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Applications of smartphone-based in improving self-management of non-communicable disease: Literature review

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ABSTRACT Non-communicable diseases (NCDs) are one of the leading health problems that occur in the adult people. One strategy to improve self-management of NCDs during the COVID-19 pandemic is to use a smartphone-based application. This literature review is structured to describe applications smartphone-based to improve self-management of NCDs. The databases in e-resources included Wiley Online, ScienceDirect, and Cambridge Core from 2010-2021. A literature search resulted in 15 articles that focused on using applications as a medium for improving self-management of NCDs. Various studies have shown the benefits of the use of smartphone-based applications to improve self-management strategies, including (1) the application to count the physical activity score; (2) the self-management application to manage nutritional diets; (3) the application of pain evaluation; (4) the application of weight management, and (5) the application of self-disease management record. The existence of a smartphone-based application can reduce the limitations in the process of implementing and evaluating self-management of non-communicable diseases.

1.Introduction

The global problem of NCDs is one of the main causes of death with a reasonably high prevalence in the adult and elderly group. In 2016, an estimated 71% of patients worldwide died from NCDs.[1] The Southeast Asian region has a 25% chance of death in the population aged 30-70 years.[2] If NCDS are not stopped by prevention and treatment, it can affect the level of productivity and quality of life. The COVID-19 pandemic has caused health services to experience delays in intervention in patients with NCDS.[3,4] One of the intervention strategies is self-management. Self-management is treatment given to improve the patient's ability to manage signs and symptoms, treatment, physical and psychosocial consequences, and lifestyle changes due to chronic illness.[5] Self-management interventions focus on orientation in overcoming problems by planning educational approaches and cognitive and behavioral changes.[6]

Various studies show that self-management interventions have good results but also include some problems and difficulties, such as the limitations of health workers in introducing self-management and evaluating the interventions provided.[7-9] The condition of the COVID-19 pandemic has made it increasingly difficult for health workers to supervise the patient's self-management process. One way to overcome this limitation is to utilize new technology to manage self-care to overcome chronic disease problems.[10,11] The use of smartphone applications in health interventions to date has been widely carried out. It is used to improve health by providing information, advice, and support in monitoring or recording forms of chronic disease self-management.[10] One of the reviews describes smartphone applications facilitating clients/patients in setting goals for self-

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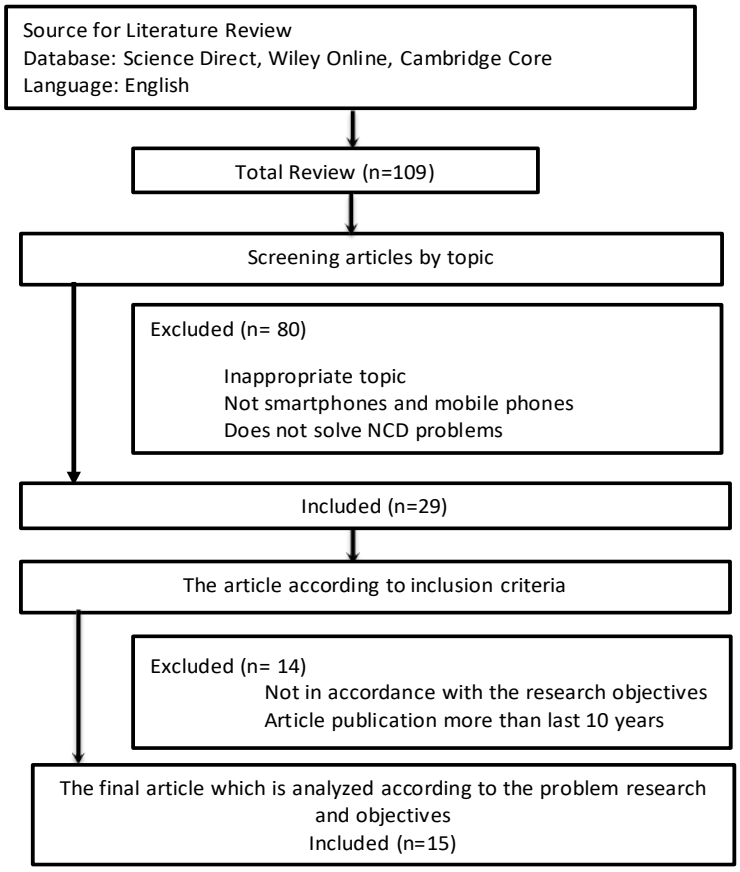

Figure 1. The process of article identification.

