

Self-management of Chronic Conditions Using mHealth Interventions in Korea: A Systematic Review

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Objectives: Population aging has increased the burden of chronic diseases globally. mHealth is often cited as a viable solution to enhance the management of chronic conditions. In this study, we conducted a systematic review of mHealth interventions for the self-management of chronic diseases in Korea, a highly-connected country with a high chronic care burden.

Methods: Five databases were searched for relevant empirical studies that employed randomized controlled trial (RCT) or quasi-experimental methods published in English or Korean from the years 2008 to 2018. The selected studies were reviewed according to the PRISMA guidelines. The selected studies were classified using the Individual and Family Self-Management Theory conceptual framework. **Results:** Sixteen studies met the inclusion criteria, 9 of which were targeted towards diabetes management, and 7 of which were RCTs. Other target diseases included hypertension, stroke, asthma, and others. mHealth interventions were primarily delivered through smartphone applications, mobile phones connected to a monitoring device, and short message services (SMS). Various self-management processes were applied, including providing social influence and support, and facilitating self-monitoring and goal setting. Eleven studies showed mHealth interventions to be effective in improving self-management behaviors, biomarkers, or patient-reported outcome measures associated with chronic diseases.

Conclusions: While the number of identified studies was not large, none reported negative impacts of mHealth on selected outcomes. Future studies on mHealth should design interventions with a greater variety of targeted functions and should adopt more rigorous methodologies to strengthen the evidence for its effectiveness in chronic disease management.

Keywords: Mobile Applications, Medical Informatics, Chronic Disease, Self Care, Review

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I. Introduction

As of 2017, Korea officially became an 'aged' society, in which those aged 65 and older comprise of more than 14% of the total population [1]. One of the biggest challenges of an aging society is the increasing burden of chronic conditions. In Korea, while mortality rates of chronic disease have been reduced, especially in relation to cardiovascular disease, the longevity of chronically ill patients has prolonged the amount of time individuals spend living with diseases [2]. Unlike acute conditions, chronic diseases require consistent care and management outside of the healthcare setting, in

the community or primary care setting, in terms of medication, lifestyle management, and health behavior modification. High rates of avoidable hospitalizations for chronic conditions including chronic obstructive pulmonary disease (COPD), asthma, and diabetes, and the healthcare costs that these unnecessary episodes incur, imply that chronic care in Korea is suboptimal and that innovative interventions are required to improve the sustainability of the system [3].

The epidemiologic transition from communicable diseases to chronic disease requires re-centering of the health system from the disease to the individual [4]. A shift away from paternalistic healthcare delivery models, care for chronic diseases involves active participation and responsibility of the patient in day-to-day disease management. Self-management, defined as one's ability to manage the symptoms, treatment, physical and psychosocial consequences, and lifestyle changes inherent in living with a chronic condition, has been cited as a key component of chronic disease management [5]. Because self-management of chronic disease requires adherence to treatment or behavioral modifications outside the traditional healthcare setting, supportive tools are needed to maintain practice in daily life.

One potential solution to enhance such person-centered and person-driven chronic care is mHealth, the "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" as defined by the World Health Organization [6]. The popularization of mobile phones and smart devices has integrated mobile technology into various aspects of daily life, including healthcare and disease management, to overcome traditional barriers of the healthcare delivery system, including distance, time, and cost [7]. Features of mHealth, including short messaging services (SMS), smartphone applications, and decision-support systems, can assist in bridging the gap between required levels of self-management and current practice by providing personalized data, active reminders, and disease information [8].

With highly fragmented and episode-oriented care, Korea's health system is ill prepared to meet the needs of the rapid demographic and epidemiologic transition [9]. Utilization of mHealth for such conditions is suggested as a feasible solution in Korea because it is one of the most connected countries in the world [10]. In addition to almost-universal usage of the internet across the country, 88.7% of the population reported using a smartphone, and even among those 60 and older, usage rates were as high as 62% [11]. The adoption of mobile devices in healthcare has been lauded as a break-

through for uHealth services due to its comparatively low levels of regulation and high degree of personalization and connectivity [12]. Despite the growing interest in both the public and private sector, the evidence for the effectiveness of mHealth for disease management in Korea remains insufficient. Although several studies have already reviewed the international trend in mHealth solutions [7,8], most of the studies included in the reviews were conducted on Western populations, and all of the reports were written in English. Therefore, this review will identify and appraise the current evidence for the effectiveness of mHealth solutions for self-management of chronic conditions specifically in the unique context of Korea and suggest areas that require development.

