Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Jan 06; 9(T5):142-151.
https://doi.org/10.3889/oamjms.2022.7859
eISSN: 1857-9655
Category: *T5 - "Re-Advancing Nursing Practice, Education and Research in the Post Covid"*
Section: *Cardiology*

Mobile Health Application to Support Family Caregivers in Recurrent Stroke Prevention: Scoping Review

Erfin Firmawati[1,2,*], Ismail Setyopanoto[3], Heny Suseani Pangastuti[4]

[1]Doctoral Program, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia; [2]School of Nursing, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia; [3]Doctoral Program, Faculty of Medicine, Health Community and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia; [4]Department of Nursing, Faculty of Medicine, Health Community and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

Edited by: Igor Spiroski
Citation: Firmawati E, Setyopanoto I, Pangastuti HS. Mobile Health Application to Support Family Caregivers in Recurrent Stroke Prevention: Scoping Review. Open Access Maced J Med Sci. 2022 Jan 06; 9(T5):142-151. https://doi.org/10.3889/oamjms.2022.7859
Keywords: Caregivers; Mobile applications; Recurrent stroke
***Correspondence:** Erfin Firmawati, Doctoral Program, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Indonesia School, Yogyakarta, Indonesia.
E-mail: erfin.firmawati@umy.ac.id
Received: 06-Nov-2021
Revised: 24-Dec-2021
Accepted: 27-Dec-2021

Funding: This study was supported by Universitas Muhammadiyah Yogyakarta and Universitas Gadjah Mada
Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Caregivers play a key role in continuum care for stroke patients. Involvement of caregivers in stroke care was important. With the advancement of information technology and the rapid growth worldwide in cell-phone use and internet connectivity, additional evidence may be needed in the use of mobile applications to support caregivers in stroke care.

AIM: The aims of this review were to identify existing mobile application designed to support family caregivers of people with stroke disease.

METHODOLOGY: A scoping review study framework was carried out in this study, using the EBSCO, Cochrane, PubMed, ProQuest, and Science Direct databases using search keywords: "family caregiver," "mobile health application," and "recurrent stroke or secondary stroke prevention." This review examined studies published between January 2011 and December 2020. Of a total of 728 papers found, 9 journals were selected.

RESULTS: The results founded three categories and their attendant sub-categories. The categories were caregivers support, involvement caregivers in stroke care, and barriers. The majority of mobile application was used to provide video education for caregivers. Caregivers involved in stroke care including emotional care, nutrition, exercise, and recurrent stroke prevention. Poor connection was the most barrier in using mobile application.

CONCLUSION: Mobile application can support caregivers in stroke care. Healthcare providers are expected to utilize mobile applications in helping caregivers in post-stroke care.

Introduction

Stroke is the second leading cause of death (11.8% of all deaths) and the third leading cause of disability (4.5% of all disabilities) in the worldwide [1], [2] Stroke patients are higher risk to experience a recurrent stroke. Recurrent stroke is a new neurological deficit or exacerbation of a previous neurological deficit with clinical evidence which occurred more than 24 h after stroke onset, occurring in the same or different vascular [3], [4]. Recurrent stroke can be more severe than the previous stroke, increasing even more the probability of death or disability [5]. According to Global Burden Disease 2013, recurrent stroke can be caused by 91% modifiable risk factors [6].

Recurrent stroke can be prevented by risk factors management that includes monitoring blood pressure, blood glucose, and cholesterol, lifestyle modifications such as healthy diet, increased physical activity, smoking, and alcohol cessation. Several studies indicate that control of all modifiable risk factors would reduce up to 75% the incidence of recurrent stroke [6].

The importance of secondary stroke prevention, but many patients are not optimal in risk factor management. Many factors cause it, including lack of knowledge [7], [8], motivation, patient awareness [8], cognitive decline, and disability [9]. Therefore, role of family caregivers is very important in helping stroke patients to manage risk factors [8], [10], [11]. Family support has a very significant effect on risk factors control and lifestyle changing of stroke patients in preventing recurrent stroke [12], [13], [14], [15], [16]. Family caregivers roles include identifying signs and symptoms of recurrent stroke [17], [18], assessing risk factors [18], managing hypertension, physical activity [12], [14], [16], medication, healthy diet [12], [13], [19], [20], smoking cessation and alcohol [12], [14], and helping control to health services [12], [19]. Many roles of family caregivers, there is needed to identify intervention to support their roles.

In recent years, several interventions for post-stroke patients were provided using mobile application. Mobile health application is defined as medical and public health practices that are supported by mobile devices, such as mobile phones, personal

digital assistants, patient monitoring devices, and other devices [21]. The use of mobile applications is recommended as an alternative in post stroke management [21], [22], [23], [24], one of which is the prevention of recurrent stroke [22], [23], [24]. Mobile application showed significant improvement regarding risk factor control of recurrent stroke such as hypertension, diabetes, physical inactivity and obesity [25].

A previous content reviews explored mobile application functionalities for caregivers with stroke; however, there was no studies focuses on family caregivers involvement in stroke caregiving to prevent recurrent stroke using mobile application [26]. Need to identify available evidence on mobile application for stroke family caregivers in recurrent stroke prevention. The aim of this review was to identify mobile application that supports family caregivers in their roles of recurrent stroke prevention.

Methods

The aims of this review were to identify existing mobile application designed to support family caregivers in recurrent stroke prevention. This study utilized scoping review, which may give appropriate an overview of the available documentation to examine the current of knowledge on a particular subject. A scoping review was appropriate for identifying mobile applications, which may support family caregivers in recurrent stroke prevention. Scoping review are used to present a broad overview of the evidence pertaining to a topic, irrespective of study quality, and are useful when examining areas that are emerging to clarify key concepts and identify gaps.

