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REVIEW ARTICLE

Mobile App-based Interventions for Patients with Noncommunicable Diseases in Japan: A Scoping Review

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ABSTRACT

Noncommunicable diseases (NCDs) emerged as a persistent challenge to be addressed globally. The use of mobile apps has increased and their effectiveness – alongside the effectiveness of traditional face-to-face interventions – has been reported for patients with NCDs. However, there exist no integrated studies of mobile app-based interventions for patients with NCDs in Japan, and the current status and challenges remain unclear. Therefore, in order to provide a basis for developing mobile app-based education and intervention for patients with NCDs in Japan, this review aimed to identify and overview the status of mobile app-based interventions for patients with NCDs in Japan. The PubMed, Scopus, and Ichushi-Web electronic databases were searched for reports published till March 29, 2023, without language restrictions. The study characteristics, the intervention's main results, and the app content were extracted and synthesized. A total of 814 reports were identified, of which 8 ultimately met the inclusion criteria. The app content included self-monitoring, goal setting, counseling, education, feedback, and others. The findings revealed that intervention improved patients' clinical parameters and medication adherence. As the theory related to behavior change has not been used to design interventions in most studies, developing theory-based interventions is required in the future.

Keywords: Noncommunicable diseases, mobile apps, Japan

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1. Introduction

Noncommunicable diseases (NCDs) are a collective term for chronic diseases associated with modifiable behaviors, such as unhealthy diet, physical inactivity, tobacco use, and harmful use of alcohol[1]. NCDs include a wide range of diseases, including cardiovascular disease and diabetes, which typically require prevention and appropriate control, mainly through lifestyle changes such as diet and exercise[1]. NCDs account for approximately 74% of all deaths globally[1] and exemplify a significant economic burden[2]. In Japan, 85% of all deaths are attributed to NCDs[3] and, therefore, must be considered one of the priority issues to be addressed.

Against this background, the widespread use of digital technology in recent years, alongside traditional face-to-face interventions, has led to the use of mobile health, which provides health services to patients using mobile devices, mainly in the form of smartphone apps[4]. In this context, mobile apps collect data from a variety of sources, including medical devices and wearable devices, which are then integrated into smartphone-based apps to help promote healthy behaviors in patients through monitoring and advice[5]. Mobile apps constitute a promising approach to disease management for patients with NCDs[6], providing personalized support anytime, anywhere, and facilitating communication with healthcare providers (HCPs)[7-10].

Previous studies concerning mobile app-based interventions for patients with NCDs have shown significant improvements in blood pressure[8,11] and blood glucose levels[12] , ameliorated medication adherence[11,13] , and reduced rehospitalization rates[14]. These mobile apps included features such as self-monitoring, reminders, automatic feedback, and education to encourage lifestyle changes, while the interventions varied from using the apps alone, to remote monitoring and regular coaching or consultation by HCPs[8,11-14].

Conversely, in Japan, although there are some reports on mobile app-based interventions for patients with NCDs such as hypertension and diabetes, there exist no studies that have integrated multiple information and findings. Within the nation of Japan, apps have recently been treated as a type of medical device, and apps for smoking cessation and hypertension treatment are covered by insurance[15]. Therefore, it is expected that mobile apps will become increasingly popular for more efficient and effective treatment. This means that the evidence pertaining to mobile app-based interventions for patients with NCDs in Japan is currently being developed, while it is also thought that the content of mobile app-based interventions and their effects are not sufficiently clear.

Therefore, we considered it necessary to summarize the current status of mobile app-based interventions for patients with NCDs in Japan so as to provide a basis for the development of mobile app-based education and interventions for patients with NCDs in the aforementioned country. Additionally, we decided to focus on NCDs such as hypertension and diabetes, especially considering the disease structure in Japan[16].

Therefore, this review aimed to identify and overview the status of mobile app-based interventions for patients with NCDs in Japan.

2. Methods

2.1. Overview

A scoping review summarizes the published literature on mobile app-based interventions implemented in patients with NCDs in Japan. The review was conducted using the framework developed by Arksey and O'Malley[17] and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR)[18].

