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Mobile-Health Reminder Management System to Monitor Hypertension Patients: A Systematic Review

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Abstract--- *Information technology can be a medium for improving consumer health care. Since the development of industry 4.0, mobile phones have become an important tool for monitoring health interventions. The purpose of this review was to assess the effectiveness of an m-Health reminder management system for patients with hypertension. The review identified fifteen related studies following the defined inclusion and exclusion criteria, in PubMed, Science Direct, ProQuest, Sage, EBSCO, and Scopus, limited to the last 5 years, 2015 to 2020. Fifteen articles were involved in the review. Mobile phones are used as a tool for monitoring physical activity, healthy diets, education, blood pressure monitoring, symptoms and activating notifications (Reminder Management System) as a lifestyle monitoring tool every day. m-Health makes it easy for consumers to management hypertension. There should be further research related to the lifestyle monitoring of patients with hypertension.*

Keywords--- *application, m-Health, management hypertension, reminder management system*

I. INTRODUCTION

High blood pressure or hypertension is a major cause of cardiovascular disease, disability, and death in the world. In 2017 there were 10.4 million people in the world who died due to hypertension [1]. The increasing prevalence of hypertension from 2000 to 2010 was 25.9% to 31.1% [2]. The prevalence of hypertension in Indonesia in 2018, among the adult population (≥18 years), reached 34.1%. As many as 45.6% of patients do not regularly take medication. And some patients do not feel symptoms of hypertension at (59.8%) [3]. One of the causes of death is ischemic heart disease and stroke triggered by hypertension [4]. People with hypertension who have controlled blood pressure are only 13.8% of people diagnosed with hypertension [2]. Hypertension problems need to be overcome with proper hypertension management [5].

The role of patients in managing hypertension is to make lifestyle choices, manage symptoms that occur, target blood pressure, increase medication adherence, reduce salt intake, increase potential physical activity or management of [1]health problems and have the support of a health care professional [6], [7], [8], [9], [10]. Blood pressure management

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can reduce the risk of stroke, heart attack, heart failure, and cardiovascular death [11]. Effective blood pressure control depends on patient self-management, where individuals play a central role in their decisions and behavior related to the management of this chronic condition. Various tools to improve self-management can be used as a strategy to improve the management of health problems. An important part of self-management is that the patient is actively involved [12].

The development of mobile medical technology involves a tool to improve self-management with two-way communication available via mobile phones [13]. The advantage of m-Health for patients is that the progression of disease recovery is monitored [14]. The popularity of mobile phones can be used for solutions in improving the treatment and management of disease including hypertension [12]. The impact of m-Health on public health workers is that m-Health interventions can remind people with hypertension diagnoses to encourage healthy behavior, attendance at follow-up appointments, and health data collection. The authors also noted the need for innovation and research into m-Health solutions for clinical decision support [15].

Health interventions with m-health facilitate monitoring of hypertension. Patients need to activate notifications on the mobile phone to remind them of some physical activity that is useful as a reminder of system management. The purpose of this study is to conduct a systematic review of the Mobile-Health of Reminder Management System for Monitoring Patient Hypnosis. Therefore, the aim of this review is to gather scientific evidence on the effective uses of mobile phones through SMS, telephone and mobile applications, to see the effect m-Health on a reminder management system for patients with hypertension.

II. METHODS

Data Sources

The present study is a systematic review using a randomized controlled trial and mixed method. A literature search was performed on databases such as PubMed, ScienceDirect, ProQuest, Sage, EBSCO, and Scopus to identify articles published from 2015 to 2020. The keywords to search those journals were “hypertension” OR “hypertensive” OR “High Blood Pressure” AND “application” OR “software” OR “technology” OR “mobile” AND “reminder management” OR “reminder system”.

