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Reflection on Mobile Applications for Blood Pressure Management: A Systematic Review on Potential Effects and Initiatives

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Abstract. Introduction: Ischemic heart disease and stroke have been considered as the first global leading cause of death in last decades [1]. Blood pressure (BP) management is one of the easiest ways suggested for preventing and controlling cardiovascular diseases before the patient develops complications and death-following outcomes. Appearance of technology advancements in the health system has motivated researchers and health providers to study its different aspects and applications in order to improve disease prevention and management. Following these efforts, mobile health (mHealth) technologies were presented to provide people with fast and easier- to- use services. Although there are some unsolved challenges, these technologies have become popular among many people. As an important part of mHealth, mobile applications (apps) have been the focused subject of many studies in the last decade. The objective of this systematic review is to assess the potential effects of mobile apps designed for BP management by scrutinizing the related studies.
Materials and Methods: Search methods: We searched the following electronic databases in December 2016: Medline (PubMed), National Center for Biotechnology Information (NCBI), Cochrane Central Register of Controlled Trials (CENTRAL), PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Education Resources Information Center(ERIC), Web of Science, ProQuest, and Google Scholar. No language restriction and start point limitation were imposed.
Selection criteria: We included studies that evaluated and assessed mobile apps for BP management and related clinical trials that considered mobile app as the only difference between intervention and control groups.
Data collection and analysis: Two review authors applied the eligibility criteria, extracted data and assessed the quality of included studies.
Results: Literature search resulted in 13 included studies and 27 reviews. 12 records of 13 included studies identified as interventional studies. The review showed that the mobile apps may improve individual's BP condition and medication adherence.
Conclusion: Most of the studies had emphasized positive effects of mobile apps in BP management. However, there is a necessity for performing further investigations due to the identified issues in this study such as low number of

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participants and limited intervention period in randomized controlled trials, and interventions limited to only hypertensive or high-risked individual.

Keywords. Hypertension, blood pressure, mobile application, mobile health

Introduction

Administrating a continuous procedure, heart is considered as a key organ which provides the demands of body cells by pumping blood. The exerted force against blood vessels caused by blood flow is referred as blood pressure (BP) which is commonly used as a heart condition determinant. Followed by heart systolic and diastolic phase, a maximum and minimum pressure can be measured as systolic and diastolic blood pressure. Going out of normal range can cause different problems and complications. Cardiovascular diseases and stroke, the world's biggest killers, are considerable outcomes of uncontrolled BP. Hypertension(HTN), a condition of having persistent elevated BP, is a common condition which can be easily prevented[2]. However, the complications may be developed gradually behind the probable asymptomatic phase of disease. Helping people being alert of silent variations of BP has become a thought-provoking issue among health providers, professionals, and researchers[3].

Integrating technology advancements and health services have opened a new era in reinforcing health care quality. Going beyond customary sphygmomanometer and previous disease management and prevention methods, mobile health (mHealth) (defined as an area of electronic health that provides information and health services via mobile phone) technologies have brought up as a strong solution for some of the requirements in this issue. Mobile applications (apps), as part of mHealth technologies, are providing health care professionals, patients, and even healthy people with different services like measurement of vital signs, medication reminding, and nutritional consultation. However, some remained challenging issues are motivating researchers and health providers to investigate if these mobile apps will play a useful role in the health system [4]. The objective of this systematic review is to assess the potential effects of mobile apps in blood pressure management by scrutinizing related studies.

1. Methods and Materials

A comprehensive literature review was conducted according to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)[5]. The main question was framed based on PICO (Population, Intervention, Control, and Outcome) model and the search strategy was developed subsequently, which was inspected with the help of an expert team consisting of a general practitioner, a cardiologist, and an information technology expert.

Two main research areas were considered for designing the search strategy as follows:

- Diseases and conditions; such as Hypertension, blood pressure, chronic diseases.
- Mobile area; such as Applications, software, mobile programs.

The considered databases for the study are Medline (PubMed), National Center for Biotechnology Information (NCBI), Cochrane Central Register of Controlled Trials (CENTRAL), PsycINFO, Cumulative Index to Nursing and Allied Health Literature

(CINAHL), Education Resources Information Center (ERIC), and Web of Science. They were searched in December 2016 without any language restriction and start point limitation. Additionally, we searched ProQuest and Google Scholar for gray literatures.

Two reviewers (R.M. and M.A.T.) independently perused the extracted articles and identified their suitability by focusing on their title and abstract. Eligibility was determined by applying inclusion/exclusion criteria on full texts of all reports that appeared to meet inclusion criteria or if their title and abstract provided insufficient detail. The considered criteria are mentioned below:

- All published studies that were conducted to assess and evaluate mobile apps designed for BP or HTN management were included.
- Clinical trials were included if the mobile application was the only difference between intervention and control groups.