2.2. Research question and search strategy

This study pertains to the following research question: "What is known about mobile app-based interventions for patients with NCDs in Japan?" Therefore, three electronic databases, PubMed, Scopus, and Ichushi-Web (ver. 5), were used to search for literature from the publication date to March 29, 2023, with no language restrictions. The reference lists of the included studies were hand searched. In this study, NCDs were defined as "diabetes," "hypertension," "cardiovascular disease," and "liver disease" based on the views and data of the Ministry of Health, Labor and Welfare[19], the Japan Lifestyle-related Disease Prevention Association[20], and the Japanese Association of Preventive Medicine for Adult Disease[21]. The main search terms were ("Diabetes Mellitus" OR "Hypertension" OR "Cardiovascular Diseases" OR "Liver Diseases") AND "Mobile Applications". The search also included terms which were similar to the aforementioned main search terms. For PubMed and Scopus, the key term "Japan" was included. The full search strategy is shown in Figure 1. The identified studies were managed in EndNote20, and duplicates were extracted and removed before the screening.

Database name	Search strategy	Number of hits
PubMed	((((((Diabetes Mellitus[MeSH Terms]) OR ((((("Diabetes Mellitus"[Title/Abstract]) OR (Diabetes[Title/Abstract])) OR (DM[Title/Abstract])) OR (diabetic*[Title/Abstract]))) OR ((Hypertension[MeSH Terms]) OR (((((Hypertension*[Title/Abstract]) OR ("High blood pressure*"[Title/Abstract])) OR (HT[Title/Abstract])) OR (HBP[Title/Abstract])) OR (hypertensive[Title/Abstract]))))) OR ((Cardiovascular Diseases[MeSH Terms]) OR ((((((("Cardiovascular Disease*"[Title/Abstract]) OR (CVD[Title/Abstract])) OR ("myocardial infarction"[Title/Abstract])) OR (MI[Title/Abstract])) OR ("heart attack*"[Title/Abstract])) OR (angina[Title/Abstract]))))) OR ((Liver Diseases[MeSH Terms]) OR ((((((("Liver Disease*"[Title/Abstract]) OR ("Hepatic disease*"[Title/Abstract])) OR ("alcohol liver disease*"[Title/Abstract])) OR ("non alchoholic fatty liver disease"[Title/Abstract])) OR (ALD[Title/Abstract])) OR (NAFLD[Title/Abstract])))) **AND** ((Mobile Applications[MeSH Terms]) OR (((((((("mobile app*"[Title/Abstract]) OR ("smartphone app*"[Title/Abstract])) OR ("portable electronic app*"[Title/Abstract])) OR ("portable software app*"[Title/Abstract])) OR ("phone app*"[Title/Abstract])) OR ("cellphone app*"[Title/Abstract])) OR ("mobile health"[Title/Abstract])) OR (mHealth[Title/Abstract])) OR (m-health[Title/Abstract])))) **AND** ((japan[MeSH Terms]) OR ((japan) OR (japanese)))	62
Scopus	(((TITLE-ABS-KEY ("diabetes mellitus") OR TITLE-ABS-KEY (dm) OR TITLE-ABS-KEY (diabetic*) OR TITLE-ABS-KEY (diabetes))) OR ((TITLE-ABS-KEY (hypertension*) OR TITLE-ABS-KEY ("high blood pressure") OR TITLE-ABS-KEY (ht) OR TITLE-ABS-KEY (hbp) OR TITLE-ABS-KEY (hypertensive))) OR ((TITLE-ABS-KEY ("cardiovascular disease*") OR TITLE-ABS-KEY (cvd) OR TITLE-ABS-KEY ("myocardial infarction") OR TITLE-ABS-KEY (mi) OR TITLE-ABS-KEY ("heart attack*") OR TITLE-ABS-KEY (angina))) OR ((TITLE-ABS-KEY ("liver disease*") OR TITLE-ABS-KEY ("hepatic disease*") OR TITLE-ABS-KEY ("alcohol liver disease*") OR TITLE-ABS-KEY ("non alchoholic fatty liver disease") OR TITLE-ABS-KEY (ald) OR TITLE-ABS-KEY (nafld)))) **AND** ((TITLE-ABS-KEY ("mobile app*") OR TITLE-ABS-KEY ("smartphone app*") OR TITLE-ABS-KEY ("portable electronic app*") OR TITLE-ABS-KEY ("portable software app*") OR TITLE-ABS-KEY ("phone app*") OR TITLE-ABS-KEY ("cellphone app*") OR TITLE-ABS-KEY ("mobile health") OR TITLE-ABS-KEY (mhealth) OR TITLE-ABS-KEY (m-health))) **AND** ((ALL (japan) OR ALL (japanese)))	323
Ichushi-Web (ver. 5)	Omitted because the search strategy is written in Japanese	429