II. Methods

1. Conceptual Framework

Ryan and Sawin's Individual and Family Self-Management Theory [13] provided the conceptual model for this review (Figure 1). The model outlines the role of outside intervention on the context and process of self-management, and its impact on proximal (self-management behaviors) and distal (health status, quality of life, etc.) outcomes. We employed this model (1) to identify what features of the self-management process are employed in the identified mHealth interventions and (2) to describe its impact on meaningful health and behavior outcomes.

2. Search Strategy

A literature review was conducted in 2018 on 5 databases, EMBASE, Korean Studies Information Service System (KISS), Korean Medical Database (KMbase), KoreaMed, and PubMed, limiting the search results to articles published in the past decade and those published in English or Korean. We constructed two sets of keywords, one that described chronic diseases (diabetes, diabet, hypertension, heart failure, pulmonary disease, chronic obstructive, asthma, stroke, cardiovascular disease, coronary disease, blood glucose, blood pressure, cancer, chronic disease) and another for mHealth interventions (mHealth, eHealth, uHealth, smartphone, application, mobile, cellphone, PDA). For non-Korean databases, we also included the key term 'Korea'. For databases KISS and KMbase, only keywords for mHealth interventions were searched due to a lack of appropriate search functions that allow for Boolean phrases. Instead we limited the search results to include only those in the medical subject category.