Study Selection

The feasibility of each study was assessed using the PICOT framework. The eligibility criteria for study inclusion were: (1) patient with hypertension, (2) m-Health intervention, (3) types of study: RCT, mixed method, prespective, crossover design study, (4) outcome: assement of hypertension and reduce the increasing number of hypertensive related to lifestyle, (5) full text available, and (6) publications written in English. Exclusion criteria were: (1) studies that focus on chronic diseases that are not hypertension, (2) studies in which a mobile phone was used together with other web-based interventions, (3) reviews, policy papers, feasibility studies, and book chapters and (4) publications not written in English.

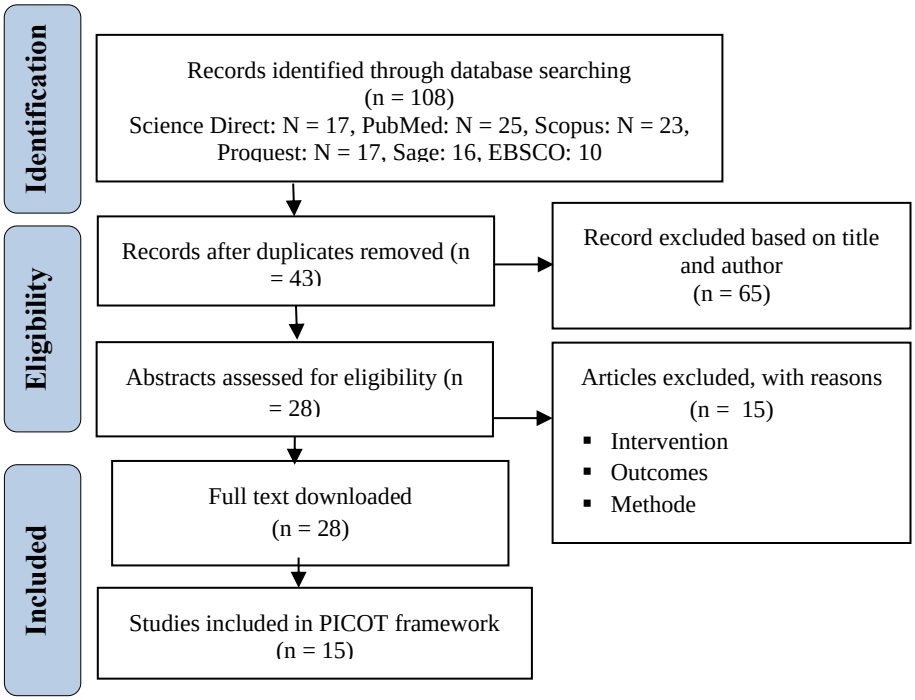
Data Extraction

The information was extracted from 15 articles: demographics information, study design, outcome measures, sample size, intervention, control, and year of publication from each study. Information was collected on relevant outcome data and included point estimates, measures of variability and number of participants.

.Quality Assessment

This study used the Cochrane collaboration tool to assess the risk of bias from studies conducted.

Figure 1. Flow diagram of the study selection process



III. RESULTS

From a total of 108 potential research results, 28 full texts were selected for review, and 15 articles were included, following the inclusion criteria. These studies included 9 randomized controlled trials, 4 mixed methods, 1 perspective, and 1 crossover design study.

Study Selection

The tree-step strategy was used in the initial phase of the literature search in six databases with the specified keywords and 108 articles were obtained. These consisted of 23 articles from Scopus, 17 articles from ScienceDirect, 10 articles from EBSCO, 16 articles from Sage, 25 articles from PubMed and 17 articles from ProQuest. The second step was to review each abstract retrieved for eligibility criteria. We excluded some articles that did not match the inclusion criteria. The third step was reviewing the full articles. Relevant data regarding inclusion criteria (participants, interventions, and outcomes), risk of bias, and results were extracted. At the end of the process, 15 studies were included in this systematic review. Nine studies were RCT, 4 mixed methods, 1 perspective, and 1 crossover design study.

Characteristics of Reviewed Studies

Health Content Area

Twelve studies focused on hypertension [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], three studies related to coronary heart disease [28], [29], [30]. All articles focused on secondary prevention related to hypertension management (medication adherence, diet, lifestyle changes, and blood pressure monitoring).

