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Article

Detecting Usability and User Experience Issues in Stroke Caregiving Apps: An Analysis of User Reviews

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Abstract: (1) Background: Existing research has demonstrated the potential of mHealth apps in improving the caregiving outcomes of stroke. Since several apps were published in commercially available app stores without explaining their design and evaluation processes, it is necessary to identify the usability and user experience issues to promote long-term adherence and usage; (2) Methods: User reviews were extracted from the 47 previously identified apps that support stroke caregiving needs using a python-scraper. The reviews were pre-processed and filtered using python scripts. The final corpus was classified based on usability and user experience dimensions to highlight issues within the app; (3) Results: A total of 162,095 were extracted from the two app stores. After filtration, 15,818 reviews were included and classified based on the usability and user experience dimensions. Findings highlight critical issues related to the errors/effectiveness, efficiency and support that contribute to decreased satisfaction, emotion and frustration in using the app; (4) Conclusion: The study identified several usability and user experience issues due to the inability of the app developers to understand the needs of the user. Further, the study describes the inclusion of a participatory design approach to promote an improved understanding of user needs; therefore, limiting any issues and ensuring continued use.

Keywords: mHealth; App; Stroke; Caregiver; Usability; User Experience; Needs; Design)

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1. Introduction

Stroke caregiving is often associated with persistent psychological distress leading to depression, decreased life satisfaction and reduced quality of life [1]. The impact of stroke caregiving is due to the sudden onset of the disease that requires the caregiver to adjust to a new role with little to no preparation [2] resulting in the caregiver feeling disconnected, isolated, and distant from the recovery process [3].

Technological interventions such as telemedicine, mHealth and so on have in the past highlighted numerous benefits in the healthcare environment to enable caregivers to easily access valuable resources and participate in a variety of activities using their devices [4]. These interventions allow the caregiver to ask questions or manage the survivors' needs at any given place or time [5]. Hence, ensuring they feel prepared to manage the disease throughout the disease trajectory [6]. In addition to ensuring that the caregiver feels prepared [7,8], technology in stroke caregiving has the potential to reduce caregiver burden [6,9], improve caregiver health status [6,9–12], ensure better healthcare utilisation [13], and enhance caregiver self-efficacy and esteem [9,11,14].

For over a decade, the number of people using mobile or other portable devices has increased exponentially [15] as a means to communicate with one another and access information at any place or time [16]. In 2020, it was estimated that more than 85% of Americans

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own a smartphone, which is expected to rise in the coming few years [17]. Consequently, there has been a significant rise in the development of mobile health apps [18] to address critical healthcare delivery issues through education/awareness, improved risk factor control, efficient screening procedures and sustainable health system cost reductions [19]. The benefits of mHealth apps in healthcare are promising, with research highlighting enhanced support for families caring for their loved ones, improved symptom management, and decreased hospital visits [20].

Despite the potential benefits of mHealth applications, the overall adherence of these technologies is relatively low, with most end-users withdrawing from the application within two weeks of download [21]. To improve adherence of such technological interventions, researchers have suggested using usability and user experience techniques. As a consequence, usability and user experience techniques are considered to be a recognized standard [22] for technological improvement [23] that focuses on achieving user satisfaction by concentrating on hedonic and pragmatic goals [24].

This study, therefore, aims towards analysing and evaluating the user reviews of apps that support stroke caregivers healthcare needs [25] based on usability and user experience dimensions [26]. The results of this analysis can potentially help mobile app developer's researchers to understand the factors that affect long-term adherence and usage in stroke caregiving technology.

2. Materials and Methods

2.1. App Identification

Relevant apps were systematically extracted between October 2019 to September 2020 from two app stores (i.e. Google Play Store and Apple App Store) and one commercial mobile repository (i.e. 42matters) based on keywords related to stroke and caregiving. The apps were initially screened based on their published meta-data using a well-defined selection criterion. Then the eligibility of the app was determined after installing the app on compatible devices. A detailed description of the app filtration and identification process is described in a previous study [25].

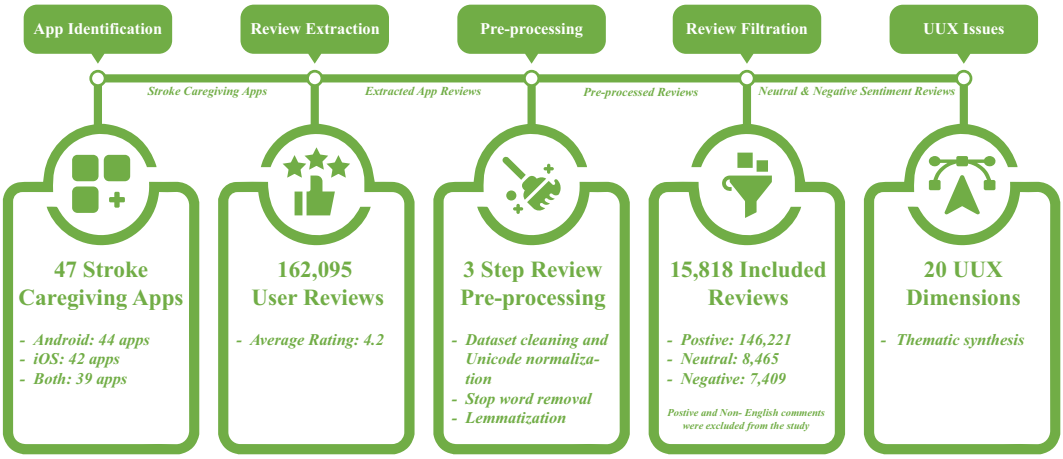

Figure 1. Research Approach.

