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mHealth Applications to Support Caregiver Needs and Engagement during Stroke Recovery: A Content Review

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ABSTRACT

Caregiving in stroke results in severe physical, psychological, and social impacts on the caregiver. Over the past few years, researchers have explored the use of mHealth technologies to support healthcare-related activities due to its ability to provide real-time care at any given place or time. The purpose of this content review is to investigate mHealth apps in supporting stroke caregiving engagement based on three aspects; motivation, perceived value and satisfaction. We searched app stores and repositories for apps related to stroke caregiving published up to September 2020. Apps extracted were reviewed, and filtered using inclusion criteria, and then downloaded onto compatible devices to determine eligibility. Results were compared with evidence-based frameworks to identify the ability of these apps in motivating the caregiver. Forty-seven apps were included in this review that enabled caregivers to support their needs, such as adjustment to new roles and relationships, involvement in care and caring for oneself using several different functionalities. These functionalities include information resources, risk assessment, remote monitoring, data sharing, reminders and so on. However, no single app was identified that focuses on all aspects of stroke caregiving. We also identified several challenges faced by users through their reviews and the factors associated with perceived value and satisfaction. Our findings can add to the knowledge of existing mHealth technologies and their functionalities to support stroke caregiving needs, and the importance of considering user engagement in its design. They can be used by developers and researchers looking to design better mHealth apps for stroke caregiving.

Keywords: mHealth; App; Caregiving; Engagement; Support; Purpose; Functionality; Activities; Needs

1. Introduction

Stroke is one of the leading causes of death and disability worldwide (Feigin, Norrving, & Mensah, 2017). It tends to abruptly affect individuals and caregivers in their daily life (Tsai, Yip, Tai, & Lou, 2015). The impact of stroke on the patient and their caregiver can be physical, psychological, and social (Bucki, Spitz, & Baumann, 2019). This impact can be mitigated by adhering to a set of clinical guidelines that might improve the quality-of-life of the patient and reduce the risk of a secondary occurrence. These guidelines include routine monitoring of vitals such as blood pressure, heart rate, blood oxygen, glucose, sleep, and so on, and also modification of lifestyle factors such as smoking cessation, increased physical activity, diet, and other such factors (Prasad et al., 2011). Despite the plethora of existing literature regarding secondary prevention and lifestyle modifications (Teasell et al., 2009), caregivers often feel uncertain about their role in providing care due to a lack of understanding of the disease and its contributing factors (Cameron et al., 2014). This has been attributed to the lack of information and resources provided to the caregiver and patient post-discharge to support care (Saengsuwan, Suangpho, & Tiamkao, 2017). Moreover, the lack of information and resources

leads to reduced engagement and motivation in recovery practices (Eng, Brauer, Kuys, Lord, & Hayward, 2014).

Due to the complexities involved in stroke care (Clarke & Forster, 2015), including the management of risk factors and symptoms, monitoring of vitals, and changes to lifestyle, people with stroke are more likely to depend on caregivers as a means for support (Young, Lutz, Creasy, Cox, & Martz, 2014). Beyond ensuring secondary prevention, the caregivers are expected to play a vital role in the continuum of care, which involve decision-making, assisting in rehabilitation, providing physical and emotional support, support in patient daily living and assisting with other tangible aspects such as specialized hospital care, community re-integration, managing relationships, financial, insurance, and transportation (Haley et al., 2019; Zawawi, Aziz, Fisher, Ahmad, & Walker, 2020). With the number of active roles required for the caregiver to fulfil, there is a need to identify interventions to support these roles better, while continually engaging the patient cognitively, emotionally, and physically, with an intention to enhance recovery.

In recent years, mobile technology has altered the way health information and resources are delivered (Logan, 2013) with a focus towards improving patient experiences and reducing the cost for healthcare (Chaudhry et al., 2006). Mobile technology, through the use of mHealth applications (or apps), has empowered the users to manage, monitor, and track chronic diseases, which has improved medication adherence, offered remote assistance, and improved health outcomes (West, 2012). This has led to rising acceptance and growth in the global mHealth market in the past decade (Global QYResearch, 2019). According to recent statistics, the projected growth of the global mHealth market is expected to be around 58.6 billion dollars by the end of 2020 (Statista Research Department, 2020). Apart from this, the digitalization of healthcare through mHealth has led to increasing awareness and self-management of several different medical conditions (Global QYResearch, 2019).

Previous studies have either explored the use of mHealth apps in managing and supporting several different chronic diseases (Årsand et al., 2012; Chomutare, Tatara, Årsand, & Hartvigsen, 2013; Jibb et al., 2017; Schnall, Cho, Mangone, Pichon, & Jia, 2018) or designed mHealth apps based on user requirements (Castensøe-Seidenfaden et al., 2017; Gabrielli et al., 2017; Garcia, 2019; Sobrinho, da Silva, Perkusich, Pinheiro, & Cunha, 2018), while other studies have review apps in popular app stores to support particular chronic conditions (Bender, Yue, To, Deacken, & Jadad, 2013; Giunti, Giunta, Guisado-Fernandez, Bender, & Fernández-Luque, 2018; Jamaladin et al., 2018; Shen et al., 2015). However, none of these studies focuses on stroke caregiving engagement and support in the popular app. An understanding of current mHealth apps could serve as a preliminary study to identify the key elements currently available and classify the apps based on the requirements of the caregiver to guide developers further to create usable apps and improve existing apps for the caregiver.