Table 1. List of question in applications.

Question	Point
1. How active are you in physical activity today (during the day)?	
More sitting	1.55
Sit/stand/walk	1.65
More standing/walking	1.85
Lots of work	2.2
2. How active are you in your free time/evening physical activity?	
More sitting	+ 0
Walk for 30 minutes	+ 0.06
Cycling 30 minutes	+0.15
Cycling 60 minutes	+0.29

management strategies.[12] Since the beginning of the pandemic, telemedicine and other digital tools have increased.[13] This literature review aimed to describe research results using various types of smartphone applications in managing self-management of NCDs.

2. Methods

This study conducted a literature review in two stages, such as searching for literature from several databases and selecting literature according to inclusion criteria. The inclusion criteria in this study were full-text articles, articles focusing on information technology in the management of NCDs, and the publication of articles from 2011-2021. The research question is "what are the types of smartphone applications that can be used for self-management of NCDs?". The sources and tools used

Table 2. Studies of application for improving self-management of non-communicable disease.

No.	Researchers	Title	Journal	Method	Result
1.	Bexelius, C., Sandin, S., Lagerros, Y. T., Litton, J. E., & Löf, M. (2011).	Estimation of physical activity levels using cell phone questionnaires: A comparison with accelerometry for evaluation of between-subject and within-subject variations.	Arthritis and Rheumatology	Quasi	This study describes a comparative study of physical activity motivational interventions with smartphone applications and interventions using accelerometers.
2.	Allen, J. K., Stephens, J., Dennison Himmelfarb, C. R., Stewart, K. J., & Hauck, S. (2013).	Randomized controlled pilot study testing use of smartphone technology for obesity treatment.	Journal of Obesity	Pilot study	This study describes the feasibility evaluation of a smartphone-based behavior change intervention.
3.	Bromberg, M. H., Connelly, M., Anthony, K. K., Gil, K. M., & Schanberg, L. E. (2014).	Self-reported pain and disease symptoms persist in juvenile idiopathic arthritis despite treatment advances: An electronic diary study.	Arthritis and Rheumatology	Quasi	This study describes electronic diaries as a medium for reporting patient progress in the implementation of self-management
4.	Shinohara, A., Ito, T., Ura, T., Nishiguchi, S., Ito, H., Yamada, M., … Aoyama, T. (2013).	Development of lifelog sharing system for rheumatoid arthritis patients using smartphone.	IEEE Engineering in Medicine and Biology Society, EMBS	Pilot study	This study describes a pilot study to test the feasibility of this application as a consulting media.
5.	Carter, M. C., Burley, V. J., Nykjaer, C., & Cade, J. E. (2013).	Adherence to a smartphone application for weight loss compared to website and paper diary: Pilot randomized controlled trial.	Journal of Medical Internet Research	Quasi	This study describes the feasibility evaluation of a weight management intervention using a smartphone.
6.	Kristjánsdóttir, Ó. B., Fors, E. A., Eide, E., Finset, A., Stensrud, T. L., Van Dulmen, S., … Eide, H. (2013).	A smartphone-based intervention with diaries and therapist feedback to reduce catastrophizing and increase functioning in women with chronic widespread pain. part 2: 11-Month follow-up results of a randomized trial.	Journal of Medical Internet Research	Quasi	This study describes electronic diaries as a medium for reporting patient progress in implementing pain management.
7.	Azevedo, A. R. P., de Sousa, H. M. L., Monteiro, J. A. F., & Lima, A. R. N. P. (2015).	Future perspectives of Smartphone applications for rheumatic diseases self-management.	Rheumatology International	Systematic review	This study describes a systematic review of perspectives related to smartphone-based applications in overcoming rheumatic problems.
8.	Choi, W., Zheng, H., Franklin, P., & Tulu, B. (2019).	mHealth technologies for osteoarthritis self-management and treatment: A systematic review	Health Informatics Journal	Systematic review	This study describes a systematic review of the benefits of m-health application.
9.	Monaco, A., Palmer, K., et.al (2021).	Digital health tolls for managing non-communicable disease during and after the COVID-19 pandemic: Perspectives of patients and caregivers.	J Med Internet Res	Pilot study	This study describes the management perspective of caregivers in utilizing digital applications to manage a non-communicable disease.
10.	Portelli, P., & Eldred, C. (2016).	A quality review of smartphone applications for the management of pain.	British Journal of Pain	Literature review	This study describes pain management with a smartphone-based approach.
11.	Bartholdy, C., Bliddal, H., & Henriksen, M. (2019).	Effectiveness of text messages for decreasing inactive behavior in patients with knee osteoarthritis: a pilot randomized.	BMC Health Service	Quasi	This study evaluates the feasibility of short messages in health behavior.