A scoping review was carried out by following the five stages as suggested by Arskey and O'Malley [27] including; (1) identifying research questions; (2) identifying relevant studies; (3) selecting studies; (4) mapping data; and (5) compiling, summarizing and reporting results.

A systematic search strategy was used to identify relevant journals articles related to mobile application for caregivers in secondary stroke prevention. The inclusion criteria for journal articles in this scoping review were published between January 1, 2011 and January 31, 2020; written in English; available in full text, and provided information about the design, development and evaluation of the use of mobile applications. The exclusion criteria were journal articles that reported information about mobile application not specifically for recurrent stroke prevention.

Stage 1: Identifying research questions

This scoping review aimed to answer the following research questions. There are research questions in this review:

1. What is the contribution of mobile health application in supporting family caregivers of people with stroke?
2. What is the involvement care of caregivers in recurrent stroke prevention?
3. What are the outcomes of using mobile application for family caregivers and stroke patient?
4. What are the barriers in the implementation of mobile health application for caregivers with stroke in recurrent stroke prevention?

Stage 2: Identifying relevant studies

To identify relevant previous studies regarding mobile health application for family caregivers of people with stroke, the authors determined keywords based on the research question. The following databases were searched with the keywords; "family caregivers," "mobile application," and "recurrent stroke or secondary stroke." Electronic databases including EBSCO, Cochrane, PubMed, ProQuest, and Science Direct were used to look for journal articles that met the inclusion criteria. Searching using scan reads was also conducted to find journals manually by searching for specific journals and identified papers or reviews. The publication date was limited to journals published in the last 10 years, form January 2011 through December 2020.

Stage 3: Study selection

The inclusion criteria for this review were; research published in English, quantitative study. We excluded studies that did not create mobile application for both caregivers and patient. Figure 1 shows the flowchart of the mobile application selection process.

Stage 4: Mapping the data

The results of the study selection obtained nine journals. These journals were read by authors several times to capture information and to ensure important data were missed. The datasets taken are grouped into several categories, which include the author, research objectives, research design, participants or samples and mobile applications used as well as the results found in the practical table (Table 1). The design of this dataset was discussed among the review authors to ensure all relevant information was entered.

Stage 5: Compiling, summarizing and reporting the results

In compiling and summarize including managing data thematically can use various ways. Thematic analysis is a method that can help authors to identify, analyse, and inform the pattern obtained in the dataset. The themes reflect the main concepts that