Study Design and Sample

Out of the fifteen studies, nine studies used a randomized controlled trial [16], [28], [18], [19], [29], [20], [25], [26], [27], four were mixed methods [21], [22], [23], [30], one study used a perspective method [24], and there was one crossover design study [17]. Regarding sample size, four studies had sample sizes above 250 [28], [18], [29], [26], and eleven studies had sample sizes of less than 150 [16], [17] [19]–[25], [27], [30]. Regarding the age of the participants, the age range of the fifteen studies was 22-80 years old.

Technology and Mode of Intervention

Of the fifteen studies, one study used SMS as a notification reminder [28], two studies compared two interventions, namely comparing SMS with telephone [25], and comparing telephone with m-Health applications [19], one study used the WeChat Application [26], and 10 studies using m-Health applications [16], [17], [30], [18], [20]–[24], [27], [29]. The frequency of sending messages (SMS), voice calls, and m-Health notifications varied from study to study. In two studies, SMS was sent every week [28]; in one study SMS and telephone were only sent once for assessment [25]; for one comparison of interventions between telephone and m-Health were carried out weekly [19]; using WeChat carried out 7-14 days [26]. Research using m-Health notification applications was carried out every day [20], [22], every week [18], [23], [24], [26], [28], every two weeks [21], every month [16], [17], every three months [29], and, in one study, it was carried out in stages starting at 2 weeks and going on to 12 weeks [30]. For all studies, SMSs were sent in the local language or the language that the patient understood for better and more convenient access. One study was only conducted on one day for data collection [25], twenty-one days [22], six weeks [19], [21], eight weeks [24], twelve weeks or three months [17], [18], [23], 4. 5 months [30], six months [16], [20], [26], [28], nine months [27], two years [29].

Clinical Outcome

Studies Measured Adherence and Outcome of Care

Of the fifteen studies, six studies reported treatment adherence, three studies reported physical activity, six studies reported on self-management for outcome criteria, two studies included knowledge of hypertension, and the majority made clinical outcome the main outcome. Each of the studies reported on more than one outcome. Some of these outcome criteria were combined with clinical outcomes.

Adherence to Treatment and Health Care Behavior

In the review article, the main concept of measuring compliance with medication was according to the doctor's advice. There were also studies using the concepts of self-efficacy, knowledge, attitudes, practices, and quality of life. The tools used to measure compliance were drug refills, number of pills, and self-reporting.

Clinical Improvement

Six of the fifteen studies reported significant changes in clinical outcomes as a result of several cell phone notification systems [18], [20], [26]–[28], [30]. Other studies only measured questionnaires and did not give clinical results.

Hypertension and Coronary Heart Disease

One study in a patient with Coronary Heart Disease was related to blood pressure monitoring [28]. The study reported average blood pressure before administration and after an intervention. The mean blood pressure before the intervention was systolic blood pressure 128.8 (12.3), 82.9 (7.5) diastolic in the intervention group and systolic 128.7 (12.2), diastolic 82.9 (7.4) in the control group. After being given the intervention for six months, the influence on blood pressure was systolic 128 (127 to 130), 81 (80 to 82) diastolic in the intervention group and 136 systolic (134 to 137), diastolic 84 (83 to 85) in the control group.

IV. DISCUSSION

This review identified 15 studies on behavioral health that evaluated the effectiveness of SMS mobile, telephone, and mobile applications. This review excluded articles that combined m-Health interventions with other web-based components such as email, Skype, video conferencing, Bluetooth and telecommunications, to find clear evidence about whether m-Health itself may have an impact on clinical results, because mobile technology is easily accessible and affordable.