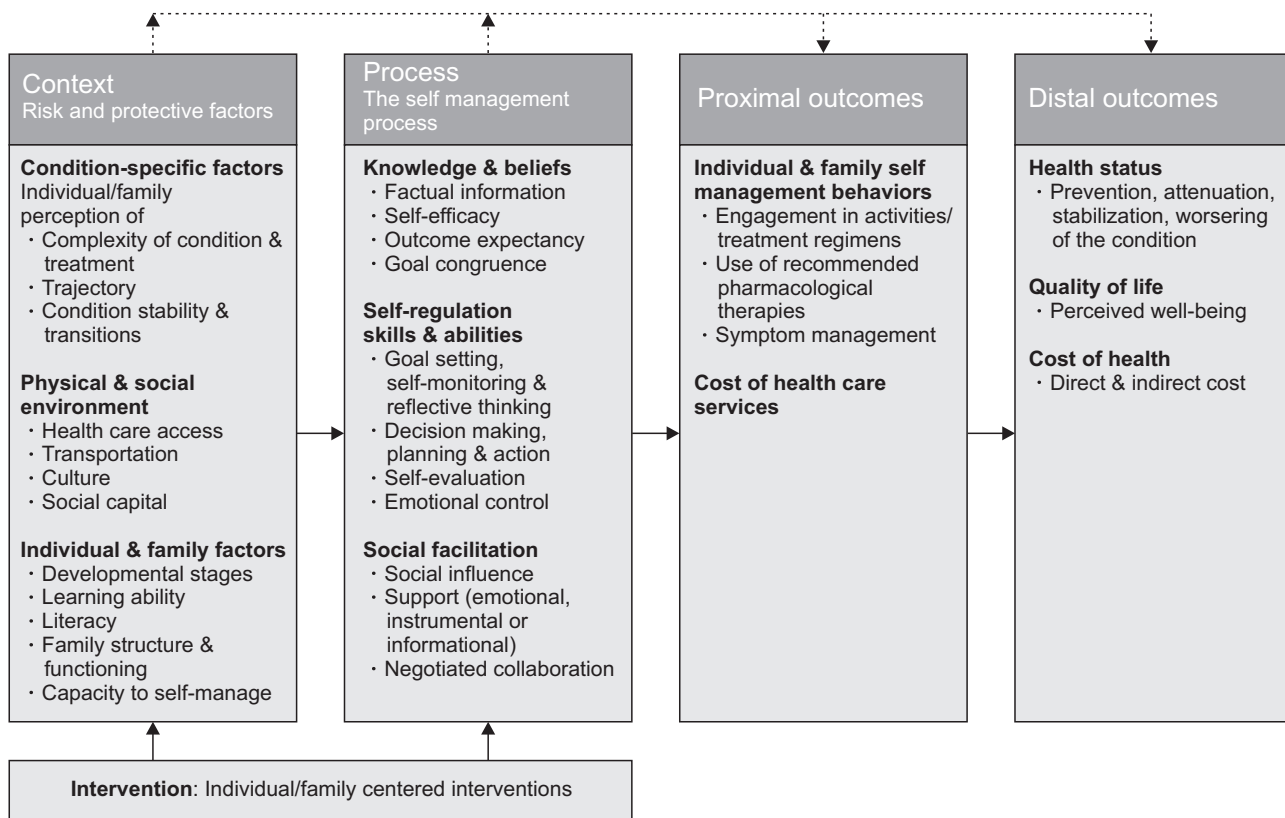


Figure 1. The individual and family self-management theory. Modified with permission of the authors [13] from: <https://uwm.edu/nursing/about/centers-institutes/self-management/theory/>.

3. Selection of Articles

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [14] for this report. We included original research articles that employed randomized-controlled trial or quasi experimental methods, which evaluated mHealth interventions for chronic disease management in the Korean population with measurable outcomes. We excluded papers if they only had an abstract, were reviews, development, usability, or feasibility studies, had a non-Korean sample, described interventions for which the end-users were not patients with chronic conditions, if the intervention did not employ mobile technology, or if they did not incorporate any self-management process. References of articles were sorted using the Endnote Desktop program.

4. Data Extraction and Analysis

Two of the authors screened the publications, first based on title and abstract, and then through full-text reviews. Any discrepancies were resolved by consensus among the authors. Descriptive characteristics of studies were organized, including study design, sample size, target disease, and age and sex proportions. Next, the interventions described in the

studies were profiled along with information about control treatments. Self-management processes incorporated in the interventions were classified based on the conceptual framework. Finally, we described the statistical results for proximal and distal outcomes reported in the studies and categorized them based on study design and effectiveness.

III. Results

1. Summary of the Selected Studies

The initial search of the five databases resulted in a total of 1,776 studies, of which 51 full-text articles were reviewed. After the screening process, 15 studies were selected based on the inclusion and exclusion criteria. Seven of the studies employed a randomized controlled trial design, 3 used a case-control design, and 5 had a pre-post design. More than half (8 studies) of the interventions described were designed for patients with diabetes. Other target diseases included hypertension, stroke, asthma, hyperlipidemia, and metabolic syndrome (Table 1, Figure 2).