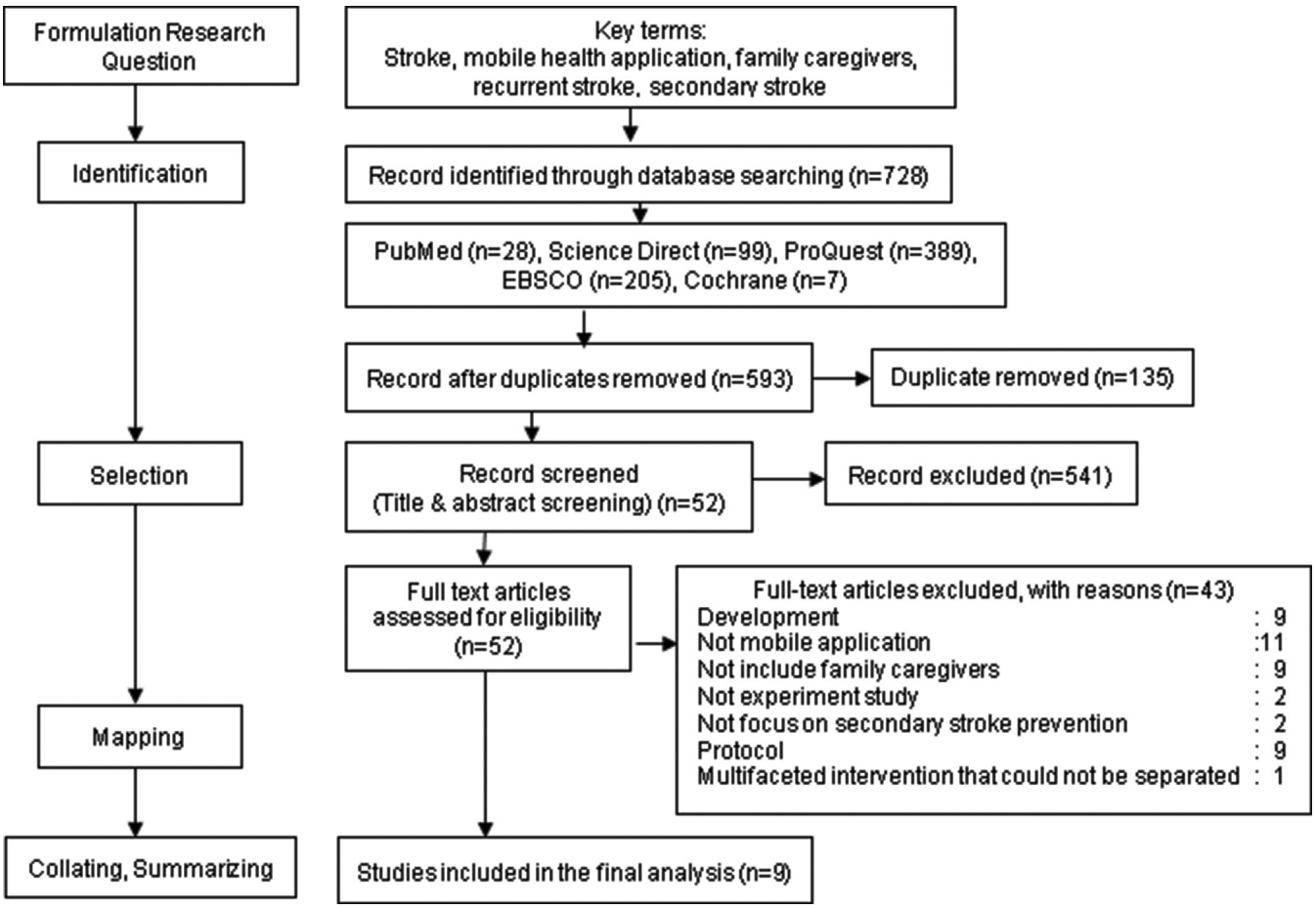

Figure 1: Flowchart of search strategy and selection process

occur repeatedly in the text and answer the questions asked [28].

Results

A total nine papers were reviewed in the current scoping review. The studies came from seven countries: United States, Pakistan, Netherlands Korea, India, China, and Sweden. Mostly all of the papers were studies that developed and tested of mobile application and two papers developed and tested a web-based. The themes were identified (Table 2):

Caregivers support

Five subcategories were identified, namely caregiver education, communication, reminder, monitoring, information link, and assessment.

Caregiver education

The most common features of the mobile application were the providing education for caregivers [29], [32], [33], [35]. All of these studies used video as the way to deliver education from health professionals. Family caregivers and stroke patients watched many topics the video education in a few minutes. Mostly of studies provided many contents of education in the video [29], [32], [35], only one study delivered a single topic [33]. The content of education included introduction of stroke [29], [35], rehabilitation skills, swallowing skill, speaking skill [29], post-stroke depression management [33], exercise and activity daily living [35], and recurrent stroke prevention [29], [32]. Only two studies provided education about comprehensive of recurrent stroke prevention. Components of education included exercise, blood pressure and blood glucose control, diet modification, depression management, medication adherence [29], [32], diabetes management, smoking cessation, and alcohol restriction [32].

Communication

Communication feature was designed to help family caregivers communicate with health professionals and other participants during provide treatment for stroke patients. Two studies designed e-mail service [32], [33] and one study designed online chat in mobile application [33]. Caregivers received

Table 1: Summary of selected articles

Author/ Year	Type of Study	Sample size of participant	Name of application	Type of application	Features	Involvement care of caregiver	Barrier using of application	Country	Result
[29]	Randomized control, outcome assessor–blinded, parallel group, single-center superiority trial Length of movie program for 3 month Follow up at 1, 3, 6, 9, and 12 months after discharge) Time: During admission up to after discharge	115 stroke patients (ischemic or hemorrhagic) and caregivers in experiment group and 115 in control group	Movies 4 Stroke	Mobile application	Education using 5 minutes video, consist of 4 topics. Skills (swallowing, exercises, and nasogastric tube feeding). Emergency preparedness (as cardiopulmonary resuscitation, seizures, heart attack, and hypoglycemia). Medications (anticoagulants, antihypertensive, lipid-lowering). secondary stroke prevention (exercise, physical activity, depression, diet modification, and measurement of BP and blood sugar levels) Follow-up using SMS (short message service) at 1, 3, 6, 9, and 12 months after discharge	Not reported	Not reported	Karachi Pakistan	Patient: no significant in blood pressure, HbA_{1c}, and LDL, significant effect on dependency
[30]	Observer-blinded multicenter randomized controlled trial length of exercise program for 8 weeks at least 5 times a week for 30 min Time: admission up to at home	66 stroke patient and caregivers	Care 4 stroketele-rehabilitation services like telephone, video conferencing or email when appropriate in between the weekly exercise sessions	Web-based Telephone-based	Reminder and providing motivation using email, video conference, and telephone to perform exercise 5 times/week for 30 min for 8 weeks	Assisted stroke patient to perform exercise 5 times a week for 30 min	Not reported	Amsterdam, Netherlands	Patient: no significant regarding self-perceived mobility and LOS, significant effect on anxiety Caregiver: significant effect on depression
[31]	Pilot prospective randomized controlled trial with open blinded end point Length of intervention: 180 days Time: 2 weeks after discharge	36 stroke patients (ischemic or hemorrhagic) 17 in the smartphone group, and 19 in the food journal group With caregiver (if applicable)	Swipe out mobile app	Mobile application	Daily monitoring of caloric intake Reminder messages (first 30 days), weekly summaries plus reminder messages on missed days (days 31–90), and weekly summaries only (days 91–180) were sent through push notifications Food information link Type of exercise information	Monitoring and reminding of daily caloric consumption	Not reported	Texas, United States	Patient: decreased of depression, no significant weight change
[32]	Pilot randomized controlled trial intended Length of intervention: 9 weeks Time: 1 year after stroke	36 ischemic patients and caregivers 18 in intervention and 18 in control group	Web-based stroke education program	Web-based	Education using video about recurrence prevention for 15–20 min Automatic feedback related to health behaviours e-mail service to network with health professionals External links to websites related to stroke information	Not reported	Barriers Internet access and computer as the majority of potential participants lacked Internet access n e-mail system for contact between participants and health professionals	Chungnam, Republic of Korea	Patient: improved on sense of control, health motivation, regular exercise, and diet Caregiver: improved of caregiver mastery
[33]	Randomized controlled trial Length of intervention: 1 month Time: after stroke	38 stroke patients and caregivers 19 in control group and 19 in experimental group	Web-based intervention	Web-based	Providing education using video (8 videos, 17 minutes every video) Online chat, e-mail, message and link information service	Emotional care	Not reported	Ohio, United States	Patient: no significant effect on depression Caregiver: decreased of depression
[34]	Single-center pilot study Length: 3 months Time: being discharged to a nursing home	56 ischemic stroke patients and carepartner 6 and 12 weeks of post stroke hospitalization	CarePartner IVR	Mobile application	Weekly IVR calls monitoring both depressive symptoms and medication adherence for 3 months Automatic re-calls in the event of a busy signal or no answer Tailored and structured feedback supporting depressive symptom self-management	Support depressive symptom self-management Notified medication non adherence, moderately severe depressive symptom, suicidal ideation management plan	Not reported	Michigan, United States	Stroke patients with depressive symptoms were able to engage in a IVR call system

