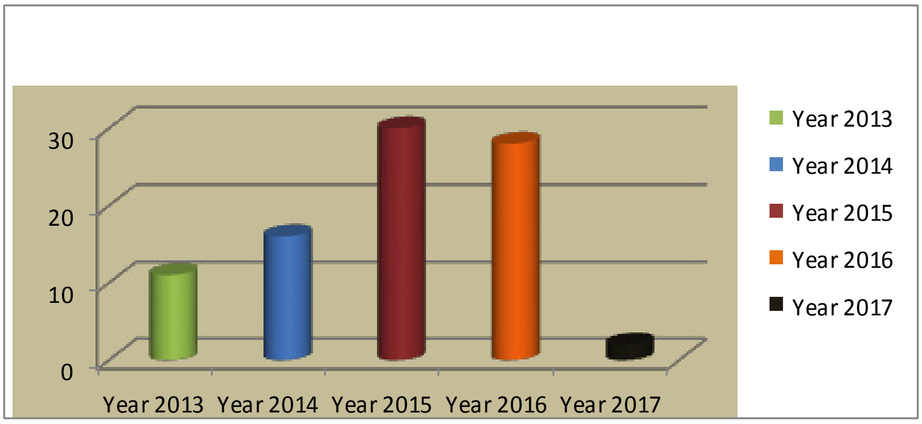

Fig. 2. Number of retrieved documents from Scopus database for a search keyword challenging issues in mHealth applications

The process of selecting and analyzing relevant documents involved with scanning the title and abstracts of all retrieved documents. Then, knowledge extraction is conducted on each relevant document.

3 Result analysis and discussions

3.1 Trends of mHealth apps

A personal organizer (PDA) with email and Internet access had become the most popular gadget in the years before 2007. At that time, mHealth research focused on the use of PDA. Then in the year 2007-2012, mobile phones started to gain popularity and there was a shifting movement from PDA to mobile phones. In the most recent years, people have focused more on smart devices along with the penetration of smartphones around the globe [6]. The recent explosion of work in mHealth apps has coming from research in health sciences, human-computer interaction, as well as software developer industries [2]. Based on a survey report [7], there are 58,000 mHealth apps publishers, where 75% of mHealth publishers are developing their mHealth apps on both iOS and Android platforms. The survey also published that 88% of the mHealth publishers developed mHealth apps for Android while 84% for iOS. The android platform is becoming more popular to newcomer publishers with 86% of them using the Google operating system compared to 81% for Apple. As stated in [8], more than 50% of American adults own smartphones and half of those owners use their phones to search for health information. Approximately 50% of mobile subscribers use fitness apps. The apps focus on tracking fitness, weight, diet, food and sleep, calorie counter, tracking stress, improving fat loss and skin hair, just to name a few. Self-health management includes monitoring blood pressure, heart rate, breath rate, providing awareness on some deadly virus, keeping health record, among others.

A conducted survey [7] over 2600 respondents in the year 2016 concluded that smartphones remain the main preferred device for mHealth apps. The statistics Portal (2016) estimated that 3.2 billion of downloads for mHealth applications. The statistic data also shows that the number of downloads keeps on increasing from 1.7 billion in 2013 to 3.2 in 2016 (Fig. 3). The mobile health market is expected to reach 23 billion, in 2017 while monitoring diagnosis and treatment related program will be half of the market within the next four years [9]. Currently, there are more than 60,000 health-related apps available in the Apple App Store and the Google Play Store [10], which most of these applications had been developed for health fitness and self-health monitoring [11] as illustrated in Fig. 4. The current mHealth applications achieve their functions with the help of mobile networks, by using simple techniques which are easily accepted by common users and health care without the need of high-level technology knowledge. Normally they are used to fulfill people immediate need and benefit mobile phone users directly [12]. Correspondingly, mHealth apps are moving towards consumer health informatics. It is increasingly becoming a key platform for delivering health interventions; from encouraging physical activity, to assisting cancer patients with the management of chemotherapy side effects [2]. mHealth apps have been used for giving treatment, making the diagnosis, illness monitoring, self-management, or promoting healthy lifestyle behaviors. Ventola [13] noted that 24% of mHealth apps are used as medical information, 22% are dedicated to the monitoring of physical parameters, 18 % to track disease, 16% for education and management, and 6% to diagnosis.