2. mHealth Interventions & Self-management

The most commonly described mode of delivery for

Table 1. Study design and sample characteristics

Reference	Year	Study design	Target disease	Sample size (n)	Age (yr)	Sex, female (%)
Ahn et al. [15]	2016	NRS	Diabetes	IG: 14 CG: 12	IG: 50.5±17.1 CG: 49.7±16.4	IG: 57.1 CG: 41.7
Cho et al. [24]	2009	RCT	Diabetes	IG: 35 CG: 34	IG: 51.1±13.2 CG: 45.2±11.3	IG: 20.0 CG: 26.5
Cho et al. [19]	2010	RCT	Hyperlipidemia	IG: 327 CG1: 294 CG2: 297	IG: 42.2% aged 50–59 CG1: 33.0% CG2: 34.3%	IG: 50.5 CG1: 62.6 CG2: 60.3
Cho et al. [25]	2011	RCT	Diabetes	IG: 35 CG: 36	IG: 65.3±9.3 CG: 63.1±10.3	IG: 56 CG: 66
Chung et al. [26]	2013	Pre-Post	Hypertension	51	51.7	41
Chung et al. [27]	2014	Pre-Post	Diabetes	56	55.2±8.1	39.30
Jung and Lee [22]	2017	NRS	Hypertension	IG: 31 CG: 33	IG: 80.9±6.6 CG: 81.2±4.1	IG: 77.4 CG: 87.9
Kim and Kim [20]	2008	RCT	Diabetes	IG: 18 CG: 16	IG: 45.5±9.1 CG: 48.5±8.0	IG: 50 CG: 56
Kim et al. [16]	2014	NRS	Diabetes	IG: 35 CG: 35	IG: 51.8±10.3 CG: 53.8±9.0	IG: 43 CG: 43
Kim et al. [17]	2016	RCT	Asthma	IG: 22 CG: 22	IG: 49 CG: 51	IG: 82 CG: 64
Lee et al. [21]	2014	RCT	Hypertension	IG: 719 CG: 730	IG: 59.7±10.7 CG: 58.7±10.3	IG: 57 CG: 59
Noh et al. [28]	2010	RCT	Diabetes	IG: 20 CG: 20	IG: 42.5±10.6 CG: 42.3±7.6	IG: 20 CG: 25
Seo et al. [18]	2015	Pre-Post	Stroke	48	52.65±10.25	35
Song et al. [29]	2011	Pre-Post	Metabolic syndrome	316	42.4% aged 50–59	62
Yu et al. [23]	2009	Pre-Post	Diabetes	17	Male: 70.0±15.5 Female: 70.0±5.0	53

Values are presented as mean ± standard deviation.

NRS: non-randomized controlled study, RCT: randomized controlled trial, IG: intervention group, CG: control group.

mHealth interventions was the use of monitoring devices together with mobile technology. Monitoring devices included glucometers, blood pressure monitoring devices, and body composition analysis devices. These devices were used in conjunction with mobile technology often through wireless or USB sharing. Four of the more recent studies utilized smartphone applications as the mode of delivery [15-18], and three of the interventions described SMS as their mode of delivery [19-21] (Table 2).

The framework of self-management has three dimensions, including context, process, and outcomes. All the selected mHealth studies adopted interventions at the process level of

self-management, although interventions of behavior change can be implemented at both the context and process levels based on the framework (Figure 1). Social influence, social support, self-monitoring, and reflective thinking were applied in 14, 11, and 11 studies, respectively, while goal setting was used only in one study.

Social influence, which was used most frequently, was to encourage and facilitate behavior change through advice and recommendations from medical experts and health professionals as well as to provide reminders to improve medication or treatment adherence. Eleven of the selected studies adopted social support interventions to provide health-