(Contd...)

Table 1: (*Continued*)

Author/ Year	Type of Study	Sample size of participant	Name of application	Type of application	Features	Involvement care of caregiver	Barrier using of application	Country	Result
[35]	Phase I field testing: Phase II pilot testing: mixed-methods research design Length: 2 weeks during the field-testing phase and for 4 weeks during the pilot-testing phase home Time: post discharge	60 stroke patients with caregivers Phase I field testing: 30 stroke patients with caregivers Phase II pilot testing: 30 patients with caregivers mixed-methods research design	Care for Stroke	Mobile application smartphone	Education using video about stroke, home-based exercises, functional skills training, activities of daily living, and assistive devices	Not reported	Poor connectivity inside the home Video-streaming delay because of low 3G data allowance Inability to access various web pages of the intervention by sliding the touchscreen on the smartphones Inadequate clarity of the pictures	Chennai, South India	Care for stroke intervention was feasible and acceptable for patients and caregivers Patient: Improved of the scores of BI (independence in activities) and decrease of MRS (disability)
[36]	A cross-sectional study Length: one day Time: on the day before discharge	27 stroke patients, 23 caregivers	Mobile application for self-assessment	Mobile application	Self-skill assessment for patients and caregivers related to degree of disability and activities daily living of stroke patients using mRS and Barthel Index	Not reported	Not reported	Beijing china	Patient: significant difference in ADL score between patient and nurse assessment Caregiver: no significant difference between caregiver and nurse assessment in ADL score
[37]	Pre-post with control group design Length: 8 weeks Time: post discharge	13 stroke patients (hemorrhage/ infarction/an unspecified) with family caregivers 15 stroke patients (intervention group) and family caregivers (control group) Pre-post with control group design	F@ce™	Mobile application	Reminder using SMS twice daily, morning (remind to perform the activities), and evening (to respond related to daily performance scores, target activities) Automatic reminder for participant who did not reply to the SMS reminder Mobile phone calls to follow-up, exploring and resolving issues	Encouraged and assisted the stroke patient to perform daily activities. identified difficulties in performance of the activities	Not reported	Uganda Stockholm. Sweden	Patient: improved on patients' performance component, self-efficacy

IVR: Interactive voice response.

advices from physician and nursing professor through e-mail. In addition, caregivers communicated with other participants using e-mail [32]. Online chat media were used to encourage caregiver to keep providing care for post-stroke depression and discussion about home application [33].

Monitoring

Mobile health application have featured monitoring of family caregivers during provide treatment for stroke patients [31], [34]. One mobile application used interactive voice responses (IVR) calls to monitor of caregivers in depressive and medication management for stroke patients [34]. In addition, one study developed mobile application for daily monitoring of caloric intake through messages sending. This application is used to monitor caregivers in supporting stroke patient for weight loss by monitoring daily caloric intake [31].

Reminder

Reminder was another the common feature in mobile application. Reminder was used to remind the family caregivers to do the expected action. Three studies used message reminder in mobile application [29], [31], [37]. Caregivers received weekly message as a reminder to watch the education movies at home [29]. Another study used message reminder feature in mobile application to remind caregiver to encourage the stroke patient to perform daily activities [37]. In addition, one study designed mobile application to remind caregivers related to daily caloric intake for stroke patients [31].

Information link

Mobile application provided information link to websites. Caregivers can access information easily related to stroke [32], [33], post stroke caregiving, management problem for caregivers [33], and food information [31].

AQ3 **Table 2: Result of scoping review**

Categories	Sub-categories
Caregivers support	Education communication
	Reminder
	Monitoring assessment
Involvement care of caregivers	Emotional care: Depression care
	Nutrition care: Caloric consumption
	Activities and exercise
	Recurrent stroke prevention: regular exercise, diet, smoking cessation and drinking alcohol
Barriers	System: Poor connectivity
	Device: Inadequate clarity of the pictures
	Inability to access various web pages
Outcome	Caregiver
	Reduced depressive symptoms
	Improved mastery
	Improved assessment ability
	Patient
	Reduced anxiety and depressive symptoms
	Improved of independency level
	Decreased of disability
	Improved of self-efficacy
	Improved assessment ability
	Improved on sense of control, health motivation, regular exercise, and diet

Assessment

One mobile application was designed to improve family caregivers' ability to assess the degree of disability and activities daily living of stroke patients. Caregivers assess those aspects before stroke patients discharge from hospital using the Modified Rankin Scale and Barthel Index which are applied in the mobile application [36].

Involvement care of caregiver

In the several studies described caregivers' involvement care for stroke patient using mobile application intervention, including emotional care, nutrition care, activities and exercise, and recurrent stroke prevention.