Fig 1. Search strategy

2.3. Study selection and charting of the data

The selection process comprised two steps: (1) reviewing titles and abstracts and (2) reviewing the full text. First, the titles and abstracts of all the articles were screened according to the relevance and inclusion criteria. Second, the full texts of the articles were read and reviewed for eligibility based on the inclusion criteria. We included adult patients (18 years and older) diagnosed with NCDs as defined in this study and intervention studies that reported the mobile app content. Peer-reviewed scientific articles that used quantitative methodologies were included. Case reports, editorials, commentaries, and reviews were excluded. Data extraction was performed using an Excel spreadsheet based on the content suggested by Arksey and O'Malley[17]. The sheet included the author, title, year of publication, study design, patient's disease, sample size, mean age, sex, intervention duration, intervention methods, other devices used, the theory and technique used, app content, and main effects of the intervention.

2.4. Charting, summarizing, and reporting the results

The included studies were summarized using descriptive methods to determine their quantity and scope. Further, the contents of the extracted mobile apps were organized.

3. Results

3.1. Study selection

The literature search generated 814 reports. After removing duplicates, the titles and abstracts of 759 reports were screened. Of these, 744 reports that did not meet the inclusion criteria were excluded. The full text of the remaining 15 reports was screened. Of these, seven reports met the inclusion criteria, and a hand search of the reference lists of the included studies identified one report. Finally, eight reports were included in this review[22-29], six of which were published in English[22-26,29], with two published in Japanese[27,28]. The study selection process is shown in Figure 2.

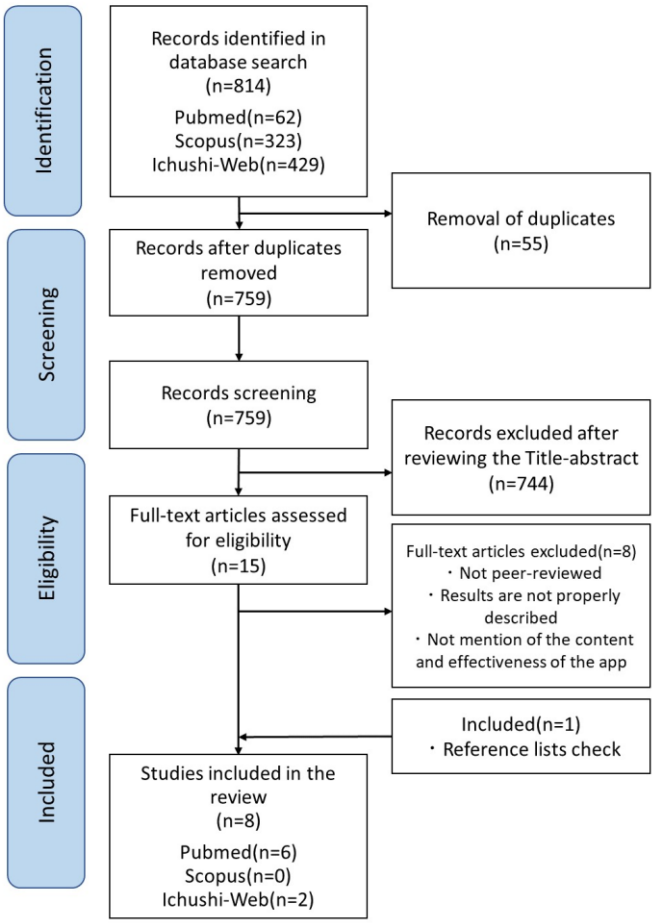

Fig 2. Study selection process

3.2. Characteristics of included studies

Of the eight included studies, one was published in 2014[29], while the others were published after 2021[22-28]. Two studies adopted randomized controlled trials (RCTs)[23,29], three adopted single-arm trials[24,26,27], and the other three adopted observational studies[22,25,28]. Four studies were conducted related to diabetics[26-29], and one study each was performed on patients with multiple lifestyle-related diseases[22], essential hypertension[23], nonalcoholic steatohepatitis[24], and atrial fibrillation[25]. The studies reported the mean age ranging from 52.2 to 67.8 years in the intervention group. All studies reported sex, with a percentage of 12.2 to 47.4% females in the intervention group. The intervention period was from one to six months. The number of participants in the intervention ranged from 10 to 199. The interventions have reported effects on patients' clinical parameters and self-reported measures. The results were examined according to the diseases of the target patients. Three of the four studies in patients with diabetes showed improvement in HbA1c levels[26,28,29]; one study revealed no improvement in HbA1c levels but in HDL-Cho levels[27]. A study regarding lifestyle-related diseases in patients showed improved blood pressure, body weight, and salt intake[22]. Another study in patients with essential hypertension indicated improvements in systolic blood pressure[23]. A study regarding nonalcoholic steatohepatitis in patients revealed improved liver-related NAFLD activity scores and histological and biochemical scores[24]. A study of patients with atrial fibrillation reported enhanced adherence to their medication[25]. Table 1 presents the characteristics of the included studies.