There were some restrictions that were identified in the systematic review related to the method that was used, full text available and the population of the intervention. Language pre-selection was another potential limitation of the review paper. Not including studies which were non-English could have altered the results of the review as it may already have excluded several critical articles that were published in other languages. Including the only article that reviews together increases the possibility of losing the opportunity to access some of the intervention is important as well. At the time of the same, the system of peer review increases the quality of a paper and it can be assumed that papers not published under the system of peer review would not have the same quality. In this systematic review, nine out of the fifteen studies were RCT, so the designs were not heterogeneous. Despite that, we observed some differences in terms of sample size, process of intervention and tools used, in drawing a conclusion about the effect of the interventions.

Four studies of five twelve had a sample size of above 250 [28], [18], [29], [26], and eleven studies had a sample size of less than 150 [16], [17] [19]-[25], [27], [30]. People who are recruited may be difficult and / or create bias , especially for some groups, particularly: the elderly or residents of rural areas or people blind letters which may not have phones or may not be able to read the message and take part dal am interventions [31]. Besides that, the background behind the culture also affects the results of a study [24]. Most great articles did not mention anything about the strain or obstacles to intervention or the patient out and / or discontinuities. Needing to own a mobile phone became one of the deficiencies in this review as one of the journals mentioned that not all participants had a mobile phone, 46% had a private mobile phone, and the rest, as much as 54%, were using a mobile phone belonging to relatives [24].

A small part of the research in this systematic review used messages or SMS [25], [28]. Interventions were made by telephone in two of the five dozen articles [19], [25]. One of the articles said that 95.7 % of patients could use the phone personally to the phone, and 35.3% could use the phone to send a message [25]. A significantly higher number

partially agreed that voice calls were more beneficial when compared to SMS (34% preferred only voice calls, 11% only preferred SMS, 44% chose voice calls and SMS, whereas 11% did not have specific preferences) [32]. Risk of bias existed in the case of only using SMS, because it targeted a group of people who were relatively young and literate in the intervention, rather than people who were blind, letters and more older [32]. This message delivered related to hypertension management, such as understanding hypertension, signs and symptoms, dietary hypertension, smoking status, physical activity, and reporting the results of blood pressure checks regularly. The lack of intervention via SMS was passive, so there were respondents who ignored the message. Text message delivery was adjusted to the language of each country or a local language understood by the respondent, so that the aims and objectives of the intervention could be carried out for the outcome.

One application used the WeChat application. In this system, it is almost the same as a text messaging system, without any interaction via telephone or direct interaction using voice. The difference between SMS and WeChat is the recipient of information or individuals. SMS is only intended for one person, while WeChat gives information in a discussion group among patients with the same health problems. So, the advantages of this system were that all patients could get information from other patients. The discussion in this group was similar to SMS related to the management of hypertension, where hypertension can be a trigger for stroke. WeChat-based research interventions related to hypertension involved health education about hypertension, health promotion about healthy lifestyles, how to avoid hypertension, how to control body weight, a group chat about the third 2 weeks containing individual experiences in disease management, and a report on their physical condition and current life status, the latest tracking of participants' blood pressure about patients reporting blood pressure measured by patients at home and researchers providing feedback on patients' monthly blood pressure reports [26].

A mobile application or m-Health was the principal tool used in ten of the five twelve interventions. m-Health is more likely to work if the project is followed up, has been designed for a particular context and strong consideration has been given to the frequency of message delivery and message content [33]. Features provided through the mobile application were health education about hypertension, reminders to measure blood pressure regularly, reminders to carry out physical activity, and reminders to take medication. The average of all studies using a mobile application as an intervention showed effective results in lowering blood pressure and increasing adherence to the treatment of hypertension. The diversity of tools, together with the content and frequency of the use of the tool, mean that making comparisons was difficult. As a conclusion, a positive effect on adherence and outcomes of health were found in most large studies that were reviewed in the short term (1-6 months). By because it is , research is further required to determine the impact of the content of the message, frequency of use, the use of media for the intervention of behavior that is different as well as the sustainability of the intervention on a larger scale and the longer term. Also, the benefits of the cost of the intervention of m-Health, compared with the education of traditional health measures, is still questionable, because so far there is not enough evidence that is available.