Emotional care

Two studies identified the role of caregivers in emotional management including depression, emotional, and behavior management [33], [34]. Web-based intervention was designed to provide education and information about emotional care to family caregivers and stroke survivors [33]. Another study explored about using IVR to support caregivers in depressive symptoms management including identifying suicidal though or suicidal plan, taking medication, and side effect of medication.

Nutrition care

One study involved caregivers in nutrition care for stroke patients. Caregivers supported stroke patients in assisting weight loss around 10% of stroke patients through monitoring and reminding of daily caloric consumption [31].

Activity and exercise

Two studies focused on the activity and exercise caregiving of stroke patients. Caregivers assisted stroke patient to perform exercise five times a week for 30 min [30]. In addition, caregivers encouraged and assisted the stroke patient to perform daily activities. Caregivers also identified difficulties in performance of the activities [37].

Recurrent stroke prevention

One application was designed which focused on recurrent stroke prevention. Caregivers were actively in lifestyle change and adherence medication (regular exercise, diet, smoking cessation and drinking alcohol; however, in this study did not explained detail about role of caregivers [32].

Outcomes after using mobile application

Based on the findings of this review, the two main outcomes affected by a mobile application intervention were caregiver and stroke patient. Of the nine papers found, four papers evaluated the efficacy of a mobile application for caregivers [30], [32], [33], [36]. Two studies showed that caregivers seem a positive effect on psychosocial functioning after using mobile application, in terms of decreased caregiver depression [30], [33]. One randomized control trial study found that caregivers' mastery was significantly improved. Caregivers learned about recurrent stroke prevention using video lecturers in application. It was easy to use and the contents were understandable [32]. Another study, mobile application to improve caregivers' ability in assessing dependency levels and activities of daily living of stroke patient using Modified Rankin Scale and Barthel Index [36]. Intervention using mobile application also provided positive effects on stroke patients including reducing anxiety [30] and depressive symptoms [31], disability increasing independency level [35], self-efficacy [37], assessment ability [36], sense of control, health motivation, regular exercises, and diet [32].

Barrier

Two studies identified barriers in using the application including system and device. System barrier is poor of connection. It was the most barrier during mobile application usage. Lack of internet connectivity was felt by caregivers [32], [35]. In device barrier, Sureshkumar *et al*. [35] found that caregivers reported inadequate clarity the pictures in application. In addition, caregivers experienced difficulty to access various pages by sliding the touchscreen on the smartphones [35].

Discussion

This scoping review aimed to identify the existing evidence on the use of mobile application to support caregivers in recurrent stroke prevention. Nine studies using smartphone applications and web-based intervention were included in this review that involved caregivers and stroke patient in the intervention. The studies came from seven countries, namely three studies from United States, one study from Pakistan, one study from Netherlands, one study from Korea, one study from India, one study from China, and one study from Sweden. Four of seven mobile applications were from developed countries. Majority of studies designed applications for caregivers and stroke patients both of ischemic and hemorrhagic [29], [30], [31], [33], [35], [36], [37]. Two studies focused caregivers with ischemic stroke patients [32], [34].

This scoping review resulted in three categories and sub categories. The first category was caregivers' support that related to features in mobile application including education, communication, monitoring, reminder, link information, and assessment. Education is the most common feature in mobile application. Providing education is fundamental in stroke care to enable providing appropriate information for family caregiver. Family caregiver education is an important aspect of achieving success in recurrent stroke care. In this review, education focused on stroke in general and post stroke care, while only two articles that focused on education of recurrent stroke prevention [29], [32]. All articles used video to provide education in mobile application. This is in line with the previous study. One study [38] used educational video to provide stroke rehabilitation for family caregivers and their patients. Educational video is acceptable for caregivers. It can help to improve the learning process and made it can be easier for caregivers to imitate and follow each step taught effectively. Family caregivers can watch the actual exercise and daily living tasks for stroke survivor. It can encourage and motivate participants to perform exercise continuously [29], [35]. In addition, family caregiver felt comfortably and privately watch the video anywhere they wanted without disturbing others and without feeling shy during doing task like in the videos [35]. Another common feature is communication. Two studies designed e-mail and online chat in mobile application. The function of these features was to communicate between family caregivers and health professionals about stroke treatments and other things. Mobile application was used to keep communication between healthcare providers and patients or family caregivers, help organize medication compliance, comply with follow-up instruction, conduct appointment scheduling, and communication the questions to health care providers. In addition, family caregivers used this feature to share information with other participants [32], [33]. Monitoring feature is used to follow-up of family caregivers in their caring for stroke patients such as medication, diet, and depressive management. The methods used are sending message and automatic calls [31], [34]. Another feature was reminder. This feature was used to help family caregivers who tended to forget things or help them to remember many treatments that must be given to stroke patients. Assessment feature was designed by [31]. Family caregivers used this application to assess dependency level of stroke patients before discharge from hospital. The last of feature was information link that was designed in mobile application. Function of this feature was provided information about all aspect of stroke and caregiving. Caregivers can access information to websites easily related to stroke [32], [33], post stroke caregiving, management problem for caregivers [33], and food information [31]. This result is supported by Sala-González *et al*. [39] that their review found that this feature was also widely used in mobile application for caregivers.