Correspondingly, mHealth apps are moving towards consumer health informatics; the apps have been used for giving treatment, making the diagnosis, illness monitoring, self-management, or promoting healthy lifestyle behaviors.

Ali and co-researchers [6] classified the purpose of mHealth intervention into five major classes: health promotion and disease prevention, diagnosis, treatment, monitoring and support for health services. According to [2], mHealth applications use four main strategies to encourage healthy behaviors: tracking and feedback, goal setting and social influence.

A survey report in [7] disclosed that diabetes remains the number one chronic illness and health care expenditures are always expensive. For an instance, to treat and prevent diabetes and its complications can exceed billions of dollars. Thus, mHealth technology is an alternative for cost effective health support.

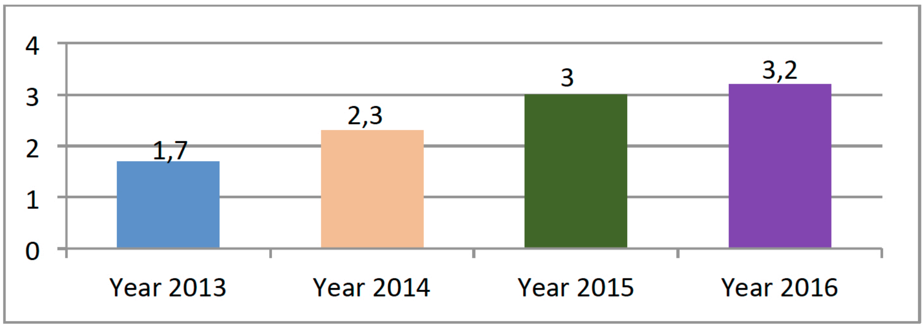

Fig. 3. Numbers of mHealth application downloads (in billions)

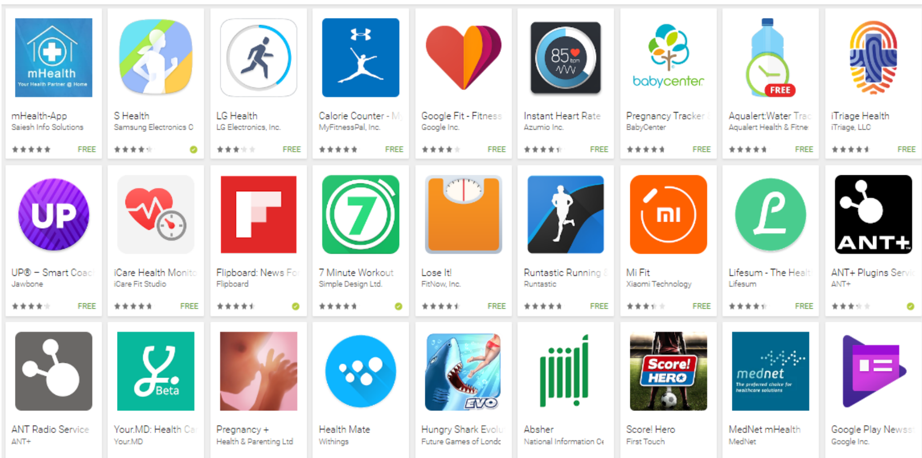

Fig. 4. A screenshot of Google Play for mHealth apps.

The review of this study also discover that mHealth researchers and publishers have focused more on individual prevention diseases (Table 1) such as self-management for diabetes [14, 15], gout [16], chronic obstructive pulmonary disease [17], bipolar disorders [18] and bowel disease [19], stroke [20,21] heart disease [22] and flu [23].