The main objective of this review was to identify apps that could support caregivers in their various roles, including to enhance patient recovery. To achieve this, we examined the relationship between literature evidence and available smartphone apps in popular app stores (i.e., Google Play Store and Apple App Store) and reported the ability of the app to promote caregiving engagement. The exploration considered four aspects; (i) identification of literature frameworks to pinpoint the key needs of caregivers in stroke, (ii) identification of apps focusing on stroke caregiving support, (iii) classification of apps based on the literature framework, and (iv) reporting the findings to guide future development of engaging stroke caregiving applications.

2. Materials and methods

2.1 Codebook Development

The codebook was developed by the primary author under the supervision of other authors to consider all aspects illustrated in the research objectives, which is the role of technology in promoting caregiver engagement. The term engagement in digital technology is typically to understand the user's experience with technology (Yardley et al., 2016) and its acceptance over extended periods (Kim, Kim, & Wachter, 2013).

According to Kim et al. (2013), engagement is based on three aspects; user motivation, perceived value, and satisfaction, where (i) motivation focuses on the technology being useful and enjoyable, and (ii) perceived value and satisfaction focuses on the overall user experience of the system. In this codebook development process, we, therefore, consider the caregiver needs identified from the literature and app functionalities from using the app to address the motivation element while considering app cost, user ratings, reviews, and comments to identify the perceived value and satisfaction of the app.

2.1.1 Identification of Caregiving Needs

A systematic search was conducted on five electronic databases; Medline, Embase, CINAHL, PsycINFO, and Web of Science, from inception to October 2019 for keywords related to stroke caregiving needs, experiences, and perspectives. After the removal of duplicates, titles and abstracts were reviewed by the primary author, and supervised by another author. The potentially relevant articles were downloaded in full-text and independently reviewed by two authors. Any discrepancies were discussed until consensus was achieved with the other authors included in this review.

Data was extracted by the primary author and was subsequently reviewed by another author for accuracy. Extracted fields consisted of qualitative data acquired from user interviews within the study.

Findings acquired were thematically synthesized, coded, and developed by two authors based on three stages including; (a) line-by-line analysis of findings, (b) translation and grouping of similar concepts into descriptive themes, and (c) generation of analytical themes (J. Thomas & Harden, 2008). The analytical themes generated were then reviewed by all authors, and discrepancies were discussed until a consensus was achieved.

2.2 App sources and strategy

Phase 1: Extraction of Apps

Between October 2019 and September 2020, a systematic app search was conducted across two app stores (Google Play Store and Apple App Store) and one commercially available mobile app repository (42matters) for keywords related to stroke and caregiving. Keywords included individual and Boolean searches of stroke and caregiving MeSH terms extracted from PubMed to ensure all relevant keywords were considered. The search was restricted to apps published in English and accessible in Australia. The apps extracted were stored in an MS Excel spreadsheet, where duplicates were identified and removed. In addition, apps available in more than one store were combined in a single row within the spreadsheet.

Phase 2: Screening of Apps

Apps were screened based on their published meta-data (i.e., title, description, screenshots, user rating, and user feedback) based on the following criteria;

- **Inclusion Criteria:** Apps were included if they; (i) provided a description about the app, (ii) were reviewed by the user, (iii) consisted of tools to support stroke caregiving activities, and (iv) intended to support people affected with stroke and their caregivers.
- **Exclusion Criteria:** Apps were excluded if they; (i) were not published in English, (ii) were not accessible in Australia, (iii) did not have any user reviews, rating, or comments, (iv) were designed for other disease types, and (v) were designed for clinicians and/or other medical professionals.

Phase 3: Determining eligibility of Apps

Apps available after screening were downloaded onto an android (Huawei Mate 9) and an iOS (iPhone 6) smartphone. The apps were then classified by the primary author as 'potentially relevant' or 'not relevant' based on its ability to support the stroke caregiving needs identified during the codebook development, which was subsequently reviewed by the other authors. Any discrepancies in determining app eligibility were discussed with authors until a consensus was achieved.

2.3 Data Extraction and App Classification

Data extraction was conducted in two phases. In Phase 1, App store meta-data - i.e., title, description, developer, developer location, installs, content rating, reviews, comments, published date and late update information - were extracted from the app store page and stored in an MS Excel spreadsheet. The outcomes of phase 1 were used to inform the (i) general characteristics of the app based on a quantitative analysis of meta-data, and (ii) user satisfaction of the apps based on qualitative coding technique similar to the methodology used in the needs identification process.

In phase 2 and 3, data were extracted from the apps installed on the smartphone device to identify its functionality and classify the functionality based on the themes identified in the codebook.