The second category is involvement care of family caregivers. The subcategories included emotional care [33], [34], nutritional care [31], exercise [30], [37], and comprehensive of recurrent stroke prevention [32]. The first subcategory is emotional care, family caregivers helped stroke patients to manage of depression that include notified medication non-adherence, depressive symptoms, suicidal ideation management plan [34]. The second subcategory is nutritional care, family caregivers helped stroke patients in achieving weight loss of 10% by monitoring and reminding of daily caloric consumption [31]. Family caregivers have responsibility to help stroke patients to modify their diet [40]. The third subcategory is exercise care. Family caregivers involved in exercise care of stroke patients, they assisted stroke patients to perform exercise, daily activities, and identified some difficulties in daily activities [30], [37]. Family caregivers have roles to help stroke patient in exercise such as providing motivation, assisting, reminder, and monitoring patient [16]. This result is supported by the previous study, [41] reported that the application was used to help family caregivers motivate and remind stroke patients to do exercises. The last subcategory is involvement care of family caregivers in recurrent stroke prevention which included assisting in lifestyle changes and medication [32], however did not explain in detail.

The third category is outcomes using mobile application. The use of the mobile application has a positive effect on family caregiver and stroke patients. Four articles [30], [32], [33], [36] reported that family caregivers received better outcomes after using mobile application including improved caregivers' mastery and ability to assess stroke dependency, and decreased depressive symptoms. Caregiver mastery had significant interaction with caregiver competence. Caregiver mastery could increase the caregiver role in recurrent stroke prevention such as being active in patient's lifestyle changes and medication adherence [32]. This

finding was supported from the previous study, van Mierlo *et al*. [42] reported that caregiver competence feeling increased after received tele-coach intervention. Another study, Grossman *et al*. found that telehealth also could enhance caregiver mastery of stress related to the caregiver role after heart failure patient discharge. Using mobile application could decrease depressive symptoms of family caregivers. They received emotional management during providing treatment for stroke patients. This evidence is supported by research conducted by [43] that mobile application provided stress reduction of caregivers with older adult. Another study, a randomized controlled trial study conducted by Fuller-Tyszkiewicz *et al*. [44] among caregivers with physical and mental disability. Caregivers received psychological intervention using mobile application for caregivers. This intervention can reduce depressive and stress symptoms of caregivers. Positive outcomes received by stroke patients after using mobile application include decreased of anxiety [30] and depression [31], improved on sense of control, health motivation, regular exercise, and diet [32], improved of independence in activities [29], [35] and decrease of disability [35]. Other results were improved of skill assessment related to degree of disability and activities daily living of stroke patients using mRS and Barthel index [36], improved on patients' performance and self-efficacy [37]. Two studies focused on application feasibility [34], [35]. Result of this review also found that mobile application had no effect on other risk factors of recurrent stroke that include blood pressure, blood glucose, cholesterol [29], and weight change [31].

The fourth category is barrier using mobile application for family caregivers of people with stroke. This review identified of barriers related to usability of mobile application. The most common barrier was lack of connection [32], [35]. Family caregivers reported that poor internet connection, especially at home disturbed mobile application use. This barrier could make educational video streaming delay [35]. The result of this review were supported by previous study, which found that the most common barrier in using stroke mobile application were connection [45]. Another barrier was difficulty of navigating the device to access various pages by sliding the touchscreen on the smartphones. In addition, inadequate clarity of pictures in mobile application was also an obstacle for family caregivers. They had difficulty understanding the meaning of pictures [35]. These results are supported by Peng *et al*. [46] who found that ease of use and simplicity in the application was factors that influence someone using the application.

Strength and Limitation

Strength of this scoping review is that the search was very comprehensive including the development of mobile application, available features of mobile application, involvement care of family caregivers, outcome, and barriers of using the mobile application.

This review had limitations. This paper reviewed only studies that published in English during last 10 years (from 2011 to 2020) of five databases were included. The number of journals that focus on applications for families was limited and journals involve families as companions for stroke patients, so this study has weaknesses in drawing conclusions.

Conclusions

With the current high prevalence of recurrent stroke related disability and death, several innovation using technology including mobile health application have been developed in different countries to increase family caregivers' roles that help stroke patients to prevent recurrent stroke. This scoping review provides description related to form of features, involvement care of family caregivers to achieve the expected outcomes for both family caregivers and stroke patients, also some barriers using mobile application. These results could be considered in designing and development of mobile application for family caregivers.

References

1. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. Circ Res. 2017;120(3):439-48. https://doi.org/10.1161/CIRCRESAHA.116.308413
   PMid:28154096
2. World Health Organization. Stroke: A Global Response is Needed. Vol. 94. Geneva: World Health Organization; 2016. p. 634A-5.
3. Coull AJ, Rothwell PM. Underestimation of the early risk of recurrent stroke: Evidence of the need for a standard definition. Stroke. 2004;35(8):1925-9. https://doi.org/10.1161/01.STR.0000133129.58126.67
   PMid:15192248
4. Xu G, Liu X, Wu W, Zhang R, Yin Q. Recurrence after ischemic stroke in chinese patients: Impact of uncontrolled modifiable risk factors. Cerebrovasc Dis. 2007;23(117):117-20. https://doi.org/10.1159/000097047
   PMid:17124391
5. Khanevski AN, Bjerkreim AT, Thomassen L, Logallo N, Kvistad CE. Recurrent ischemic stroke: Incidence, predictors, and impact on mortality. Acta Neurol Scand 2019;140(1):3-8. https://doi.org/10.1111/ane.13093
   PMid:30929256
6. Feigin VL, Roth GA, Naghavi M, Parmar P, Krishnamurthi R, Chugh S, Mensah GA, *et al*. Global burden of stroke and risk factors in 188 countries, during 1990-2013: A systematic analysis for the global burden of disease study 2013. Lancet

Glob Health. 2016;4422(16):1-12.