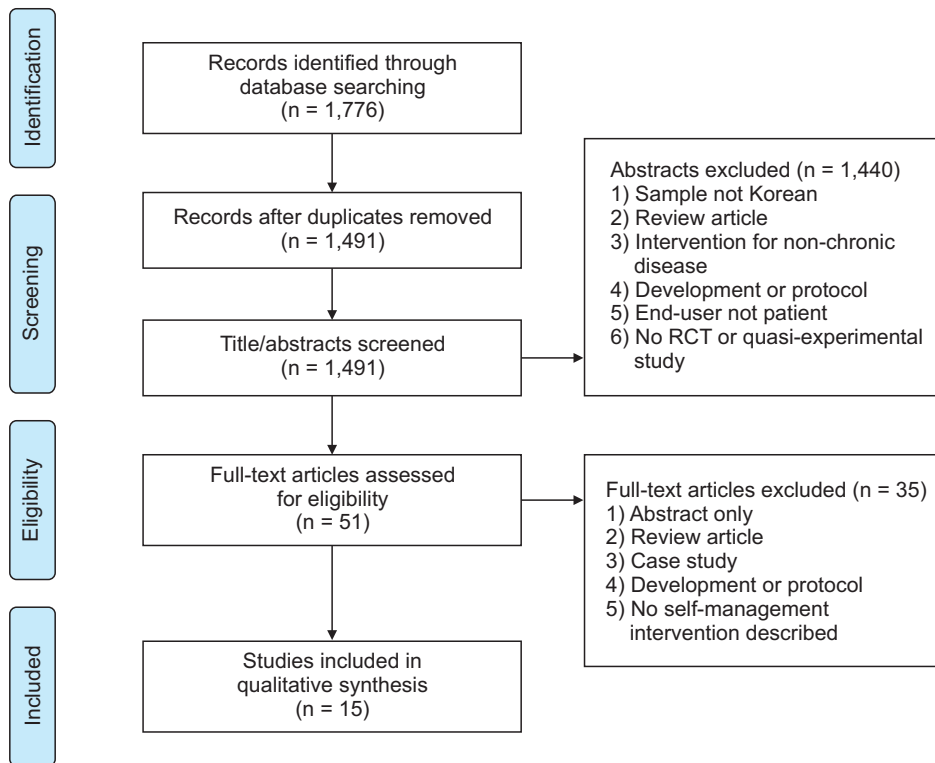


Figure 2. Flow diagram of the study selection process using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. RCT: randomized controlled trial.

related information through mHealth. The contents of information included diet plans, physical activity schedules for a healthy lifestyle, and knowledge of disease management for patients. Participants (or patients) of 11 studies that utilized self-monitoring and reflective thinking monitored or measured their own health indicators, such as body composition, diet, and biomarkers, by themselves with mobile devices. Using the gathered health information, patients were able to frequently follow-up their own health status and be provided with real-time, tailored medical recommendations. Only one study used goal-setting intervention for self-management. Participants of the study set a goal (e.g., glucose level which patients want to reach) and managed diet intake and physical activity to achieve the goal.

3. Outcomes

A total of 6 studies measured dietary behavior/intake, outpatient attendance, health knowledge, medication adherence, self-care behavior, self-efficacy, and social support as proximal outcomes of interventions that directly influenced self-management behaviors [15,17,19,21-23]. Changes in distal outcomes, such as glucose level, blood pressure, fat level, and body size and composition were obtained in 13 studies. Three studies out of the 13 studies additionally measured patient reported outcome measures (PROMs), such as quality of life, treatment acceptance, and patient satisfaction [16-

18,20-29].

Even though the study results appeared to be inconsistent, 11 studies reported a statistically significant beneficial effect of mHealth intervention, which improved at least one outcome measure. Four studies found no effect of mHealth intervention and concluded that all the outcomes were not statistically significant [16,21,24,25]. However, none of the studies reported negative results related to behavior changes and biomarkers (Table 3).

From the 6 studies measuring proximal outcomes, self-management behavior was improved through mHealth interventions in 5 studies, among which 2 were randomized controlled trials (RCTs), 2 were non-randomized controlled studies (NRSs), and 1 was a pre-post study. In the case of distal outcomes, including biomarkers and PROMs, only 3 out of 8 studies reporting positive results were RCTs. The rest included 4 pre-post studies and 1 NRS.

IV. Discussion

This study reviewed the current state of literature for mHealth interventions that facilitate the self-management of chronic diseases in Korea. mHealth is differentiated from traditional health practice in that it can utilize data that is consistently tracked outside of traditional healthcare settings and provide real-time recommendations and consultations

Table 2. Summary of mHealth interventions for chronic disease management

Ref.	Mode of delivery	Intervention description	Intervention period	Control treatment	Self-management process
[15]	Smartphone application	Self-record of diet intakes; providing meal plan and nutrition/behavior correction based on the gathered patient diet information	1 month	Off-line diabetes diet-management	- Self-monitoring & reflective thinking - Social influence - Social support
[24]	Monitoring devices with mobile technology & SMS	Self-measured blood glucose; providing medical recommendations via SMS	3 months	Internet-based diabetes management	- Self-monitoring & reflective thinking - Social influence - Social support
[19]	SMS	Reminders via SMS on medication adherence and schedule to visit primary care office	5 months (24 weeks)	CG1: postal reminder CG2: no intervention	- Social influence
[25]	Monitoring devices with mobile technology	Self-measured blood glucose; providing information about lifestyle modification, drug, problem assessment, etc. to nurses of primary healthcare posts	12 weeks	Usual diabetes management	- Social support - Social influence
[26]	Monitoring devices with mobile technology	Patient-measured body composition data sent to service center; reminders for medication/visit; center sends out weekly/monthly report with personalized exercise routine, diet plan; health consultation via phone/video/SMS	5 months (24 weeks)	None	- Self-monitoring & reflective thinking - Social support - Social influence
[27]	Monitoring devices with mobile technology	Self-measured blood glucose and body composition levels; providing patient with health reports and personal advice on health, nutrition, and exercise	6 months	None	- Self-monitoring & reflective thinking - Social support - Social influence
[22]	Monitoring devices with mobile technology	Community based eHealth monitoring; monthly telephone counseling	6 months	Informational poster	- Self-monitoring & reflective thinking - Social support - Social influence
[20]	SMS	Self-monitored blood glucose levels and drug information sent to Internet server via SMS, and researcher sent optimal recommendations to each patient via SMS and Internet	1 year (weekly)	No intervention	- Self-monitoring & reflective thinking - Social influence
[16]	Smartphone application	Self-measured blood glucose and blood pressure data transferred to the medical staff via app; recommendations and feedback were sent to the patient	12 weeks	No intervention	- Self-monitoring & reflective thinking - Social support - Social influence