3.3. Characteristics of interventions

Two studies exclusively used the mobile app[25,29], two included additional phone call support[22,27], and the others incorporated additional regular care[23,24,26,28]. Four studies involved the borrowing of a defined device for measurement[22,23,27,29]. One study described the relevant theory and intervention techniques related to the intervention[22].

App content was divided into six categories, including others. All studies included self-monitoring[22-29]. Goal setting was employed in three studies[22-24], one of which used phone call support from HCPs[22]. Three studies used counseling[22-24]. Education was provided in five studies[22-25,28], one of which was aided by HCPs[28]. Feedback was specified in six studies[22-24,27-29], two of which were supported by HCPs[22,28]. Others included self-planning and evaluation in two cases[23,24], reminders of oral medications in one[25], and a search for the food ingested in one case[26]. Table 2 presents the characteristics of interventions.

Table 1. Study characteristics

Authors	Year of publication	Study design	Disease	Intervention duration	sample size (n)	Age (year) mean±SD	Sex (female)	Intervention main effects[a]
Kanai, M. et al.[22]	2022	Retrospective observational study	Multiple Lifestyle-Related Diseases : Hypertension, diabetes, dyslipidemia	6 months	IG: 125	IG: 55.3±6.2	IG: 17 (13.6%)	SBP, DBP BW, BMI Salt intake
Kario, K. et al.[23]	2021	RCT	Essential hypertension	24 weeks	IG: 199 CG: 191	IG: 52.4±8.1 CG: 52.0±7.6	IG: 35 (17.6%) CG: 42 (22.0%)	(Results at 12 weeks) 24-h ambulatory SBP (CG<IG) nighttime SBP (CG<IG), morning home SBP (CG<IG), evening home SBP (CG<IG), office SBP (CG<IG)
Sato, M. et al.[24]	2023	single-arm trial	Nonalcoholic steatohepatitis	48 weeks	IG: 19	IG: 52.2±10.8	IG: 9 (47.4%)	NAFLD activity score Steatosis score, Ballooning score, Lobular inflammation score, Fibrosis stage (0-4) in patients with stage F2/3 fibrosis ALT, AST, GGT, ALP BW, WC,
Senoo, K. et al.[25]	2022	Prospective observational study	Atrial fibrillation	1 month over	IG: 136	IG: 64.2±9.6	IG: 28 (20.6%)	The self-reported 8-item Morisky Medication Adherence Scale (MMAS-8)
Tsunemi, A. et al.[26]	2021	single-arm pilot trial	Diabetes	3 months	IG: 18	IG: 53.4±7.8	IG: 7 (38.9%)	HbA1c, Glycated albumin BW, BMI
Sato, M. et al.[27]	2022	single-arm trial	Diabetes	6 months	IG: 10	IG: 67.8±3.8	IG: 4 (40.0%)	HDL-Cho
Tomonaga, O. et al.[28]	2021	Retrospective observational study	Diabetes	3 months over	IG: 74	IG: 53.9±8.4	IG: 9 (12.2%)	HbA1c BW
Waki, K. et al.[29]	2014	RCT	Diabetes	3 months	IG: 27 CG: 27	IG: 57.1±10.2 CG: 57.4±9.4	IG: 7 (25.9%) CG: 6 (22.2%)	HbA1c (CG<IG) Fasting blood sugar (CG<IG)

RCT, randomized controlled trial; IG, intervention group; CG, control group; SBP, systolic blood pressure; DBP, diastolic blood pressure; BW, body weight; BMI, body mass index; ALT, serum alanine aminotransferase; AST, serum aspartate aminotransferase; GGT, serum gamma-glutamyl transferase; ALP, serum alkaline phosphatase; WC, waist circumference; HbA1c, hemoglobin A1c; HDL-Cho, high-density lipoprotein-cholesterol.

[a] Results show only those that were effective.