3. Results

3.1 Identification of Caregiving Needs

Caregiver needs as identified from the literature can be classified into three domains; (i) adjust to new role and relationships (Barbic, Mayo, White, & Bartlett, 2014; Bulley, Shiels, Wilkie, & Salisbury, 2010; Buschenfeld, Morris, & Lockwood, 2009; Cameron, Naglie, Silver, & Gignac, 2013; Cao et al., 2010; Cobley, Fisher, Chouliara, Kerr, & Walker, 2013; El Masry, Mullan, & Hackett, 2013; Gosman-Hedström & Dahlin-Ivanoff, 2012; Graven, Sansonetti, Moloczij, Cadilhac, & Joubert, 2013; Gustafsson & Bootle, 2013; Howe et al., 2012; Hunt & Smith, 2004; Krieger, Feron, & Dorant, 2017; Silva-Smith, 2007; Smith, Lawrence, Kerr, Langhorne, & Lees, 2004; Wagachchige Muthucumarana, Samarasinghe, & Elgán, 2018), (ii) involvement in care (Cameron et al., 2014; Chow & Tiwari, 2014; Creasy, Lutz, Young, Ford, & Martz, 2013; Danzl et al., 2016; Gosman-Hedström & Dahlin-Ivanoff, 2012; Graven et al., 2013; Gustafsson & Bootle, 2013; Krieger et al., 2017; Pesantes, Brandt, Ipince, Miranda, & Diez-Canseco, 2017; Rochette, Racine, Lefebvre, & Bastien, 2014; Subgranon & Lund, 2000; M. Thomas & Greenop, 2008) and (iii) care for oneself (Barbic et al., 2014; Bastawrous, Gignac, Kapral, & Cameron, 2014; Bulley et al., 2010; Buschenfeld et al., 2009; Cao et al., 2010; Chow & Tiwari, 2014; Cobley et al., 2013; Gosman-Hedström & Dahlin-Ivanoff, 2012; Gustafsson & Bootle, 2013; Howe et al., 2012; Hunt & Smith, 2004; Pesantes et al., 2017; Silva-Smith, 2007; Smith et al., 2004; M. Thomas & Greenop, 2008). These domains involve a wide-range of sub-domains to be considered when performing stroke caregiving activities as shown in **Figure 1**.

3.2 Identification of Apps that support Stroke Caregiving

The app store and repository searches initially identified 5373, potentially relevant apps (Google Play Store = 750, Apple App Store = 701 and 42matters = 3922). After screening, 85 apps were considered relevant based on the inclusion criteria. Of these 85 apps, 38 apps were excluded as they were duplicates (i.e., apps with the same name but different platforms). Meta-data of duplicate apps were combined with averages in user rating data and sums of user comment data being considered. Overall, 47 apps were reviewed with **Figure 2** demonstrating the filtration process, **Table 1** provides an overview of general app characteristics, and supplementary material consists of all apps included in this review.

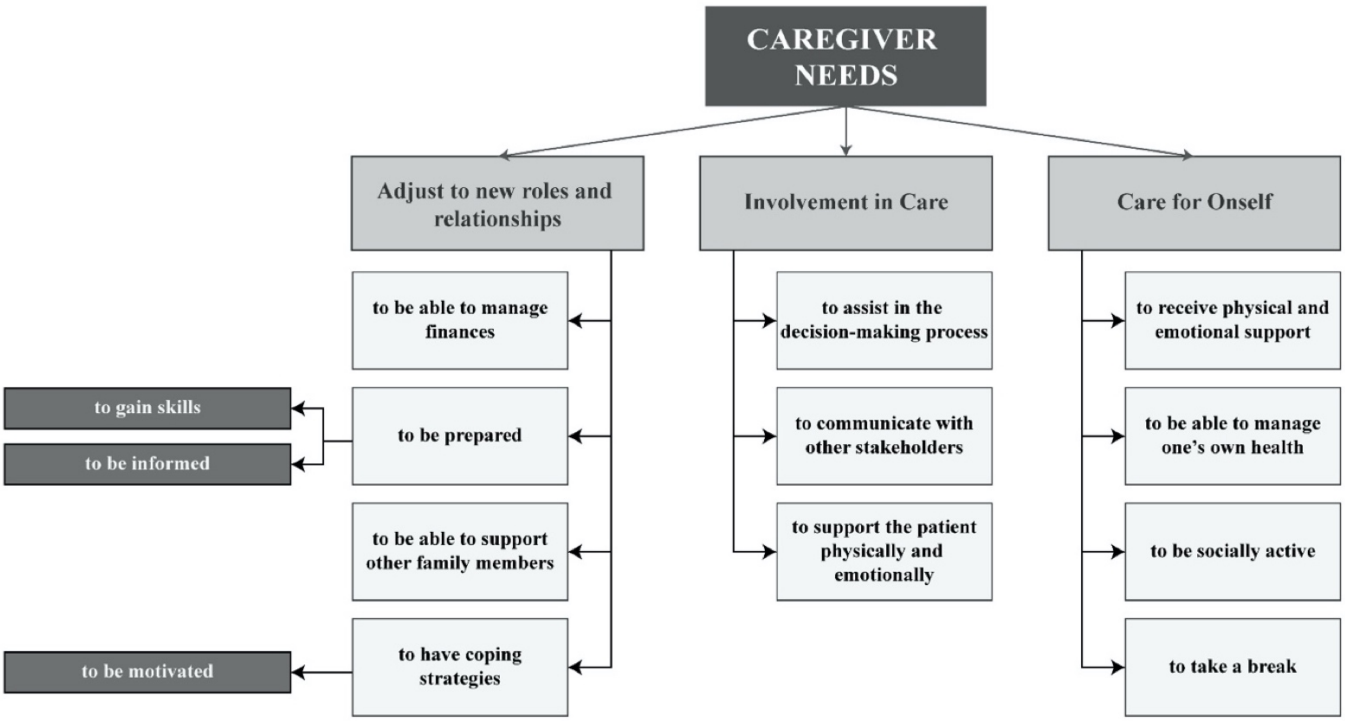

FIGURE 1. Caregivers Needs

3.2.1 General Characteristics

a) **Accessibility:** Of the 47 apps reviewed, 44 apps were available in Android, 41 apps in iOS and 38 apps in both platforms. They could be found in eight distinct categories (Health & Fitness = 23, Medical = 14, Education = 5, Productivity = 1, Communication = 1, Parenting = 1 and Games = 1). A majority of these apps were free (n=33; 73.7%), while the average cost of the remaining ten apps was found to be 125.34