Table 2. Continued

Ref.	Mode of delivery	Intervention description	Intervention period	Control treatment	Self-management process
[17]	Smartphone application	Self-recorded asthma symptoms and peak expiratory flow twice a day and sent to the online server, and signals were sent to the users about their asthma control status; clinical information relevant to asthma	8 weeks	No intervention	- Self-monitoring & reflective thinking - Social support - Social influence
[21]	SMS	Recommendations for antihypertensive adherence, exercise, low salt diet, and reduction of weight and alcohol	12 weeks	Appointment reminder	- Social influence
[28]	Web-based system	Provides real-time information about diet, dining out, hypoglycemia, sick-day management, stress management, and diabetes management	6 months	No intervention	- Social support
[18]	Smartphone application	Recording blood pressure and waist circumference data; automated alarm message sent to user if data exceeds predefined levels; Provides information about blood sugar, exercise, smoking, drug adherence	6 months	None	- Self-monitoring & reflective thinking - Social influence
[29]	Monitoring devices with mobile technology	Periodical health assessment, consultation about healthy lifestyle, nutrition programs, exercise	6 months	None	- Self-monitoring & reflective thinking - Social support - Social influence
[23]	Monitoring devices with mobile technology	Transmission of self-measured blood glucose (3 times a week) data to hospital; weekly phone call providing consultation and informational support	12 weeks	None	- Goal setting - Self-monitoring & reflective thinking - Social support - Social influence

SMS: short message service.

Table 3. Effects of mHealth interventions on proximal and distal outcomes of self-management

Type	Outcome measure	Reference		
		Effectiveness ($p < 0.05$)		Not significant ($p > 0.05$)
		Improved (+)	Worsened (-)	
Proximal outcome	Self-management behavior	Dietary behavior	[15]	[21]
		Dietary intake		[15]
		Outpatient attendance	[19]	[21]
		Knowledge	[15][23]	
		Drug adherence	[17]	[21]
		Self-efficacy	[22]	
		Self-care behavior	[22]	
		Social support	[22]	
Distal outcome	Biomarker	HbA1c	[18][20][27][28]	[16][23][24][25]
		FPG	[27][29]	[20][24][25][28]
		PP2	[20][28]	[24]
		Systolic blood pressure	[18][22][26][27][29]	[21]
		Diastolic blood pressure	[18][26][27][29]	[21][22]
		BMI	[18][29]	[16][27]
		Total cholesterol		[24]
		LDL-C	[27]	[16][28]
		HDL-C		[16][28][29]
		Triglyceride		[24]
		FEV1/FVC		[17]
		Waist circumference	[18][29]	
		Weight loss		[21]
		PROM	QoL	[17]
	ACT			[17]
Satisfaction			[24]	

Bold is defined as non-randomized controlled trial and underline is defined as randomized controlled trial.

