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].
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:

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>What is the contribution of mobile health application in supporting family caregivers of people with stroke?</td>
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<tr>
<td>2.</td>
<td>What is the involvement care of caregivers in recurrent stroke prevention?</td>
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<tr>
<td>3.</td>
<td>What are the outcomes of using mobile application for family caregivers and stroke patient?</td>
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<tr>
<td>4.</td>
<td>What are the barriers in the implementation of mobile health application for caregivers with stroke in recurrent stroke prevention?</td>
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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
occur repeatedly in the text and answer the questions asked [28].

Results

A total of 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 mobile applications, and two papers developed and tested a web-based application. 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>
<thead>
<tr>
<th>Author/ Year</th>
<th>Type of Study</th>
<th>Sample size of participant</th>
<th>Name of application</th>
<th>Type of application</th>
<th>Features</th>
<th>Involvement care of caregiver</th>
<th>Barrier using of application</th>
<th>Country</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>[29]</td>
<td>Randomized controlled trial, outcome assessor–blinded, parallel group, single-center superiority trial</td>
<td>Length of movie program for 3 months</td>
<td>Movies 4 Stroke</td>
<td>Mobile application</td>
<td>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</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Karachi, Pakistan</td>
<td>Patient: no significant in blood pressure, HbA1c, and LDL, significant effect on dependency</td>
</tr>
<tr>
<td>[30]</td>
<td>Observer-blinded multicenter randomized controlled trial length of exercise program for 8 weeks at least 5 times a week for 30 min</td>
<td>Time: admission up to at home</td>
<td>Care 4 stroke rehabilitation program</td>
<td>Web-based application</td>
<td>Reminder and providing motivation using email, video conference, and telephone to perform exercise 5 times/week for 30 min for 8 weeks</td>
<td>Assisted stroke patient to perform exercise 5 times a week for 30 min</td>
<td>Not reported</td>
<td>Amsterdam, Netherlands</td>
<td>Patient: no significant regarding self-perceived mobility and LOS, significant effect on anxiety Caregiver: significant effect on depression</td>
</tr>
<tr>
<td>[31]</td>
<td>Pilot prospective randomized controlled trial with open blinded end point Length of intervention: 180 days Time: 2 weeks after discharge</td>
<td>Time: 2 weeks after discharge</td>
<td>Swipe out mobile app</td>
<td>Mobile application</td>
<td>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</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Texas, United States</td>
<td>Patient: decreased of depression, no significant weight change</td>
</tr>
<tr>
<td>[32]</td>
<td>Pilot randomized controlled trial intended Length of intervention: 9 weeks Time: 1 year after stroke</td>
<td>Time: 1 year after stroke</td>
<td>Web-based stroke education program</td>
<td>Web-based</td>
<td>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</td>
<td>Not reported</td>
<td>Barriers Internet access and computer as the majority of potential participants lacked Internet access e-mail system for contact between participants and health professionals</td>
<td>Chungnam, Republic of Korea</td>
<td>Patient: improved of self-perceived health, motivation, regular exercise, and diet Caregiver: improved of caregiver mastery</td>
</tr>
<tr>
<td>[33]</td>
<td>Randomized controlled trial Length of intervention: 1 month Time: after stroke</td>
<td>Time: after stroke</td>
<td>Web-based</td>
<td>Web-based</td>
<td>Providing education using video (8 videos, 17 minutes every video) Online chat, e-mail, message and link information service</td>
<td>Emotional care</td>
<td>Not reported</td>
<td>Ohio, United States</td>
<td>Patient: no significant effect on depression Caregiver: decreased of depression</td>
</tr>
<tr>
<td>[34]</td>
<td>Single-center pilot study Length: 3 months Time: being discharged to a nursing home</td>
<td>Time: being discharged to a nursing home</td>
<td>CarePartner IVR</td>
<td>Mobile application</td>
<td>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</td>
<td>Support depressive sympotm self-management</td>
<td>Not reported</td>
<td>Michigan, United States</td>
<td>Patient: Stroke patients with depressive symptoms were able to engage in a IVR call system</td>
</tr>
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(Contd...)
advice 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].
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 subcategories. 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


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