Compliance refers to the action following the recommendation that was made by the provider in relation to time, dosage, and frequency of intake of drugs [34]. Adherence of patients to the regimen of medication that is recommended is the final step in the path of developing symptoms to receive curative treatment and when patients do not use drugs based on appropriate advice, it may be a result of patients not having access to affordable treatment and / or not receiving instructions that are appropriate, rather than factors of non-compliance of the patients associated [32]. Adherence to the regimen of treatment of what was mostly a large inversely with duration of treatment and the frequency of administration. Due to the disease being chronic it is more important to have mechanisms and strategies of follow-up that strongly

improve the adherence of patients to the regimen of treatment. There are various differences in the definition and measurement of compliance, tools that are used, the content and frequency of the use of the tool, as well as in the field of clinical and context of the country.

A patient may not fully follow the regimen of treatment or advice as prescribed, but still be able to receive treatment that is adequate or follow some changes in lifestyle, which in the end, can improve the clinical results. An 80% compliance rate for drug intake is not enough as a measurement, as a form of drug intake may be more important than the level of compliance. For example, skipping one week of drug antihypertensive completely can lead to a blood pressure high, with the risk of stroke or heart failure. But the amount that each of the doses were missed during the period of three months is not going to have the effect that can be measured in the control pressure of blood. The definition of compliance is more robust in terms of dose, duration and frequency and will contribute significantly to comparing the results of various studies, which are less in the review of this. Many reviews indicate that the biological test is the size of the compliance of patients the most accurate, followed by the number of pills, the reports themselves become the most is not accurate. However, do not exist measure single- compliance that can be recognized as the most can be reliable and accurate. A major problem in identifying patients who are not compliant is not able unreliability of many measures that are used to assess compliance, because there are a lot of factors: psychological, social and demographics, medications - drugs and doctors, which may affect adherence at various levels. Six of the studies studied reported significant changes in clinical outcomes as a result of several mobile phone notification systems [18], [20], [26]-[28], [30]. The limitation of this study is that the data in several articles did not involve families at home who were monitoring hypertension using applications. So that the elderly who have sensory disorders, can affect the effectiveness of m-Health.

V. CONCLUSION

There was always a positive impact on compliance with disease management, as well as on health outcomes in almost all the articles reviewed. But variability in the types of interventions (tools and tool use) as well as in the lack of information in most articles about the details of the intervention process and the concept of behavior change, make it difficult to draw conclusions. In addition, the methods used to measure impact, as well as the design, sample and measured results (measured compliance and clinical outcomes) also differed. However, the issue of cost effectiveness and sustainability of m-Health is still questionable. There is potential in implementing m-Health with technological advances and various levels of cellular network coverage, thereby offering the potential to reduce populations that need long-term care - due to chronic diseases / conditions, making m-Health an important part of the health sector. In addition, the low amount of literature published on the topic also reduces the power of conclusions.

CONFLIC OF INTEREST

No conflict of interest has been declared.