USD. Over 80% (n=38) of the apps reviewed had 1000+ installs; the median range of installs was between 500 and 10,000,000. The average user rating of all apps reviewed was found to be 4.2 on a scale of 1 – 5, where one demonstrates the least satisfaction, and 5 demonstrates the most satisfaction.

b) **App Source:** A majority of apps reviewed were developed by small to medium-sized enterprises (n=35; 74.5%) followed by patient organizations (n=4; 8.5%), educational organizations (n=2; 4.3%), individuals (n=2; 4.3%), governmental agency (n=2; 4.3%), healthcare organization (n=1; 2.1%) and non-governmental agency (n=1; 2.1%). The developer meta-data published demonstrated that a majority of apps were published between 2009 and 2020 in countries such as USA (n=19; 40.4%), India (n=5; 10.6%), Canada (n=3; 6.4%), Singapore (n=3; 6.4%), Australia (n=2; 4.3%) and other countries.
Only one app (Constant Therapy) reviewed cited the publication reviewing the accuracy of the app within its description. The remaining 46 apps did not publish or cite any material in the description or within the app interface. However, an extensive search of Google Scholar based on app names demonstrated five other apps being validated based on the apps ability to provide recovery and care. Distribution of apps based on its source can be found in the supplementary material.

c) **Privacy and Confidentiality:** Forty-three apps out of the 47 reviewed had the privacy policy available within the app or as a link on the app description page. Of these forty-three apps, 38 apps collected user personal information, 23 apps shared user personal information with third-party websites, and 19 apps demonstrated data security and privacy methodology.