No.	Researchers	Title	Journal	Method	Result
12.	Anthony, Bokolo. (2020)	Use of Telemedicine and Virtual Care for Remote Treatment in Response to COVID-19 Pandemic.	Journal of Medical Systems	Literature review	This study describes the results of several studies in utilizing telemedicine in the era of the COVID-19 pandemic
13.	Orr, J. A., & King, R. J. (2015).	Mobile phone SMS messages can enhance healthy behavior: a meta-analysis of randomized controlled trials.	Health Psychology Review	RCT	This study evaluates the feasibility of instant messaging in behavior change.
14.	Fikky Aprico, Arif, M. S., Muriyatmoko, D., Musthafa, A., Ramadhan, A., Phuspa, S. M., & Ratih Andhika Akbar Rahma. (2019).	Kerja Sehat : Aplikasi Mobile Untuk Mengurangi Resiko Musculoskeletal.	Jurnal Rekayasa Sistem Dan Teknologi Informasi	Pilot study	This study tested its application in reducing the risk of musculoskeletal problems
15.	Eccleston, Christopher. et al (2020).	Managing patients with chronic pain during the COVID-19 outbreak: considerations for the rapid introduction of remotely supported (eHealth) pain management services	Pain	Literature review	This study describes chronic pain management using eHealth during the COVID-19 pandemic

included Science Direct (74), Wiley Online (9), and Cambridge Core (26) databases.

The keywords used to compile the literature review are "smartphone," "technology," "non-communicable disease," and "mobile phone." The literature search results found fifteen articles that matched the criteria. The process of identifying the articles followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (Figure1). The inappropriate article was eliminated because it met the exclusion criteria.

3. Results and Discussion

Several smartphone applications that have been created as self-management of NCDs, namely physical activity calculators, self-management applications in lifestyle changes to manage nutritional diet, pain evaluation, weight management, and chronic disease self-management records.

3.1. Physical activity score calculator app

The physical activity levels calculator (Physical activity levels calculator) developed by Bexelius et al. uses a telephone device to evaluate the physical activity of a person who is undertaking a weight management program.[14]

The study conducted by Baxelius et al. also uses a comparative method of measuring physical activity with an accelerometer. This method of measuring physical activity using a telephone device focuses on assessing a person's level of physical activity with a questionnaire compiled on a smartphone device. The questions compiled consist of two questions that should be completed by someone committed to weight management. The person must fill out these two short questions every day at 9 pm as a form of evaluation of the physical activity carried out on that day (Table 1).

The study of Bexelius et al. showed that the evaluation instrument using a smartphone device is in line with the increase in the level of physical activity that is assessed also using an accelerometer. Therefore, the physical activity evaluation instrument using a smartphone device is a promising method for assessing physical activity level (PAL) in epidemiological studies.[14] However, the research conducted by Bexelius et al. has limitations on the number of samples involved in this study (Table 2).

Table 3. Public acceptance of household cloth masks

	Smartphone	Paper Diary	Website	p
Weight				
Baseline	96.8	97.9	96.4	
6 months	92.2	95.0	95.1	
Body Mass Index	33.7	34.5	34.5	
Baseline	32.1	33.4	34.0	
6 months				

Respondents involved in this study were female, so this harmonious research should be carried out again with male respondents. The research should be varied to give more valid measurement results in measuring the level of physical activity using smartphone media on various respondents with any gender characteristics. In addition, this study was also conducted on female respondents who have health characteristics in good indicators. The results of this study should also be carried out on the elderly or less healthy groups of respondents.[14]

Self-management of the implementation of physical activity is also done by using text messages as a form of education.[15] The research of Bartholdy et al. involves patients with a diagnosis of osteoarthritis. Every three times/per week for six weeks, patients are given messages via text messages. The message contains the patient's motivation to perform regular physical activity. After six weeks of being given a message via a smartphone-based short message, they were then monitoring the level of physical activity using an accelerometer for three days. During giving educational messages through these short messages, patients were not given feedback by health workers. Therefore, the results of this pilot study did not show any significant difference between the intervention group and the control group regarding physical activity self-management.[15]

The results differ from the Orr and King study, which showed that short messages were effective in behavior change.[16,17] Short messages are used as a supporting medium in the intervention. This short message results in an estimate of affordable service costs because health workers can provide education easily and quickly to patients.