Table 1. Examples of available mHealth apps on Google Play as of April 2017

Diseases	Apps on Google Play for individual prevention diseases
Diabetes	Diabetes Journal, Diabetes Monitor, Diabetes Connect, Diabetes Tracker, Diabetes Recipes, Diabetes Symptom, Diabetes Tracker Free, Calorie Counter and Food Diary
Stroke	Stroke Riskometer, Stroke Disease & Symptoms, Stroke Guidelines, Neurology- Stroke localization, Stroke Box
Flu	Cold or Flu Test, Home Remedies, Swine Flu Swine Flu Disease & Symptoms, Cold and Flu
Gout	Gout, Gout Calculator, Inside Gout, Gout Symptoms, Managing Gout, Dr. Gout, Gout Diet
Bowel disease	Poocount, My IBD+, IBD, GI Buddy, IBD Diary

Article [23] presented HHeal, an app which integrates flu risk information and flu preventive behaviors, which provide a personal flu risk bar that arises when a user is near someone with flu-like symptoms and drops when the user finishes one of the suggested flu-preventive behaviors. The app was designed for assisting elderly patients and their caregivers in the medication management at their homes.

Another important mHealth intervention is to promote personal health safety in sex-related apps and dating apps as stated by [24] that majority of these apps contained no sexual health content. According to their survey, out of out of 137 apps identified, only 15 had sexual health content.

The work of Peyton [25] is an example of mHealth apps for improving health. Peyton (who is a women's specialist) with two HCI researchers have made a preliminary study to design and build an mHealth app that treats pregnancy as a teachable moment for health wellness, and social support throughout the life course.

Researchers and software developers in behavior change also have explored the possibility of mHealth technologies. Their aim was to promote behavior change for improving well-being. Studies of [26,27, 28] disclosed that healthy adults have some interests in mHealth apps that attempt to support health-related behavior change. However, there are still a number of unresolved challenges such as how to make the behavior change techniques appealing to users, and how to incorporate these techniques into health behavior change apps while avoiding content and features which may embarrass, irritate, upset, worry, or burden users [26,27].

Another interesting research of mHealth apps for improving well-being is a mood detector. The purpose of any mood study is to accurately capture user's perception and feelings, such as angry, sad, happy, and so on. In basic research and in clinical practice, pen-and-paper mood scales are normally used. Research work of [29)] presented the used mobile technology to extend mood self-assessment from lab to real life, by introducing mobile mood scales (MMS). MMS uses visual effects such as color, changing brightness, animation, and photos. Having MMS on a smartphone allows mood data to be collected frequently over a long period in a variety of life situation. In their evaluation survey, 61% of 48 participants found special features such as the use of color, brightness, and photos are helpful in reflecting on a person's mood; 83% of 48 participants preferred mobile mood scales over pen-and-paper scales.

Depression is a common problem in every nation and is known as a silent killer. Normally, depression patients are treated using antidepressant medication. However, outcomes of this treatment are poor due to lack of communication between patient and physician and monitoring system. Having mHealth apps which can advise on response to treatment may reduce depressive severity. Mohr and co-researchers [30] reported on the 4-week pilot deployment MedLink; an app which provides the depression patients with information, and collects data on symptoms and side-effects. In this app, a cellularly-enabled pill bottle monitors medication adherence. Then, collected data is shared among a physician and patient to assist communication and adjust medication. By using the app, depressive symptom severity was reported significantly reduced.

3.2 Opportunities for mHealth apps

There is no doubt mHealth apps can be very useful tools for all parties including healthcare institutions, physicians, community healthcare workers, and individual in developing countries. mHealth apps can provide a better health care system in the developing countries by being great assistants to the community health workers; the most cost effective way to save lives and improve healthcare outcomes [31,32,33]. This is achieved as mHealth apps are able to improve performance and motivation by reducing the time need for travel from place to place. The apps are able to facilitate feedback and information and improve communication between supervisors and health workers in identified communities [34].

Several studies have reported on the effectiveness of diabetes self-management [14,15,35]. The diabetes management app is considered effective if it is able to remind diabetes patients to take medications at appropriate times [15] .The success of the app for adults with type 2 diabetes had been reported in [35]. It was reported that costs associated with the patients failing to take their medication properly have reached $300 billion annually.

Currently, the mean price of the most downloaded apps is only 2.24 US dollars [36]. This suggests that mHealth apps which are able to alert diabetes patients may potentially reduce such huge costs, and offer clinical staff with convenient tools which are ready to access resources and communication mechanism at anywhere and anytime. Old things can be done in new ways, such as recording health measures digitally, rather than on paper.