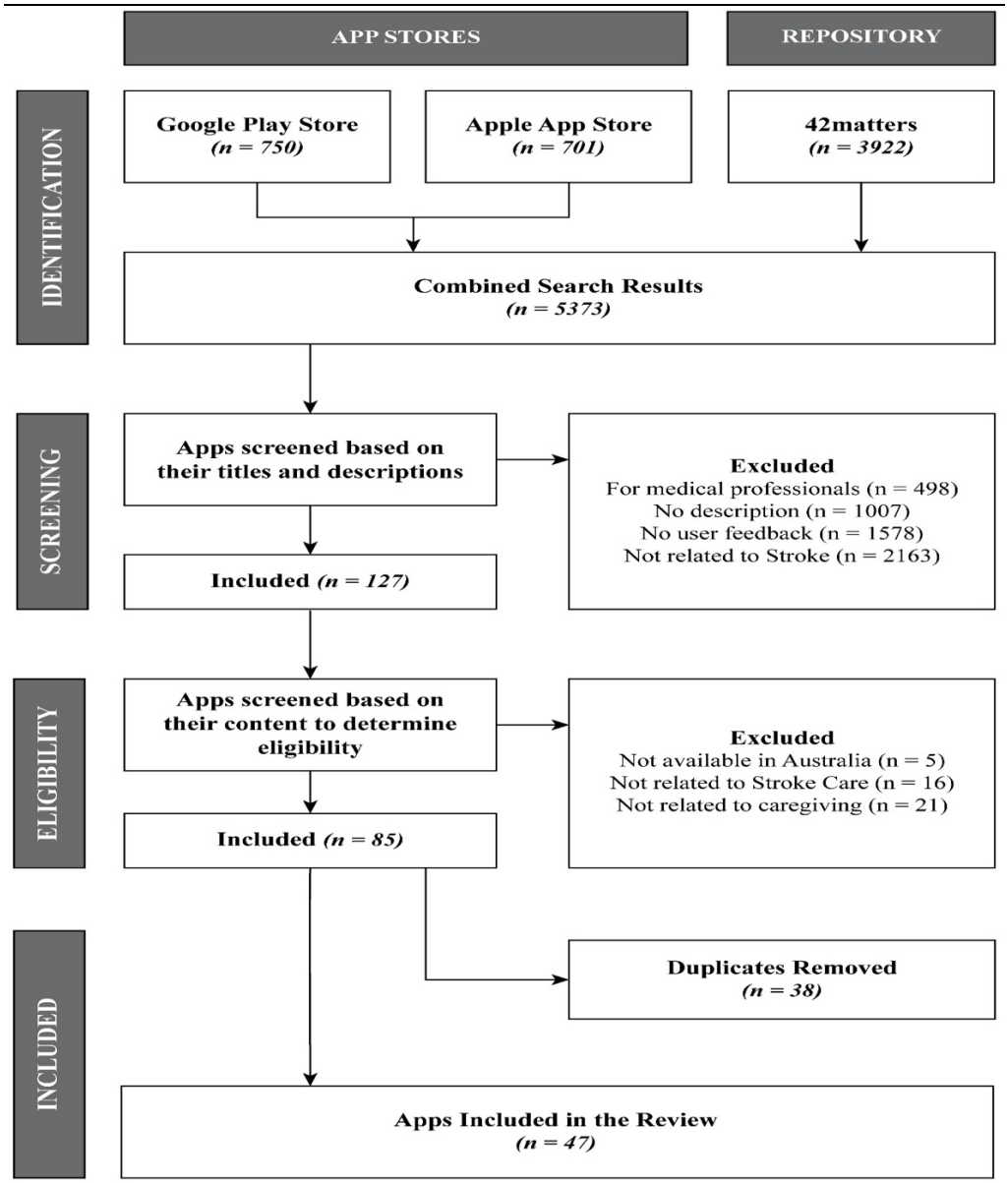

FIGURE 2. App Filtration Process

TABLE 1. Distribution of Apps based on its Characteristics

Characteristics		Platforms, n (%)			
		Android	**iOS**	**Both**	**Total**
Cost	Free	31 (66.0%)	28 (59.6%)	26 (55.3%)	33 (70.2%)
	Paid	13 (27.7%)	13 (27.7%)	12 (25.5%)	14 (29.8%)
Categories	Health & Fitness	23 (48.9%)	20 (42.6%)	20 (42.6%)	23 (48.9%)
	Medical	12 (25.5%)	12 (25.5%)	10 (21.3 %)	14 (29.8%)
	Education	4 (8.5%)	4 (8.5%)	3 (6.4%)	5 (10.6%)
	Productivity	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
	Lifestyle	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
	Parenting	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
	Communication	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
	Games	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
Downloads	500+	6 (12.8%)	8 (17.0%)	5 (10.6%)	9 (19.1%)
	1000+	13 (27.7%)	10 (21.3%)	5 (10.6%)	13 (27.7%)
	10000+	13 (27.7%)	12 (25.5%)	5 (10.6%)	13 (27.7%)
	100000+	3 (6.4%)	2 (4.3%)	5 (10.6%)	3 (6.4%)
	1000000+	6 (12.8%)	6 (12.8%)	5 (10.6%)	6 (12.8%)
	10000000+	3 (6.4%)	3 (6.4%)	5 (10.6%)	3 (6.4%)
Ratings	5	2 (4.3%)	3 (6.4%)	2 (4.3%)	3 (6.4%)
	4.5	19 (40.4%)	16 (34.0%)	16 (34.0%)	19 (40.4%)
	4	19 (40.4%)	16 (34.0%)	16 (34.0%)	19 (40.4%)
	3.5	4 (8.5%)	5 (10.6%)	4 (8.5%)	5 (10.6%)
	3	0 (0.0%)	1 (2.1%)	0 (0.0%)	1 (2.1%)
Developer Affiliation	Individuals	2 (4.3%)	1 (2.1%)	1 (2.1%)	2 (4.3%)
	Patient Organizations	2 (4.3%)	4 (8.5%)	2 (4.3%)	4 (8.5%)
	Healthcare Organization	1 (2.1%)	0 (0.0%)	0 (0.0%)	1 (2.1%)
	Governmental Agency	2 (4.3%)	1 (2.1%)	1 (2.1%)	2 (4.3%)
	Non-Governmental Agency	1 (2.1%)	1 (2.1%)	1 (2.1%)	1 (2.1%)
	Educational Organization	1 (2.1%)	2 (4.3%)	1 (2.1%)	2 (4.3%)
	Small and Medium-sized Enterprises	35 (74.5%)	32 (68.1%)	32 (68.1%)	35 (74.5%)
Location	Australia	2 (4.3%)	2 (4.3%)	2 (4.3%)	2 (4.3%)
	Canada	3 (6.4%)	3 (6.4%)	3 (6.4%)	3 (6.4%)
	India	5 (10.6%)	2 (4.3%)	2 (4.3%)	5 (10.6%)
	Singapore	3 (6.4%)	3 (6.4%)	3 (6.4%)	3 (6.4%)
	Spain	2 (4.3%)	2 (4.3%)	2 (4.3%)	2 (4.3%)
	USA	16 (34.0%)	18 (38.3%)	15 (31.9%)	19 (40.4%)
	Others	9 (19.1%)	8 (17.0%)	8 (17.0%)	9 (19.1%)
	None identified	4 (8.5%)	3 (6.4%)	3 (6.4%)	4 (8.5%)
Privacy and Confidentiality	Privacy Policy Available	42 (89.4%)	39 (83.0%)	38 (80.9%)	43 (91.5%)
	Personal Data Collected	37 (78.7%)	35 (74.5%)	34 (72.3%)	38 (80.9%)
	Data Shared with Third-party Websites	23 (48.9%)	21 (44.7%)	21 (44.7%)	23 (48.9%)
	Data Sharing Methodology Illustrated	18 (38.3%)	18 (38.3%)	17 (36.3%)	19 (40.4%)

3.3 Classification of Apps based on Caregiving Needs and Functionalities

App functionalities can be classified into text, image and video-based information resources (n=11), goal setting and progress tracking (n=28), risk assessment (n=1), remote monitoring (n=13), reminders (n=19), therapy (n=17), data sharing (n=16), audio and video conferencing (n=10), social media communication (i.e. blogs and chats) (n=11), diary (n=7), e-commerce (n=7) and local community services (n=11); with one app having one or more functionalities as shown in the supplementary material. These functionalities can be used to (i) enable caregiver preparedness through skill generation and knowledge acquisition using information-based resources, (ii) have coping strategies identified through past experiences of other caregivers available through social media communication, (iii) be able to assist in the decision making process by performing risk assessments, remote monitoring, goals and progress tracking, reminders, diary, therapy and skill generation to make decisions based on the patients' outcomes, (iv) be able to communicate with the different stakeholders using audio and video conferencing functionalities and social media communication, (v) ensure the patient is physically and emotionally supported by understanding the past experiences of caregivers available on social media tools and using information resources, (vi) receive physical and emotional support from medical professionals through audio and video conferencing or by sharing thoughts and needs on the social network, (vii) be able to track one's own health using remote monitoring, reminders and diary functionality of the app, (viii) be socially active by promoting interaction through the app using the social communication functionalities, and (ix) be able to take a break through therapy and sharing information with other stakeholders involved in care when the caregiver is involved in other activities (**Table 2**).

While the functionalities available could manage a majority of the needs of caregivers, no single app consisted of all functionalities to support the needs of caregiving. Moreover, needs such as managing finances and the ability to support other family members were not considered (**Figure 3**).