7. Martinez M, Prabhakar N, Drake K, Coull B, Chong J, Ritter L. Identification of barriers to stroke awareness and risk factor management unique to hispanics. Environ Res Publich Health. 2016;13(23):ijerph13010023.
8. Lennon OC, Doody C, Choisdealbh CN, Blake C. Barriers to healthy-lifestyle participation in stroke: Consumer participation in secondary prevention design. Int J Rehabil Res. 2013;36(4):354-61. https://doi.org/10.1097/MRR.0b013e3283643d48
   PMid:23873221
9. Al Alshaikh S, Quinn T, Dunn W, Walters M, Dawson J. Predictive factors of non-adherence to secondary preventative medication after stroke or transient ischaemic attack: A systematic review and meta-analyses. Eur Stroke J. 2016;1(2):65-75. https://doi.org/10.1177/2396987316647187
   PMid:29900404
10. Magwood GS, Ellis C, Nichols M, Burns SP, Jenkins C, Woodbury M, *et al*. Barriers and facilitators of stroke recovery: Perspectives from african americans with stroke, caregivers and healthcare professionals. J Stroke Cerebrovasc. 2019;28(9):2506-16. https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.06.012
    PMid:31255440
11. Farahani MA, Bahloli S, Jamshidiorak R, Ghaffari F. Investigating the needs of family caregivers of older stroke patients: A longitudinal study in Iran. BMC Geriatr. 2020;20(1):313. https://doi.org/10.1186/s12877-020-01670-0
    PMid:32859159
12. Jiang S, Shen L, Ruan H, Li L. Family function and health behaviours of stroke survivors. Int J Nurs Sci. 2014;1(3):272-6.
13. Wong HJ, Harith S, Lua PL, Ibrahim KA. A qualitative study exploring understanding and perceptions of stroke survivors regarding healthy lifestyle changes for secondary prevention. Malaysian J Med Health Sci. 2021;17(1):33-41.
14. Kavga A, Govina O, Galanis P, Kalemikerakis I, Vlachou E, Fotos N, *et al*. determinants of health promotion behaviors among family caregivers of stroke survivors. Diseases. 2021;9:10. https://doi.org/10.3390/diseases9010010
    PMid:33499270
15. Pangastuti HS, Rustina Y, Kamso S, Sitorus R. Success stories from patients with stroke recurrence prevention: A qualitative sttudy. Indones Nurs J Educ Clin. 2020;4(2):168-75.
16. Parappilly BP, Mortenson WB, Field TS, Eng JJ. Exploring perceptions of stroke survivors and caregivers about secondary prevention: A longitudinal qualitative study. Disabil Rehabil. 2020;42(14):2020-6. https://doi.org/10.1080/09638288.2018.1544296
    PMid:30669873
17. Saad S, Waqar Z, Islam F, Iqbal H, Nomani AZ. The awareness of stroke in caregivers of stroke patients in Pakistan. J Neurol Disord. 2017;5(4):1000359. https://doi.org/10.4172/2329-6895.1000359
18. Yesilbalkan OU, Karadakovan A, Dogru BV, Akman P, Ozel E, Bozturk Y. Awareness of risk factors and warning signs of stroke among caregivers of patient with and not with stroke: Results from questionnaire. J Pak Med Assoc. 2019;69(8):1114-8.
    PMid:31431763
19. Agianto A, Nuntaboot K. Role and function of family in care of patients with stroke in community. Dunia Keperawatan. 2018;6(1):134-44. https://doi.org/10.20527/dk.v6i2.5226
20. Sjöholm ME, Eriksson G, Bii A, Asungu J, Von Koch L, Guidetti S. Living with consequences of stroke and risk factors for unhealthy diet experiences among stroke survivors and caregivers in Nairobi, Kenya. BMC Public Health. 2021;21:511.
21. World Health Organization. mHealth New Horizons for Health through Mobile Technologies. Vol. 3. Proceeding International Work Content-Based Multimed Index; 2011. p. 130-5.
22. Adeoye O, Nyström KV, Yavagal DR, Luciano J, Nogueira RG, Zorowitz RD, *et al*. Recommendations for the establishment of stroke systems of care: A 2019 update: A policy statement from the American Stroke Association. Stroke. 2019;50(7):e187-210. https://doi.org/10.1161/STR.0000000000000173
    PMid:31104615
23. Demaerschalk BM, Berg J, Chong BW, Gross H, Nystrom K, Adeoye O, *et al*. American telemedicine association: Telestroke guidelines. Telemed J E Health. 2017;23(5):376-89. https://doi.org/10.1089/tmj.2017.0006
    PMid:28384077
24. Blacquiere D, Lindsay MP, Foley N, Taralson C, Alcock S, Balg C, *et al*. Canadian stroke best practice recommendations: Telestroke best practice guidelines update 2017. Int J Stroke. 2017;12(8):886-95. https://doi.org/10.1177/1747493017706239
    PMid:28441928
25. Fruhwirth V, Enzinger C, Weiss E, Schwerdtfeger A, Gattringer T. Use of smartphone apps in secondary stroke prevention. Wien Med Wochensschr. 2020;170(1-2):41-54. https://doi.org/10.1007/s10354-019-00707-3
    PMid:31535230
26. Lobo EH, Frølich A, Kensing F, Rasmussen LJ, Livingston PM, Grundy J, *et al*. mHealth applications to support caregiver needs and engagement during stroke recovery: A content review. Res Nurs Health. 2021;44(1):213-25. https://doi.org/10.1002/nur.22096
27. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. Int J Soc Res Methodol Theory Pract. 2005;8(1):19-32.
28. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77-101. https://doi.org/10.1191/1478088706qp063oa
29. Kamal A, Khoja A, Usmani B, Magsi S, Malani A. Effect of 5-minute movies shown via a mobile phone app on risk factors and mortality after stroke in a low- to middle-income country: Randomized controlled trial for the stroke caregiver corresponding author. JMIR mHealth uHealth. 2020;8(1):e12113.
    PMid:32012080
30. Vloothuis JD, Mulder M, Nijland RH, Goedhart QS, Konijnenbelt M, Mulder H, *et al*. Caregiver-mediated exercises with e-health support for early supported discharge after stroke ($CARE_4STROKE$): A randomized controlled trial. PLoS One. 2019;8:e0214241. https://doi.org/10.1371/journal.pone.0214241
    PMid:30958833
31. Ifejika NL, Bhadane M, Cai CC, Noser EA, Grotta JC, Savitz SI. Use of a smartphone-based mobile app for weight management in obese minority stroke survivors: Pilot randomized controlled trial with open blinded end point. JMIR mHealth uHealth. 2020;8(4):e17816. https://doi.org/10.2196/17816
    PMid:32319963
32. Kim J, Lee S, Kim J. Effects of a web-based stroke education program on recurrence prevention behaviors among stroke patients: A pilot study. Helath Educ Res. 2013;28(3):488-501. https://doi.org/10.1093/her/cyt044
    PMid:23515115
33. Smith GC, Egbert N, Dellman-Jenkins M, Nanna K, Palmieri PA. Reducing depression in stroke survivors and their informal caregivers: A randomized clinical trial of a web-based intervention. Rehabil Psychol. 2012;57(3):196-206. https://doi.org/10.1037/a0029587
    PMid:22946607