With mHealth apps installed on smartphones, patients are encouraged to monitor their disease states. More medical data will be generated by patients and processed by computers. The quality and efficiency of existing healthcare delivery models can be improved, and medicine's diagnostic and monitoring aspects will be shifted from a human doctor to a software doctor [37]. It is exciting to see mHealth apps are doing things in entirely new ways and driving real innovation in health care delivery such as an eye examination using a smartphone as presented in [38].

3.3 Challenging Issues of mHealth apps

The mHealth interventions have encouraged healthcare institutions, mHealth publishers, and public users to disseminate and exchange health information. However, it is very crucial to identify how this information is constructed, developed and delivered, to ensure that it is understandable and can be acted on. One of the major issues to consider is health literacy. Health literacy was defined in [39] as "the degree to which individuals have the capacity to obtain, process and understand basic health information and services they need to make appropriate health decisions". The success of the intervention of mHealth apps is only for high health literacy, while low health literacy still remains a problem. Thus, mHealth apps have "to be developed using best practice strategies to present information in ways that are understandable to each intended audience [39]".

Currently, many released mHealth apps are not grounded in theory. For example, behaviour change principles are not adapted for mHealth apps [40]. Some of the mHealth apps are not thorough enough and many mHealth app's developers or publishers fail to conduct need assessments of their end-users [41]. For example, [42] addressed that early pregnancy education and social support is crucial for women to enable them to achieve a healthy pregnancy weight, and mHealth apps can be used to aid to aid in pregnancy health management. However, their preliminary study in utilizing mHealth apps for lower-income pregnant American women, discover that existing apps ignore the crucial role of the spouse, overstate the need for social sharing with strangers, and fail to provide targeted and individualized information about early pregnancy.

Furthermore, not everyone has enough digital knowledge to participate in mHealth activities. An exploratory mHealth pilot program was conducted at a local clinic in Canberra, Australia [43]. The pilot program was conducting on mobile tablet devices and applications to help type 2 diabetes patients in self-management of their disease. Their study concluded that users must be equipped with an appropriate level of digital literacy in order to successfully and effectively use mHealth apps. A weight loss program so called Myfitnesspal (an app for daily tracking of caloric input and energy expenditure) has been claimed in a recent research as the most popular mHealth app [44]. Therefore, [45] has utilized the app for weight loss program, on American Indian and Alaska Native (AI/AN) women. The major challenge that they discovered was only 1 out of 17 participants own a smartphone. This indicates not everyone on the earth owns a smartphone. Thus the cost of smartphones (although it can be argued that the cost of smartphones is getting less) can be a barrier to those unfortunate people who cannot afford to have ones. The rapid increase of mHealth apps also requires health agency to pay attentions for regulations on mHealth app risk assessment. Unfortunately, these existing and upcoming regulations have not yet been accompanied by a mobile auditing framework, which provides real-time monitoring of mHealth apps' resource usage and triggers alerts to users if abnormal resource usage patterns are detected [46]. An app risk assessment is a critical issue, which requires many agencies to put effort on it. Despite mHealth apps can facilitate any diseases self-management as previously mentioned, they are more towards physical activity self-support rather than decision supports for the self-initiation of medical therapy. Research findings of [18] pointed out that out of the 238 apps screened, none of the apps facilitates a decision support. Usability is another critical issue in mHealth applications. Usability testing conducted by Ben-Zeev and co-researchers [47] on mHealth apps for illness self-management system for people with schizophrenia also revealed several design vulnerabilities. Security is also an issue in mHealth apps because, without security concern, patient privacy is vulnerable. For example ``the patient's physiological vital signals are very sensitive (i.e., if a patient has some embarrassing disease), so any leakage of individual disease data could make him/her embarrassed [48]".

Evaluation is a vital component to any policy and program including mHealth apps. Unfortunately, an effort made for evaluation of mHealth apps especially in developing countries is still low. The World Health Organization conducted a survey on eHeatlh and mHealth [49] and found out that only 7% of responding developing countries reported conducting mHealth evaluation. The survey also uncovered that mHealth research in the developing countries does not include adequate evaluation on intervention, and insufficient evidence on health impact. As reported in [50], the current state of mHealth apps is that mHealth effort requires monitoring and evaluation. Despite mHealth intervention can be very helpful for health care workers and individual in developing countries, the cost of mobile technologies such as smartphones and internet access are very expensive. Furthermore, current mHealth interventions do not meet standards for scale up mHealth projects as argued in [50]. Besides insufficient clinical evidence [48, 49], most of the mHealth apps are developed in the English language, thus it can be a challenge to those people who are not eloquent in this language. Above all, the majority mHealth publishers are not making money with mHealth apps; 79% of mHealth publishers are reported to have made less than US$100,000 from their entire mHealth app portfolio business in 2015 [7].