TABLE 2. Classification of App Functionalities based on Caregiving Needs

Caregiver Needs		**Functionalities**
Adjust to new role and relationships	to be able to manage finances	
	to be prepared	Information resources
	to be able to support other family members	
	to have coping strategies	Social Media Communication
Involvement in Care	to assist in the decision-making process	Risk Assessment, Remote Monitoring, Goals and Progress Tracking, Reminders, Diary, Therapy and Information Resources
	to communicate with other stakeholders	Audio and Video Conferencing and Social Media Communication
	to support the patient physically and emotionally	Information resources, E-commerce, Local Community Services and Social Media Communication
Care for Oneself	to receive physical and emotional support	Audio and Video Conferencing, Local Community Services, Therapy and Social Media Communication
	to be able to manage one's own health	Remote Monitoring, Goals and Progress Tracking, Therapy, Reminders, and Diary
	to be socially active	Data Sharing, Therapy, Audio and Video Conferencing, Social Media Communication
	to take a break	Data Sharing and Therapy

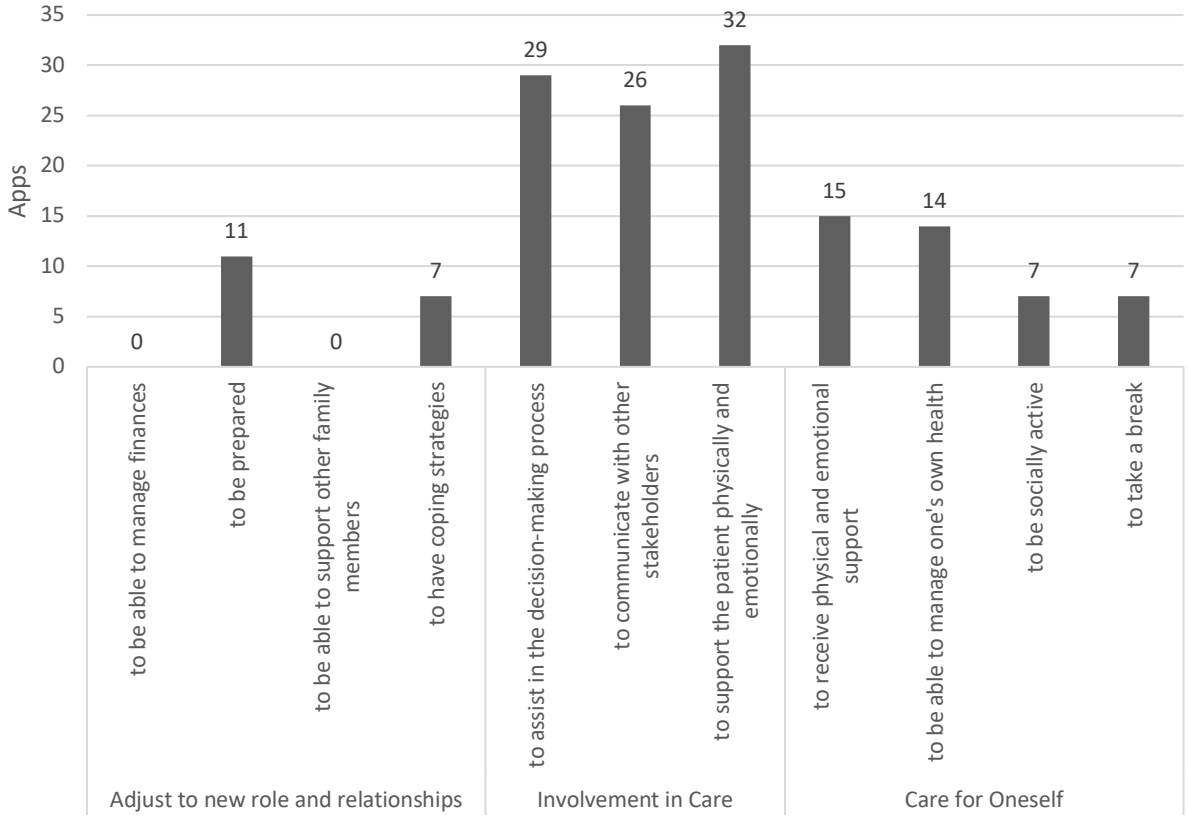

FIGURE 3. Distribution of Apps based on Caregiver Needs

3.4 Targeted Users and User Feedback

Only one app (Stroke Riskometer) reported its target user group within its description, which is 20+ years. However, on examination of the user permissions, it was found that a majority of the apps (n=45) could be accessed by children (aged 3+), while the other two apps could be accessed by youth above the ages of 12 years. Nineteen apps reviewed explicitly focused on caregiver support.

In terms of user rating, the average user rating for the apps reviewed was found to be 4.2, with three apps (iana care, Carer - Healthcare for the elderly and Small Talk Aphasia – Female) rated the highest on a scale of 1 to 5. However, one app (Small Talk Aphasia – Male) was rated the lowest. E-commerce apps were found to be the most popular functionality with an average rating of 4.6, followed by goal setting and progress tracking, remote monitoring, reminders, social media communication, local community services, therapy, data sharing, diary, information resources and risk assessment. However, the most downloaded app was found to be from the therapy category delivered through games. Three apps (Lumosity, Elevate, and Peak) were downloaded more than 10,000,000 times and hence demonstrating its popularity on its targeted user group.