Two review authors collaboratively extracted data by using a designed data extraction form which had been finalized after a pilot test followed by a revision by the expert team. Reviewers' disagreements were resolved in each stage of the study via discussion and if they couldn't come to an agreement the opinion of the third author (S.H.) was asked. For each initiative, we extracted information on publication details, study design, participants, and intervention characteristics.

To assess the quality of recorded studies, reviewers used Critical Appraisal Skills Program (CASP)[6] and STROBE[7] checklists to classified ones based on senses they reached in totally. In order to reduce the risk of bias, reviewers were blinded to authors and institutions during the review and quality assessment procedures[8].

2. Result

The search strategy identified 2656 unique records (2901 total records) which were screened for eligibility. After eliminating irrelevant records, 82 records were obtained for further assessment in full version. 42 further records were also excluded for multiple reasons such as: app designing without evaluation, only app validation, app review only aimed to figure out its application, and RCT or review protocols.

Forty related records were identified from which 13 records were selected for quality assessment (27 records were reviews that were used only to check their bibliographies for possibly-missed records). (Figure 1)

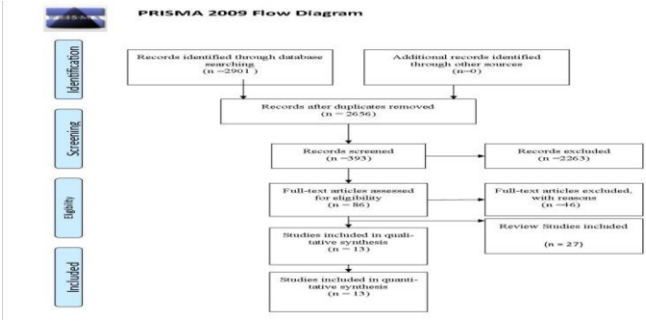

Figure 1.PRISMA flow diagram of the literature search and study selection.

All 13 final records were published from 2007 to 2016 in English. Most of these records (12 of 13) can be classified in two groups of interventional studies: trials and

before-after studies. The 13th record was identified as a qualitative study that examined the acceptability and psychosocial impacts of the app on hypertensive patients by designing an interview about technology-based self-management [9].

In all 13 studies, interventions had been performed in a time period less than a year. All participants were hypertensive or fighting with a hypertension-associated disease like diabetes or kidney transplant. Three studies had focused on assessing medication adherence facilitated by a mobile app which led to improvements in BP management [10-12]. As another outcome, in one of the records some changes in the rate of BP self-management had been detected[13]. Most of the included records assessed the tele-care systems that used a mobile app which was connected to a digital BP device and received data and collected it for further analyses [14-17]. However, manual data entering was also identified in some studies. In these cases, data was transferred to a control center through a web-based system and a further data analyses and sending feedback were performed by a practitioner. An app based on technology-supported apprenticeship was also identified and its impact on hypertension management had been assessed compared to a successful coaching model[13].

Quality assessment results contain 4 low, 2 medium and 7 high quality studies based on checklists mentioned above.

3. Discussion and Conclusion

Our literature search identified 13 records designed for investigating the impacts of mobile apps on hypertensive or high-risk individuals. This study showed that mobile applications are capable of improving individual's BP condition and its management in these health statuses. As tracking BP fluctuations is necessary for all individuals whether hypertensive or healthy, there is need for new studies focusing on all people.

Most of the studies acknowledged the fruitfulness of mHealth technologies. Due to the results of a high-quality record [16], these systems are followed by a considerable profit in short-term period, but studying for assessing long-term results is suggested. Utilizing these systems may cause impressive improvements in health condition, especially for rural areas considering data transfer speed and their ability to provide more people with more available services. Most studies were performed in American countries; while performing studies in other countries and places is suggested.

During studying records, we found some studies that only focused on designing apps or tele-health systems that used different features of mobile devices like microphone and camera for detecting BP[18-20]. Although it reflects the potential application of these devices, there is a necessity for further inspection and setting more comprehensive rules for controlling app quality. Some records had discussed this issue [21] but it requires more serious and major efforts due to the large number of designed apps. The existing apps in markets like App Store and Play Store are covering many different aspects of BP self-management such as: direct or indirect BP measurement, medication adherence, diet consultation, salt intake controlling, and activity tracking, while most identified studies related to transferring data by connecting digital BP devices to mobile devices[22, 23]. The other aspects need to receive more attention.

In included randomized controlled trials, minor population and limited intervention period may cause some biases as they may develop different results in wider studies. We did not find such studies; hence, considering this issue may clarify the impacts of mobile apps on individual's health.