4 Conclusion

This study has addressed the current state of mHealth apps' research and development, starting from its current trend towards challenges. Current mHealth apps can be categorised in terms of individual prevention disease [14-23], personal health safety [24], improving health [25,], improving well-being [26-29], and giving advice on response to treatment [30]. Evidently, many of available mHealths apps on the market are not grounded in theory. This may suggest why current mHealth apps are not able to provide great clinical impact on users. Furthermore, security issues have been also neglected, and usability needs more attention. In spite of clinical evidences on mHealth apps have not been reported so far [50], it is no doubt that mHealth apps have great potential for more successful prevention and chronic disease management strategies. The smaller number of published scientific articles compared to the number of mHealth apps on the market reflects that the movement made by mHealth apps publishers is faster than the scientific researchers in the field. Nevertheless, the mHealth apps market is still at the beginning stage; just 7 years [7]. Despite barriers and challenging issues, many great opportunities are still waiting ahead. The involvement of all healthcare stakeholders such as healthcare institutions, physicians, health care workers, individuals, and scientific researcher, software publishers, and public citizens is considered critical to the success of mHealth apps. Finally, this paper can be a great starting point to any individuals including researchers, mHealth apps publishers, health practitioners, health provider and public citizens to take part in mHealth apps intervention.

5 References

[1] Sahota, D. 85% of world population to have 3G by 2017, June 06, 2012. Retrieved from http://telecoms.com/45244/85-of-world-population-to-have-3g-by-2017-says-ericsson,

[2] Klasnja, Predrag, and Wanda Pratt. Managing health with mobile technology, interactions 21 (1), 2014, pp. 66-69..

[3] Yulin H. & Kasisomayajula V., Beyond The Hype: Mobile Technologies And Opportunities To Address Health Disparities, Journal Of Mobile Technology In Medicine,Vol. 4, Issue 1, 2015, pp. 39-40.

[4] Number of mHealth app downloads worldwide from 2013 to 2016, 2016 Retrieved from https://www.statista.com/statistics/625034/mobile-health-app-downloads/

[5] Martin, Daniel, et al. I will prescribe you an app, Proceedings of the 2014 Summer Simulation Multiconference. Society for Computer Simulation International, 2014.

[6] Ali, E. E., Chew, L., & Yap, K. Y. L. . Evolution and current status of mhealth research: a systematic review. BMJ Innovations, 2(1), 2016, pp.33-40. https://doi.org/10.1136/bmjinnov-2015-000096

[7] Research2Guidance. mHealth App Developer Economics 2016: The current status and trends of the mHealth app market, 2016, Retrieved from www.research2guidance.com

[8] Elsevier. Can your smartphone help you exercise?. ScienceDaily. 13 January 2015, Retrieved February 18, 2017 from www.sciencedaily.com/releases/2015/01/150113090318.ht

[9] Smith, A. U.S. Smartphone Use in 2015, PewResearchcenter, April 1, 2015

[10] James, M. Understanding Mobile Health Trends and Opportunities for Clinical Trials and Post-Approval Programs, November 05, 2015, http://www.ubc.com/blog/understanding-mobile-health-trends-and-opportunities-clinical-trials-and-post-approval-programs

[11] Pandey, S. et al. Sama, P. R. et al. An evaluation of mobile health application tools. JMIR mHealth and uHealth, 2(2), 2014.

[12] Zhu, X., & Ou, S. November). Research of Application of mHealth Based on Web2. 0. In Information Technology in Medicine and Education (ITME), 2015 7th International Conference on , 2015, pp. 203-207.

[13] Ventola, C. L. Mobile Devices and Apps for Health Care Professionals: Uses and Benefits. Pharmacy and Therapeutics, 39(5), 2014, pp. 356–364.