A total of 1,385,337 user comments were identified in the apps reviewed, of which only 5,681 could be accessed due to app store restrictions. An analysis of these reviews demonstrated a majority of users were satisfied with the quality of content and functionality of the app through the use of terms such as "*Excellent*", "*Great*", "*Good*" and "*Useful*" along with the content and functionalities that they believe suited their needs. However, the reliability of these users comments is unknown. A few user comments (n=91) highlighted issues related to the remote support (n=4), the usability of the system (n=19), the functionality (n=59) and/or the overall cost (n=9) of the app.

4. Discussion

4.1 Primary Findings

This study focused on forty-seven apps from popular app stores (i.e. Google Play Store and Apple App Store) and an app repository (42matters). An app repository is a commercial tool that contains a list of apps available that can be accessed by users all around the world. It was considered due to the limitation on the number of apps that could be extracted from the app stores. These apps were published from 2014 to 2020, mainly by small to medium-sized organizations, hence the lack of evaluation data. However, these apps

consisted of several functionalities required in supporting caregivers in stroke recovery (such as information resources, rehabilitation, communication, secondary prevention, risk assessment, and services). They were primarily accepted based on their user downloads and ratings. But the reliability of user feedback could not be identified.

The main finding of this study was that very few applications focused on evaluating the application prior to publishing it in the app store; identified through literature searches. Moreover, none of these apps focused on the usability of the apps in providing caregiving support, which is similar to the other reviews conducted (Bender et al., 2013; Giunti, Giunta, et al., 2018; Mobasheri et al., 2014), instead they focused on evaluating the accuracy of the app in improving recovery and user satisfaction. Accuracy in these apps was evaluated either through pilot trials (Sarfo, Adusei, Ampofo, Kpeme, & Ovbiagele, 2018), control studies (Blanquero, Cortés-Vega, García-Frasquet, Sánchez-Laulhé, & Suero-Pineda, 2019; Godlove, Anantha, Advani, Des Roches, & Kiran, 2019; Zickefoose, Hux, Brown, & Wulf, 2013), by validating the output through medical-grade devices (Proesmans et al., 2019) or by validation using available datasets (Parmar et al., 2015), while satisfaction was assessed using a 5-point Likert rating scale (Sarfo et al., 2018). Furthermore, outcomes from these studies demonstrated that users accessing these apps were shown to have significant improvement in managing tasks (Godlove et al., 2019), improved performance (Blanquero et al., 2019; Sarfo et al., 2018; Zickefoose et al., 2013), ability to identify risks (Parmar et al., 2015) and ability to monitor heart risk factor without the need for medical-grade devices (Proesmans et al., 2019). One app (9zest) demonstrated high user satisfaction towards therapy (Sarfo et al., 2018).

4.2 Analysis of Motivation

The study focused on identifying the needs of the caregiver in stroke based on a comprehensive review, and identifying means to support these needs through the use of mobile app functionalities. Past studies have considered similar approaches to support the unmet needs of caregivers. For example, Grossman, Zak, and Zelinski (2018) examined the content of mobile apps to support caregivers needs through the provision of information and resources, problem solving functions, communication tools, memory aids, and other such functionalities. However, like most studies involving mobile app content reviews, we found that a majority of the apps did not focus on all the needs of the user (Giunti, Guisado Fernández, Dorronzoro Zubiete, & Rivera Romero, 2018; Huckvale, Car, Morrison, & Car, 2012; Nicholas, Fogarty, Boydell, & Christensen, 2017); in this case the caregiver. But, with regard to caregiving in stroke; there is a clear lack of tools toward the generation of new skills, education, and other daily activities (such as managing finances and supporting other family members), which is different from other studies, where the main focus of apps is knowledge, support and skill generation (Giunti, Guisado Fernández, et al., 2018; Huckvale et al., 2012; Shen et al., 2015).

4.2.1 App Information Content

On assessing the content of the information content of these apps, the scientific reference of the data presented in the app was rarely included. This was found to be similar to the other chronic disease app reviews (Bender et al., 2013; Giunti, Giunta, et al., 2018). Previous studies that have analysed health care information online have shown a variation in the quality of data available (Air et al., 2007; Lawrentschuk et al., 2012). Inaccuracy in health data can be potentially harmful and has been documented in a number of studies (Crocco, Villasis-Keever, & Jadad, 2002; Nölke, Mensing, Krämer, & Hornberg, 2015). Moreover, there have been several concerns regarding the quality of content provided in health care apps (Grant et al., 2015; Sillence, Hardy, & Briggs, 2013; Ziebland & Wyke, 2012). This finding is consistent with the other mobile app reviewed that have discussed the need to have a review body to assess the quality of these apps to ensure quality information is delivered to the user (Bender et al., 2013; Giunti, Giunta, et al., 2018; Jamaladin et al., 2018; Shen et al., 2015). Apart from health information, several monitoring, management, and tracking apps require data to be inputted manually into the system. Manual input of data can bring about added work for the caregiver during treatment (El-Sappagh, Ali, Hendawi, Jang, & Kwak, 2019), which may affect its acceptance. Any addition of clinical data into the app would require special attention to ensure that the data inputted is accurate; otherwise, it could affect the quality of care for the patient. According to Mikesell et al. (2018), this process can be considered redundant, and it would mean duplication of work or replacing one flawed system with another.

4.3 Analysis of Perceived Value and Satisfaction

An analysis of the reviews demonstrated both positive and negative themes similar to other content reviews (Nicholas et al., 2017). While the positive reviews focused on the ability and functionality of the app to support their needs, the negative reviews focused on remote support, usability, functionality, or cost issues of the app.