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APPENDIX

Table 1 Key findings in the clinical area of hypertension

Author	Country	Study design	Sample size	Duration	Intervention	Delivery frequency	Measures of outcome	Results
Husain et al., 2020 [16]	Iran	RCT	132	6 months	Mobile Application	Every month	Clinical (blood pressure, HDL, LDL, BMI) Behavioral Adherence of medication Physical activity Smoking cessation the WHO STEPS questionnaire the Hill-Bone High Blood Pressure Therapy Compliance Scale The International Physical Activity Questionnaire (IPAQ)	Medication adherence: drug intake 30–50 %
Chow et al., 2015 [28]	Australia	RCT	710	6 months	Messages (SMS)	Every week	LDL systolic blood pressure, body mass index (BMI) physical activity, smoking status	Mean of LDL 79 mg/dL SBP 128.2 mmHg BMI 29 Physical Activity 932 min/wk Smoking status 25.9%
Mertens et al., 2016 [17]	Germany	Crossover	24	84 days	Mobile Application	Every 28 days	Patient adherence	Mean of assessed adherence increasing 50.0 to 54.0
Morawski et al., 2018 [18]	America	RCT	412	12 weeks	Mobile Application	Every week	The Morisky medication adherence scale (MMAS) systolic blood pressure	Mean the MMAS was 6.0 (intervention) and 5.7 (controls) and increase to 0.4 (intervention) the mean of SBP decreased by 10.6(16.0)mmHg (intervention) 10.1(15.4)mmHg (control)
Najafi Ghezeljeh, Sharifian, Nasr Isfahani, & Haghani, 2018 [19]	Iran	RCT	100	6 weeks	Mobile Application Telephone	Every week	Self-management behaviors	There were no statistically significant differences between the telephone and smart phone social networking
Raghu, Praveen, Peiris, Tarassenko, & Clifford, 2015 [29]	India	RCT	292	2 years	Mobile Application	Every 3 months	Evaluation of the tool	System efficiency: median time for all ASHAs was 00:21:10
Ju Young Kim, 2016 [20]	Korea	RCT	95	6 months	Mobile Application	Every day	MMAS SBD DBP Self-monitoring	Mean of (intervention group) all of part increase 6.7 34 133.4

Author	Country	Study design	Sample size	Duration	Intervention	Delivery frequency	Measures of outcome	Results
								82.8
Na Sun, 2016 [21]	China	Mixed Method	20	6 weeks	Mobile Application	Every two weeks	Self-Reflective Behavior The Change Of Lifestyle Modification Behavior	Self-reflective behavior increased from 5.56 to 6.42 with an estimated effect size of 0.410. The average score of users' attitude toward lifestyle modification behavior decreased from 6.58 to 6.38 and increased to 6.79 with an estimated effect size of 0.324.
Cechetti, 2019 [22]	Brazil	Mixed Method	14	21 days	Mobile Application	Every day	Acceptance Questionnaire Engagement questionnaire	Gamification proved to be effective for the application and promoted the desired engagement results.
Biduski, 2020 [23]	Brazil	Mixed Method	37	3 months	Mobile Application	Every week	Questionnaire to measure the long-term experience on m-Health apps.	The information contained in the app was considered useful by most users (86%).
Ammenwerth, 2015 [30]	Austria	Mixed Method	25	4.5 months	Mobile Application	Phase 1: 4 weeks Interim phase: 12 weeks Phase2: 2 weeks	Life style changes Quality of life Patient Adherence Physical activity Blood Pressure	Adherence to medication was also high with up to 87% and 80%. Pre-defined goals for physical activity were reached in up to 86% and 73% of days, respectively. Quality of life improved from 5.5 at study entry to 6.3 at the end ($p< 0.01$; MacNew questionnaire) Reductions in blood pressure
Hallberg, 2018 [24]	Sweden	Prespective	20	8 weeks	Mobile Application	Every week	The self management system	The self-reporting of BP, symptoms, medication use, medication side effects, lifestyle and well-being.
Siddiqui, 2015 [25]	Pakistan	RCT	100	One day	Telephone Messages (SMS)	Once	The self management system	A statistically significant number ($p = 0.014$) of them preferred receiving phone calls (85.2%) rather than SMS (14.8%) reminders for these interventions.
Xiaowen Li, 2019 [26]	China	RCT	464	6 months	WeChat	Every week	Blood Pressure Hypertension Knowledge The Hypertension Self-Ecacy Scale The Hypertension Patients Self-Management	SDP 135.8 mmHg DBP 83 mmHg X 5.6 % 14.9%

Author	Country	Study design	Sample size	Duration	Intervention	Delivery frequency	Measures of outcome	Results
							Behavior Rating Scale (HPSMBRS)	
Sarfo, 2018 [27]	Ghana	RCT	60	9 months	Mobile Application	7–14 days	BP MMAS Perceived confidence scale Treatment Self-regulation questionnaire hypertension stroke knowledge	Mean of (intervention group) SBP 141.3 mmHg, DBP 91.4 mmHg 10.3 82.2 64.7 8.6