Table 2. Intervention characteristics

Authors	Methods of intervention	Other device	Theory used	Technique used	App content					
					Self-monitoring	Goal setting	Counseling	Education	Feedback (includes advice)	Others
Kanai, M. et al.[22]	app +phone call support by HCPs	•Wearable device (Step, pulse rate, sleep status) •Salt-measurement device	✓	✓	✓	✓[a]	✓	✓	✓[a]	
Kario, K. et al.[23]	app + regular care	•Home blood pressure monitor			✓	✓	✓	✓	✓	✓[b]
Sato, M. et al.[24]	app +regular care	None			✓	✓	✓	✓	✓	✓[b]
Senoo, K. et al.[25]	app	None			✓			✓		✓[c]
Tsunemi A. et al.[26]	app +regular care	None			✓					✓[d]
Sato, M. et al.[27]	app +phone call support by a dietician and physical therapist	•Home blood pressure monitor •Body composition monitor			✓				✓	
Tomonaga, O. et al.[28]	app +regular care	None			✓			✓[a]	✓[a]	
Waki, K. et al.[29]	app	•Glucometer •BP monitor •Pedometer •Weight scale			✓				✓	

HCPs, Healthcare professionals.

[a]Support by healthcare professionals.

[b]Self-plannning and evaluation.

[c]Reminder.

[d]Food search.

4. Discussion

4.1. Principal findings

This review is the first to summarize mobile app-based interventions implemented for patients with NCDs in Japan. Of all studies, only one was published before 2021, which suggests that mobile app-based interventions have become more widespread in recent years. While mobile apps continue to expand during covid-19[30], mobile app-based interventions are expected to increase in number and importance. Regarding the study design, only two RCTs were conducted[23,29]. Most studies were single-arm trials[24,26,27] or observational studies[22,25,28], and therefore, further validation using RCTs is required. Concerning study outcomes, only one study used a self-report measurement for medication adherence[25], while others measured patients' clinical parameters[22-24,26-29]. Most studies have shown valid results with interventions. Of the eight studies, half were conducted in patients with diabetes[26-29], and all but one showed an improvement in HbA1c levels[26,28,29]. Blood pressure, body weight, and salt intake have improved in patients with lifestyle-related diseases[22]. Systolic blood pressure has improved in patients with essential hypertension[23] and NAFLD activity score in patients with nonalcoholic steatohepatitis[24]. These findings suggest that the app-based intervention was an effective parameter in characterizing the diseases. However, only two studies used the app[25,29], whereas the others included regular care or phone call support from HCPs[22-24,26-28]. Therefore, concluding that app-based interventions solely led to improved outcomes is difficult. In the future, accumulating effects from studies exclusively using apps is required.

The app content was organized into six categories. All included studies used self-monitoring[22-29]. Self-monitoring is a common behavior change technique[31] and is used in all the literature included in a similar review[32]. Therefore, it is useful and easy to use for patients with NCDs. Goal setting, counseling, education, and feedback are conventional and helpful methods frequently used in previous studies[33,34]. Other content included a self-planning and evaluation function for proactive implementation by the patient[23,24], a reminder function effective for medication management[25], and a search function showing the composition of ingested food[26]. These functions are very beneficial according to the disease characteristics, and the reported apps included the above-mentioned features. However, only one study clearly indicated the use of a transtheoretical model to assess stages of behavior change in patients and the use of behavior change techniques such as motivational interviewing when developing intervention programs[22]. These theories have been used in approximately 40% of the reviews of mobile apps for similar diseases published to date[35,36]. Since the use of theories related to behavior change is effective[37], the utilization of theories should also be considered in the construction of more effective interventions in Japan.

4.2. Limitations

This study has several limitations. First, not all studies were included due to the limited available databases. Second, a scoping review aims to comprehensively map the existing evidence and summarize the findings. Because a scoping review is carried out when a systematic review is not available or a comprehensive review has not been conducted, no risk-of-bias assessment or meta-analysis is performed, and the quality of the included studies cannot be assessed. Finally, to provide a comprehensive review of interventions for patients with NCDs in Japan, this study added searches not only in PubMed and Scopus, but also in Ichushi-Web. Therefore, further review is required once there has been published more English-language literature on studies involving patients with NCDs in Japan.

4.3. Conclusions

This scoping review provides the first overview of mobile app-based interventions for patients with noncommunicable diseases in Japan. The outcome set depends on the disease of the target patients, but interventions improve patients' clinical parameters or medication adherence. The app content included self-monitoring, goal setting, counseling, education, feedback, and others. However, the theory has not been used to design interventions in most studies. The development of theory-based interventions is required in the future.

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