These issues may have an effect on the acceptance of the technology over extended periods of time; as user engagement of the intervention is dependent on three factors; the mental state of the user to perform sustained cognitive processing, the assurance of experiential and instrumental value, and the emotional bonding, satisfaction and pleasure (Dovaliene, Masiulyte, & Piligrimiene, 2015). While the app may be designed to support the user needs, and consist of tools to initiate sustained cognitive processing; the issues identified may impact the user's assurance of value and emotional bonding, satisfaction and pleasure. Moreover, the high costs of the apps ranging from 1.07 USD to 399.99 USD per item could impact the perceived value of the apps especially for users with financial constraints such as caregivers (King, Ainsworth, Ronen, & Hartke, 2010).

Despite, literature demonstrating the factors associated with adherence, and value and satisfaction. The relation between these factors is dynamic and complex. For instance, Xu, Peak, and Prybutok (2015) argues that the perception of value and satisfaction is based on the benefits of the technology rather than the quality/price of the product. Moreover, consumers could be driven by the attitude towards change, re-patronage and/or brand loyalty. Surprisingly, there is very limited literature that considers user value and satisfaction in stroke caregiving technologies from a marketing perspective, and factors that may contribute towards the user accepting it in their daily life.

4.4 Analysis of Engagement

Effective strategies to promote engagement is important for the user's acceptance of the app especially with the growing number of apps in the app market. Literature highlights numerous different strategies considered by developers to promote participation and engagement; with the intention to improve their overall market share (Tarute, Nikou, & Gatautis, 2017). One such strategy that was used in this review; considered engagement as a factor of motivation, value and satisfaction (Kim et al., 2013).

The classification of apps in stroke caregiving based on this strategy highlighted the potential of mHealth apps in transforming healthcare delivery, which is consistent with the findings of Torous et al. (2018). However, the findings of this review highlight that the concept of engagement in stroke caregiving has not been extensively explored. Moreover, the inability to support engagement within the application can result in poor usability, lack of trust, lack of user-centric design, lack of trust and inefficiencies during emergencies, thereby causing more harm than good. Hence, requiring for developers and researchers to consider concepts such as engagement in the development of new mHealth apps in stroke caregiving.

4.5 Limitations

This review has limitations. One limitation is the search criteria, which involved the use of English apps and apps with descriptions. This decision for choosing English apps and apps with descriptions may have resulted in a significant amount of apps being excluded from this study, which may have otherwise been potentially relevant. Another limitation was discussed earlier is the purpose of design section. Firstly, since there is no accurate description of the app development process either in its description or as a published paper, it is unclear if the perceived purpose aligns with the purpose based on the reviewers' classification. Secondly, the number of reviews considered to draw conclusions for value and satisfaction is limited as the app store limits the number of reviews accessible to the general public. A comprehensive review of the user comments may have highlighted some issues within the app, which was not considered in this study due to this limitation. Finally, there is a lack of an evidence-based framework to classify the needs of the caregiver with the app and best practices to engage the caregiver in stroke recovery. However, this review utilized well-documented literature to classify the apps based on caregiver needs, activities and functionalities based on a framework used in most mHealth app designs.

4.6 Recommended Future Directions

With the growth of mHealth apps in stroke care, there is a growing need for a theoretical framework to measure the role of mHealth in supporting the needs of the stakeholders involved and techniques to promote engagement. Currently, available literature only provides an overview of the needs and techniques to be employed but does not provide a clear picture of stroke recovery.

The evaluation of currently available stroke recovery support apps based on existing literature demonstrated the need to create usable and affordable solutions, with solutions required to meet the needs of the stakeholder, in this case, the caregiver. These systems need to be validated for not only the user but by a medical body to ensure accuracy of content, the suitability of support advice given, and the means for delivery of support to stroke sufferers. Moreover, since the app involves the delivery of care, it should be personalized based on the needs of the user, and this would require interactions with the user.

In addition to this, there is a need for interoperability with the electronic medical records system to provide real-time feedback to the medical professionals, while ensuring that the caregiver and patient are aware of the progress, and they do not deviate from the standard care.

Finally, there is a need to ensure the user is aware of the functionality and quality of content, which should be delivered plainly using the app description page. The future direction of mHealth app development to support caregiving engagement would therefore entail the inclusion of user-centred design, most notably the participatory design principles, to ensure the design of the app includes an iterative process for development with the user at the centre of the design; guiding the process of design and usability based on their needs and requirements.

5. Conclusion

mHealth apps have the opportunity to provide the user with solutions that can be accessed around the clock to support their information, monitoring and tracking, recovery, appointments and other recovery needs. This has led to the growth of mHealth apps in the past decade and is expected to grow in the next few years. However, the development processes of these apps are unknown, and if the quality of support provided is poor it could lead to a slow recovery.

Collaboration of various medical stakeholders in the design process could help create a usable solution in this case for stroke caregiving, with the focus on a critical aspect, which is patient engagement. Moreover, by including the stakeholder in design, it could help create a usable solution focused on improving the quality of care and the decision-making process. Hence, this review highlights the need for user-centred design principles in the design of mHealth apps for stroke caregiving engagement to ensure acceptability and usability.

Abbreviations

App, Application; mHealth, Mobile Health; MS, Microsoft

Supplementary Material

All datasets supporting the manuscript are made available in the supplementary material document included with the manuscript.

What does this paper contribute to the wider global clinical community?

- An understanding of the commercially available apps and its functionalities implemented to provide stroke caregiving support
- An understanding of how the apps identified can support the different needs and activities of caregivers in stroke, while identifying means to better engage them in their daily activities
- A partial analysis of user feedback acquired from the app store to identify the satisfaction and issues faced by the user when implementing the app in their day-to-day activities

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