[14] Shah, V. N., & Garg, S. K. (2015). Managing diabetes in the digital age. Clinical Diabetes and Endocrinology, 1(1), 16. https://doi.org/10.1186/s40842-015-0016-2

[15] Ristau, R. A., Yang, J., & White, J. R. (2013). Evaluation and evolution of diabetes mobile applications: key factors for health care professionals seeking to guide patients. Diabetes Spectrum, 26(4), 2013, pp. 211-215. https://doi.org/10.2337/diaspect.26.4.211

[16] Nguyen, A. D. et al. Mobile applications to enhance self-management of gout. International journal of medical informatics, 94, 2016, pp. 67-74.
[17] Zardinge, M. et al. Using a mobile health application to support self-management in chronic obstructive pulmonary disease: a six-month cohort study. BMC medical informatics and decision making, 15(1), 2015, pp. 46 https://doi.org/10.1186/s12911-015-0171-5
[18] Matthews, M. et al. Development and evaluation of a smartphone-based measure of social rhythms for bipolar disorder. Assessment, 23(4), 2016, pp. 472-483. https://doi.org/10.1177/1073191116656794
[19] Con, D., & De Cruz, P. Mobile phone apps for inflammatory bowel disease self-management: A systematic assessment of content and tools. JMIR mHealth and uHealth, 4(1), 2016. https://doi.org/10.2196/mhealth.4874
[20] Feigin, V., P.Parmar, S. Barker-Collo, D.A Bennett, C.S Anderson, A. G Thrift, B. Stegmayr, P. M Rothwell, M.Giroud, Y. Bejot, P. Carvil, R.Krishnamurthi, N.Kasabov, Geomagnetic Storms Can Trigger Stroke: Evidence From 6 Large Population-Based Studies in Europe and Australasia, Stroke, 45(6), 2014, pp. 1639-1645 https://doi.org/10.1161/STROKEAHA.113.004577
[21] Kasabov, N., Feigin, V., Hou, Z. -G., Chen, Y., Liang, L., Krishnamurthi, R., Parmar, P. (2014). Evolving spiking neural networks for personalised modelling, classification and prediction of spatio-temporal patterns with a case study on stroke. Neurocomputing, 134, pp. 269-279. https://doi.org/10.1016/j.neucom.2013.09.049
[22] Schuuring, M. J. et al. Mobile health in adults with congenital heart disease: current use and future needs. Netherlands Heart Journal, 24(11), 2016 pp. 647-652. https://doi.org/10.1007/s12471-016-0901-z
[23] Li, N. et al. HHeal: A Personalized Health App for Flu Tracking and Prevention. In Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems, April 2015, pp. 1415-1420. https://doi.org/10.1145/2702613.2732804
[24] Huang, E. T.-Y., Williams, H., Hocking, J. S., & Lim, M. S. Safe Sex Messages Within Dating and Entertainment Smartphone Apps: A Review. JMIR mHealth and uHealth, 4(4), 2016, e124. https://doi.org/10.2196/mhealth.5760
[25] Peyton, T. Pregnancy Ecologies As Teachable Moments For The Lifecourse: Changing The mHealth Design Paradigm. In Proceedings of the 18th International Conference on Supporting Group Work, November 2014, pp. 269-271. https://doi.org/10.1145/2660398.2660438
[26] Dennison, L. et al. Opportunities and challenges for smartphone applications in supporting health behavior change: qualitative study. Journal of medical Internet research, 15(4), 2013, e86. https://doi.org/10.2196/jmir.2583
[27] Zhao J. et al. Can Mobile Phone Apps Influence People's Health Behavior Change? An Evidence Review, J Med Internet Res, 2016;18(11):e287 https://doi.org/10.2196/jmir.5692
[28] Yang, C. H. et al. Implementation of behavior change techniques in mobile applications for physical activity. American journal of preventive medicine, 48(4), 2015, pp. 452-455. https://doi.org/10.1016/j.amepre.2014.10.010
[29] Khue, L. M. et al. Mood self-assessment on smartphones. In Proceedings of the conference on Wireless Health, October 2015, p. 19. https://doi.org/10.1145/2811780.2811921
[30] Mohr, D. C. et al. MedLink: a mobile intervention to address failure points in the treatment of depression in general medicine. In Proceedings of the 9th International Conference on Pervasive Computing Technologies for Healthcare, May 2015, pp. 100-107. https://doi.org/10.4108/icst.pervasivehealth.2015.259042
[31] Niemöller, C. et al. Designing mhealth applications for developing countries 24th European Conference on Information Systems (ECIS), 2016