Finally, mobile health applications seem to be a powerful arm in managing BP; however, more efforts and studies are needed to adapt these technologies for every single community. Moreover, the other features of these apps (especially multi-functional parts) should be focused in further studies which could pave the way for having a flawless BP management mHealth technology.

References

[1] Jenkins, C., et al., Stroke patients and their attitudes toward mHealth monitoring to support blood pressure control and medication adherence. Mhealth, 2016. 2.
[2] Hall, J.E. Guyton and Hall textbook of medical physiology. 2016; Available from: https://nls.ldls.org.uk/welcome.html?ark:/81055/vdc_100052221233.0x000001.
[3] Carey, R.M. and P.K. Whelton, Prevention, detection, evaluation, and management of high blood pressure in adults: synopsis of the 2017 American College of Cardiology/American Heart Association hypertension guideline. Annals Intern Med, 2018.
[4] Jenkins, C., et al., Stroke patients and their attitudes toward mHealth monitoring to support blood pressure control and medication adherence. mHealth, 2016. 2(5).
[5] Moher, D., et al., Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS medicine, 2009. 6(7): p. e1000097.
[6] CASP, U., CASP checklists. 2015, Oxford Better Value Healthcare Ltd. Available: http://www. casp-uk. net/casp-tools-checklists. Accessed.
[7] von Elm, E., et al., [The Strengthening the Reporting of Observational Studies in Epidemiology [STROBE] statement: guidelines for reporting observational studies]. Gac Sanit, 2008. 22(2): p. 144-50.
[8] Higgins, J.P. and S. Green, Cochrane handbook for systematic reviews of interventions. 2005, version.
[9] Glynn, L., et al., Patients' views and experiences of technology based self-management tools for the treatment of hypertension in the community: A qualitative study. BMC Fam Pract, 2015. 16: p. 119.
[10] Kang, H. and H.A. Park, A Mobile App for Hypertension Management Based on Clinical Practice Guidelines: Development and Deployment. JMIR Mhealth Uhealth, 2016. 4(1): p. e12.
[11] Patel, S., et al., Mobilizing your medications: an automated medication reminder application for mobile phones and hypertension medication adherence in a high-risk urban population. J Diabetes Sci Technol, 2013. 7(3): p. 630-9.
[12] McGillicuddy, J.W., et al., Mobile Health Medication Adherence and Blood Pressure Control in Renal Transplant Recipients: A Proof-of-Concept Randomized Controlled Trial. Journal of Medical Internet Research, 2013. 15(9): p. 1-1.
[13] Moore, J.O.M.D.P., et al., Technology-Supported Apprenticeship in the Management of Hypertension: A Randomized Controlled Trial. Journal of Clinical Outcomes Management, 2014. 21(3): p. 1.
[14] Trudel, M., et al., A mobile phone based remote patient monitoring system for chronic disease management. Stud Health Technol Inform, 2007. 129(Pt 1): p. 167-71.
[15] Kim, J.Y., N.E. Wineinger, and S.R. Steinhubl, The Influence of Wireless Self-Monitoring Program on the Relationship Between Patient Activation and Health Behaviors, Medication Adherence, and Blood Pressure Levels in Hypertensive Patients: A Substudy of a Randomized Controlled Trial. J Med Internet Res, 2016. 18(6): p. e116.
[16] Bloss, C.S., et al., A prospective randomized trial examining health care utilization in individuals using multiple smartphone-enabled biosensors. PeerJ, 2016. 4: p. e1554.
[17] Earle, K.A., et al., Mobile telemonitoring for achieving tighter targets of blood pressure control in patients with complicated diabetes: a pilot study. Diabetes Technol Ther, 2010. 12(7): p. 575-9.
[18] Ilhan, I., I. Yildiz, and M. Kayrak, Development of a wireless blood pressure measuring device with smart mobile device. Comput Methods Programs Biomed, 2016. 125: p. 94-102.
[19] Goldberg, E.M. and P.D. Levy, New Approaches to Evaluating and Monitoring Blood Pressure. Curr Hypertens Rep, 2016. 18(6): p. 49.
[20] Tan, Y.Y. and W.Y. Chung, Mobile health-monitoring system through visible light communication. Biomed Mater Eng, 2014. 24(6): p. 3529-38.
[21] Seto, E., et al., Developing healthcare rule-based expert systems: case study of a heart failure telemonitoring system. Int J Med Inform, 2012. 81(8): p. 556-65.
[22] Kumar, N., et al., A content analysis of smartphone-based applications for hypertension management. J Am Soc Hypertens, 2015. 9(2): p. 130-6.
[23] Martinez-Perez, B., et al., Mobile apps in cardiology: review. JMIR Mhealth Uhealth, 2013. 1(2): p. e15.