PROM: patient reported outcome measure, HbA1c: hemoglobin A1c, FPG: fasting plasma glucose, PP2: 2-hour postprandial glucose, BMI: body mass index, LDL-C: low-density lipoprotein cholesterol, HDL-C: high-density lipoprotein cholesterol, FEV1, forced expiratory volume in 1 second, FVC: forced vital capacity, ACT: asthma control test, QoL: quality of life.

based on that information [7]. Also, mHealth has been identified as a cost-effective solution for chronic disease management. Management of chronic disease is considered suitable for mHealth because it does not require high-intensity and high-cost treatment. Rather, it requires consistent consultation, check-ups, and monitoring of a patient’s health status [30]. Because telemedicine remains illegal under the current law, the usage of personal mobile technology and devices to self-manage chronic conditions can provide an efficient technology-based disease management solution without moving beyond the boundaries of telemedicine. From the findings of this systematic review, we can describe the fol-

lowing significance, limitations, and gaps in the current state of literature on mHealth interventions for chronic disease self-management.

The use of monitoring devices with mobile technology was the most frequent mode of delivery, followed by smartphone applications, and SMS. Regardless of the mode of delivery, many interventions followed a similar pattern of self-monitoring of biomarkers and/or behavior adherence and receiving personalized feedback based on input data concerning general disease information, behavior change regimens, and health consultations. Other functions of described interventions included reminder alarms and telephone counseling.

One limitation of the study was that the selected literature covered only a limited spectrum of mHealth functions, especially centered on simpler forms, such as SMS or Web-based services. Unlike previous reviews that were conducted internationally, none of the studies in our review utilized wearable or portable monitoring devices, which is one of the most promising features of mHealth technology today. We suggest further development of mHealth interventions that incorporate such recent trends in mHealth, including gamification, social networking, or use of wearable devices that can be applied to chronic disease management.

The review of patient outcomes revealed that all studies reported that mHealth intervention has a positive impact on the proximal and distal outcome measures of self-management or has no significant impact. None of the outcomes worsened as a result of mHealth intervention. However, the evidence is insufficient to make generalizations concerning the positive results based on the findings due to the weak methodology of some of the selected studies. Less than half of the studies employed a randomized design, and all but 2 studies had a sample size smaller than 100. The failure to employ rigorous study design, especially in sampling for participants, can lead to biased results. When the studies were differentiated by study design in measuring effectiveness in improving outcomes, it was found that most of those studies that employed less rigorous methodologies showed statistically significant improvements in outcome measures. On the other hand, all but two RCT studies found non-significant impact on outcome measures. The findings fall within the scope of previously conducted reviews [7,8], that while some studies suggest the effectiveness of mHealth interventions on proximal and distal outcomes of self-management, the current state of literature fails to provide quality evidence; therefore, future studies are needed that involve higher levels of study design.

Upon categorizing the reviewed interventions based on the Individual and Family Self-Management Theory framework, we found that all mHealth interventions employed at least one self-management component. This suggests that mHealth interventions using personal mobile devices are suitable for the self-management of conditions facilitating record keeping of biomarkers, retrieving disease-related information, and receiving feedback and recommendations from professionals. According to the framework, interventions aimed at engagement in self-management can target both context (risk and protective factors) and process (the self-management process). All of the studies reviewed only described interventions aimed at the process-level, suggest-

ing that there are gaps in interventions designed to target contextual factors, such as disease-perception, social capital, literacy, and access.

Also, while several of the selected interventions employed social influence and social support tools, all were centered on the interaction between the patient and healthcare provider (doctor or nurse). As the name of the framework suggests, family members play a crucial role in disease management, especially for older adults with chronic conditions. None of the studies described interventions in which family members were involved in the self-management process. Classification of findings according to the framework suggest that the development of a greater variety of mHealth interventions is required for the self-management of chronic disease.

With recent demographic and epidemiologic changes, there are increasing concerns about the rise of healthcare expenditure and the sustainability of current care practices. Self-management of chronic conditions is rising as an effective strategy to contain costs by preventing the adverse consequences of neglected conditions and shifting the care setting away from traditional healthcare institutions into the community. In a highly-connected country such as Korea, mHealth can serve as a mechanism to bring together members of the community to guide each other in achieving health goals. The results of this review suggest there are positive associations with mHealth interventions and self-management outcomes of chronic diseases. However, we also found that there is a need for stronger empirical evidence in the literature and the development of a greater variety of intervention designs to improve the self-management of chronic conditions in diverse dimensions.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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