3.2. Self-management application lifestyle changes in managing nutrition diet

A self-management study using smartphone media conducted by Allen et al. is a method used to support the effectiveness of weight management counselling.[18] Respondents who participated in this intervention were the group with a BMI of 28-42 kg/m^2 with ages between 21-65 years. This study was conducted in the overweight group and the group with a history of coronary heart disease, diabetes, cancer treatment, orthopedic-related diseases, and arthritis pain. The preliminary study conducted on this intervention focused on counselling given by nutritionists every week. Respondents were given counselling that focused on reducing calories and recommending a healthy diet by increasing vegetables and fruits. The problem that often occurs in counselling sessions is the lack of commitment to the presence of the intervention group in the diet management treatment. Therefore, to overcome this, the application was also developed using a smartphone device to provide nutrition management counselling and training materials.

This application focuses on management promotion by utilizing smartphone devices in counselling facilities in real-time. The respondent fills in the initial data regarding weight, height, age, gender, and the target weight to be achieved in this application. After the respondent fills in the initial data, the system will calculate the number of calories needed by the respondent every day. This calorie calculation is based on the Mifflin system, which is generally used to calculate the number of calories based on body weight.

In addition to respondents getting information related to the number of calories needed, users of this application can also record food consumption every day (food intake). Application users can view recorded progress of food intake and physical activity in graphs and diagrams. The appearance of these graphs and diagrams can make it easier for respondents to see the progress of self-management being done to improve nutrient management and physical activity.[18]

This study showed no significant difference between before and after the counselling

intervention and the use of self-management smartphone applications. Although there was no statistical difference, the study results showed a change before and after the intervention, for example, a decrease in the mean BMI of 0.7 kg/m^2. This study also explains that the use of smartphone-based application devices in self-management will further increase effectiveness if it is collaborated with direct counselling methods. The result is indicated by the decrease in the average BMI of 1.8 kg/m^2 if a person uses counselling methods and smartphone applications to implement self-management. This smartphone-based application affects the effectiveness of the costs incurred by patients because there is no need to spend money on a transportation budget for counselling to health workers.[18] The use of digital applications improves communication between healthcare workers and patients during a pandemic.[4]

3.3. Pain evaluation app

A study conducted by Bromberg et al. involved the commitment of application users to report the pain scale they felt due to arthritis problems.[19] Respondents involved in this study were children aged 8-18 years with a diagnosis of arthritis. Respondents involved were committed to filling in the pain scale, stiffness scale, and level of fatigue felt for three times (morning, afternoon, and evening) in one day for one month. Self-evaluation or self-monitoring is done by filling out notes or diaries as self-reported on a smartphone application device. The recording of this pain evaluation was not only carried out by the study of Bromberg et al., but Shinora et al. had also performed this pain diary intervention in patients with osteoarthritis. The pain felt by application users is recorded in a smartphone application device, then health workers see the results of patient self-monitoring and provide recommendations.[20]

This study involved children as respondents in a self-reported intervention model using a telephone device. However, the researchers explained that the results of this study could be adopted as monitoring the effectiveness of cognitive-behavioral therapy. Smartphone devices are a technology that is often used to support interventions, one of which is self-management of pain problems in the COVID-19 pandemic era. Self-monitoring with smartphone devices can facilitate the documentation of pain scales, stiffness scales, and fatigue levels. The application makes it easier for health workers to get symptom responses and behavioral changes (psychosocial) due to pain problems experienced by application users. In addition, self-monitoring using a smartphone device can also assess the reactions raised by patients after treatment. Notes written by application users in their diaries on the device will be sent directly to health workers. If the message has been sent, health workers can quickly provide feedback and recommendations to patients to reduce the symptoms reported in the application device. This technology-based application is effectively used in the pandemic era, which makes it difficult for patients to consult and conduct examinations directly at health facilities.[13]

The study results in Bromberg et al. did not show the effectiveness of reducing the pain scale felt by application users. However, the records reported by users of the application in monitoring their pain scale showed a decrease in the average stiffness and fatigue levels between the time in the morning, afternoon, and evening. The results show that records written using smartphone devices make it easier for health workers to be responsive in providing recommendations on the scores reported by patients/application users. Therefore, recording pain scales with smartphone media can be an alternative to ease communication between health workers and patients in providing coping strategies to deal with pain, especially in the era of the COVID-19 pandemic. The behavioral component of self-management using digital technology can help manage pain and reduce emotional stress during the COVID-19 pandemic.[21]