34. Skolarus LE, Piette JD, Pfeiffer PN, Williams LS, Mackey J, Hughes R, *et al*. Interactive voice response an innovative approach to post-stroke depression self-management support. Transl Stroke Res. 2017;8(1):77-82.
PMid:27394917

35. Sureshkumar K, Murthy GV, Natarajan S, Naveen C, Goenka S, Kuper H. Evaluation of the feasibility and acceptability of the 'care for stroke' intervention in India, a smartphone-enabled, carer-supported, educational intervention for management of disability following stroke. BMJ Open. 2016;6(2):e009243. https://doi.org/10.1136/bmjopen-2015-009243
PMid:26839011

36. Chang H, Zhao J, Qiao Y, Yao H, Wang X, Li J, *et al*. Mobile phone application for self-Assessment of acute stroke patients. Medicine (Baltimore). 2018;97(26):e11263. https://doi.org/10.1097/MD.0000000000011263
PMid:29952998

37. Kamwesiga JT, Eriksson GM, Tham K, Fors U, Ndiwalana A, von Koch L, *et al*. A feasibility study of a mobile phone supported family-centred ADL intervention, F@ce™, after stroke in Uganda. Global Health. 2018;14(1):82. https://doi.org/10.1186/s12992-018-0400-7
PMid:30111333

38. Mahmood A, Blaizy V, Verma A, Sequeira JS, Saha D, Ramachandran S, *et al*. Acceptability and attitude towards a mobile-based home exercise program among stroke survivors and caregivers: A cross-sectional study. Int J Telemed Appl. 2019;2019:5903106. https://doi.org/10.1155/2019/5903106
PMid:31186627

39. Sala-González M, Pérez-Jover V, Guilabert M, Mira JJ. Mobile apps for helping informal caregivers: A systematic review. Int J Environ Res Public Health. 2021;18(4):1702. https://doi.org/10.3390/ijerph18041702
PMid:33578819

40. Dalvandi A, Fallahi-Khoshknab M, Sciences R. Family caregivers' experiences of stroke recovery among older adults living in Iran: A qualitative study. Iran Red Crescent Med J. 2015;20.

41. Olafsdottir SA, Jonsdottir H, Bjartmarz I, Magnusson C, Caltenco H, Kytö M, *et al*. Feasibility of ActivABLES to promote home-based exercise and physical activity of community-dwelling stroke survivors with support from caregivers: A mixed methods study. BMC Health Serv Res. 2020;20:562. https://doi.org/10.1186/s12913-020-05432-x
PMid:32571316

42. Van Mierlo LD, Meiland FJ, Dröes RM. Dementelcoach: Effect of telephone coaching on carers of community-dwelling people with dementia. Int Psychogeriatr. 2012;24(2):212-22.

43. Grossman MR, Psych BA, Zak DK, Psych MA, Zelinski EM. Mobile apps for caregivers of older adults: Quantitative content analysis. JMIR mHealth uHealth. 2018;6(7):e162. https://doi.org/10.2196/mhealth.9345
PMid:30061093

44. Fuller-Tyszkiewicz M, Richardson B, Little K, Teague S, Hartley-Clark L, Capic T, *et al*. Efficacy of a smartphone app intervention for reducing caregiver stress: Randomized controlled trial. JMIR Ment Health. 2020;7(7):e17541. https://doi.org/10.2196/17541
PMid:32706716

45. Pugliese M, Ramsay T, Johnson D, Dowlatshahi D. Mobile tablet-based therapies following stroke: A systematic scoping review of administrative methods and patient experiences. PLoS One. 2018;13(1):e0191566. https://doi.org/10.1371/journal.pone.0191566
PMid:29360872

46. Peng W, Kanthawala S, Yuan S, Hussain SA. A qualitative study of user perceptions of mobile health apps. BMC Public Health. 2016;16(1):1158. https://doi.org/10.1186/s12889-016-3808-0
PMid:27842533