[32] Kahn, J. G. et al. Mobile'health needs and opportunities in developing countries. Health Affairs, 29(2), 2010, pp. 252-258. https://doi.org/10.1377/hlthaff.2009.0965
[33] Thondoo, M. et al. Potential roles of Mhealth for community health workers: formative research with end users in Uganda and Mozambique. JMIR mHealth and uHealth, 3(3), 2015. https://doi.org/10.2196/mhealth.4208
[34] Gatara, M., & Cohen, J. F. Mobile-health tool use and community health worker performance in the kenyan context: a task-technology fit perspective. In Proceedings of the Southern African Institute for Computer Scientist and Information Technologists Annual Conference 2014 on SAICSIT 2014 Empowered by Technology, September 2014, p. 229.
[35] Quinn, C. C. et al. WellDoc™ mobile diabetes management randomized controlled trial: change in clinical and behavioral outcomes and patient and physician satisfaction. Diabetes technology & therapeutics, 10(3), 2008, pp. 160-168. https://doi.org/10.1089/dia.2008.0283
[36] Council for Affordable Health Coverage: Medication adherence: a $300 billion opportunity. Available from http://cahc.net/medication-adherence-a-300-billion-opportunity/. Accessed 10 March 2013
[37] Topol, E. J. The future of medicine is in your smartphone. The Wall Street Journal, 9. 2015.
[38] Nielda, D. A new smartphone attachment can perform eye exams from anywhere in the world, 13 June 2015 Retrieved from http://www.sciencealert.com/a-new-smartphone-attachment-that-could-save-you-a-trip-to-the-eye-doctor
[39] Healthy People 2010: Understanding and Improving Health. US Department of Health and Human Services, Washington, DC, USA
[40] Rivers, B. et. al. Opportunities and challenges of using technology to address health disparities. Future Oncology, 10(4), 2014. pp. 519-522. https://doi.org/10.2217/fon.14.17
[41] Oh, H. et al. What is eHealth (3): a systematic review of published definitions. J Med Internet Res, 7(1), e, 2005.
[42] Peyton, T. et al. Information, sharing and support in pregnancy: addressing needs for mHealth design. In Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing, February 2014, pp. 213-216. https://doi.org/10.1145/2556420.2556489
[43] Ristau, R. A., Yang, J., & White, J. R. Evaluation and evolution of diabetes mobile applications: key factors for health care professionals seeking to guide patients. Diabetes Spectrum, 26(4), 2013, pp. 211-215. https://doi.org/10.2337/diaspect.26.4.211
[44] Patel, R., Sulzberger, L., Li, G., Mair, J., Morley, H., Shing, M. N., ... & Sharpe, C. Smartphone apps for weight loss and smoking cessation: Quality ranking of 120 apps. NZ Med J, 128(1421), 2015, pp.73-76.
[45] Park, S et al. The Role of Digital Engagement in the Self-Management of Type 2 Diabetes. Health communication, 31(12), 2016, pp. 1557-1565. https://doi.org/10.1080/10410236.2015.1089468
[46] Nelson, L. A., & Zamora-Kapoor, A. Challenges in conducting mHealth research with underserved populations: Lessons learned. Journal of telemedicine and telecare, 22(7), 2016, pp. 436-440. https://doi.org/10.1177/1357633X15609853
[47] Ben-Zeev, D. et al. Development and Usability Testing of FOCUS: A Smartphone System for Self-Management of Schizophrenia. Psychiatric Rehabilitation Journal, 36(4), 2013, pp. 289–296 https://doi.org/10.1037/prj0000019
[48] Kumar, P., & Lee, H. J. Security issues in healthcare applications using wireless medical sensor networks: A survey. Sensors, 12(1), 2011, pp. 55-91. https://doi.org/10.3390/s120100055

[49] World Health Organization, mHealth: New horizons for health through mobile technologies, based on on the findings of the second global survey on eHealth, Global Observatory for eHealth series, 3, 2011.

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