3.4. Weight Management App

Weight loss programs are generally conducted in a self-management strategy. In a study conducted by Carter et al., weight loss management strategies were done using a smartphone-based application device.[22] The study was conducted through comparative weight loss self-management using smartphones, paper

diaries, and websites (Table 3). The smartphone-based application in this study is quite different from other applications. The application in this study is relatively mature and has provided choices for application users regarding recommendations that patients should make to change their healthy lifestyles. As a first step, the application user fills in the patient's current weight, and then the application automatically displays the ideal number of calories for the patient and menu recommendations that the patient can consume. This application has been prepared more sophisticated and in-depth because it is done without using a counselling system by health workers. Application users receive various options in planning their management. Patients can use this application in self-monitoring related to the calorie target they want to consume per day, nutrition management, and the implementation of physical activity.

This study indicates that there is a statistically significant difference between the use of smartphones, diary papers, and websites in the implementation of self-monitoring for six months. The use of smartphone applications has a higher median value (Me=82) than other devices (diary papers and websites) by patients to support self-monitoring. In addition, the results of the study also showed that there was a more significant reduction in body weight and BMI among respondents who used smartphones, diary papers, and websites as self-monitoring media for six months. The study results shown in this study indicate that the use of smartphone-based applications supports the implementation of self-monitoring interventions in changing nutrition management behavior and physical activity as a strategy to overcome NCDs, especially during the COVID-19 pandemic.

3.5. Chronic illness self-management notes app

The use of smartphone application devices to manage non-communicable diseases was also done by Kristjansdottir et al. The focus of the use of the application is used for self-monitoring of pain.[23] In general, the use of the application is consistent with other studies, but this study adds a short audio material on the practice of positive thinking (mindfulness). This application offers various interventions, namely smartphone-based diaries, direct recommendations from health workers, and audio files. The researcher realized that this application was a supporting medium in the self-management intervention done by the patient during the intervention period (11 months). Therefore, the researchers continue to provide counselling interventions as monitoring the patient's health management.

The choice of audio files was also done in a study conducted by Aprico et al., namely by providing educational menu options to prevent complications of joint disease.[24] Application users can choose a menu that provides various education-related to prevent complications from NCDs' problems. One example of education provided by this application includes education on knowledge of Musculoskeletal Disorders (MSDS) and education on correct body posture images.

The study by Aprico et al. showed no significant difference in the level of functional and symptom scoring of the disease between the intervention and control groups.[24] However, the results of this study showed a positive impact and did not show a negative impact related to the level of function and symptoms, fatigue, and emotional distress. The researchers in this study realized that the results of the research were still ambiguous. This happened because there was no significant difference between the two groups regarding function scoring and disease symptoms after the intervention. However, when referring to the initial stage, changes in function and symptoms occur in application users after smartphone-based self-management interventions are carried out. Therefore, smartphone-based applications can be used as a supporting medium for the self-management of NCDs.

This literature review has limitations in reaching the results of previous studies using smartphone applications for self-management during the COVID-19 pandemic. The implications of this research are expected to provide basic information in reviewing experimental research. This literature review can be used as the basis for determining smartphone applications for self-management of chronic diseases during the COVID-19 pandemic.

4.Conclusion

Non-communicable diseases (NCDs) are a serious health problem that has been prioritized by the WHO. The COVID-19 pandemic has limited self-management control of these NCDs. The process of controlling patients with NCDS is an import focus of smartphone-based applications. These beneficial results can be seen in the review of applications for self-management, namely Physical Activity Score Calculator, Self-Management Application Lifestyle Changes in Managing Nutrition Diet, Pain Evaluation App, Weight Management App, and Chronic Illness Self-Management Notes App.

The limited mobilization that occurred in the era of the COVID-19 pandemic made it difficult for this group to conduct direct examinations at health facilities. The existence of smartphones helps groups of sufferers to access various information and conduct counselling safely in the era of the COVID-19 pandemic. Some research results explain that groups of patients with NCDs can use the smartphones. However, it is necessary to pay attention to the accessibility of this group to the use of smartphone devices, such as visual acuity, ability to understand information, and socioeconomic level.

Conflict of interests

The authors declare no conflict of interest.

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