2.2. Review Extraction and Pre-processing

The user reviews and ratings from included apps were extracted from the app store pages (i.e. Google Play Store and Apple App store) using a Python-based scraper script and stored in a CSV file.

Prior to analyzing the dataset, the data in the CSV file was pre-processed using multiple python-based toolkits to ensure the system can understand the data. The pre-processing technique utilized in this study includes:

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- **Dataset cleaning and Unicode normalization:** It is crucial to have clean and high-quality datasets for any data processing application. The process of dataset cleaning involves splitting text into individual words and handling punctuations and cases. This process was performed using Python NLTK (or Natural Language Toolkit) script making it ready for machine learning and deep learning algorithms. Further, all characters that do not meet the UTF-8 character list were filtered using a Python-based script. For example, the script filtered Unicode characters such as 'å' or 'ĕ' and replaced them with 'a' and 'e' respectively.
- **Stop word removal:** Stop words are a list of the most commonly used words that do not have solid semantic properties but are required in a language for communicating information. These words include "the", "a", "in", "and", "this" and so on [27]. The stop words were removed using a stored list present in the Python NLTK to decrease the size of the dataset while reducing the time to train the system and improve the performance during classification.
- **Lemmatization:** Lemmatization is the process of different grouping words together with a similar meaning to be analyzed as a single item. For example, the term good or better have the same meaning but are represented differently. A Python NLTK script was implemented along with the WordNet Word repository to identify words in the dataset with similar meaning using operations such as tokenizing, classification, stemming, tagging, parsing and semantic reasoning to ensure greater accuracy.

2.3. Review Filtration

Positive reviews were excluded from this study as the primary goal was to identify usability and user experience issues present in the app. To determine all the positive, neutral and negative reviews, sentiment analysis was conducted. Sentiment analysis is a type of text classification that relies on natural language processing, data mining, machine learning, information retrieval and other processes to indicate the sentiments user expresses (i.e. positive, neutral or negative) towards a product or feature [28]. To perform a sentiment analysis on the dataset, the output of pre-processed reviews was categorized to determine users' positive, neutral, and negative opinions using a VADER sentiment library in Python. The VADER library includes a lexicon and rule-based sentiment analysis tool to score text based on its level of positivity and negativity. The tool incorporates numerous lexicon features related to common sentiment expressions, including Western-style emoticons, sentiment-related acronyms, initialisms and commonly used slang to determine sentimental values. Further, the tool converts feature candidates into sentiment expressions using a wisdom-of-the-crowd (or WotC) approach [29]. The outcomes of the sentiment analysis process would be a sum of all compound score values between the ranges of -1 to +1, where the positive sentiment would be greater than or equal to +0.05, and the negative sentiment would be less than or equal to -0.05. All other compound score values would be denoted as neutral sentiments. The negative and neutral reviews were extracted and stored in a CSV file to analyze usability and user experience issues.

2.4. Review Analysis

The negative and neutral reviews were classified by three coders using NVivo 12 following the Usability dimensions by Nielsen [30] and Bevan [24], and User Experience dimensions by Bargas-Avila and Hornbæk [31] as shown in Table 1 and Table 2. A proper classification was discussed amongst the coders until a consensus was achieved if the review was not clear. The three coders independently reviewed a sample of ten reviews to ensure classification quality, and the results were compared, which had high inter-rater reliability ($\kappa = 0.81$).

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Table 1. Usability and User Experience Dimensions.

Usability		User Experience
Dimensions [30]	Dimensions [24]	Dimensions [31]
Learnability	Anticipation	Affect and Emotion
Memorability	Overall Usability	Enjoyment, Fun
Efficiency	Hedonic	Aesthetics, Appeal
Errors/effectiveness	Detailed usability	Engagement, Flow
Satisfaction	User differences	Motivation
	Support	Enchantment
	Impact	Frustration
		Hedonic

Table 2. Definitions for the Usability and User Experience Dimensions.

Dimension	Definition
Learnability	Focuses on how easy it is for users to accomplish a task the first time they encounter the interface and how many repetitions it takes them to become efficient at that task
Memorability	Focuses on how easy it is for the users to re-establish proficiency after a long time of no use
Efficiency	Focuses on how effective the solution/product is in helping the user achieve their goal or perform a task using the system
Errors/effectiveness	Focuses on a careful design, which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action
Satisfaction	Focuses on users' comfort with and positive attitudes towards the use of the system
Anticipation	Focuses on the ability of the product to meet the expectations of the user
Overall Usability	Focuses on the satisfaction of the user when interacting with the product
Hedonic	Focuses on the fulfilment of inner needs such as pleasure, enjoyment, or things preventing this, such as frustration
Detailed usability	Focuses on the satisfaction of the product in terms of overall experience, usability and performance of the product
User differences	Focuses on the differences in features in other products and how those features impact performance and satisfaction
Support	Focuses on the aspect of human or software support available to the consumer to mitigate issues and maintain satisfaction
Impact	Focuses on how the product changed or improved the situation of the user
Affect and Emotion	Focuses on the emotion-induced when using the product
Enjoyment, Fun	Focuses on how entertained the user was while using the product
Aesthetics, Appeal	Focuses on the appreciation of beauty or looks of the system. Typically associated with graphics or sound
Engagement, Flow	Focuses on how engaged the user is in using the product. It also includes challenge versus skill balancing needed for achieving a flow state
Motivation	Focuses on what motivates the user in using the product (task/inner motivation etc.)
Enchantment	Focuses on being "both caught up and carried away" in the experience forgetting everything else, and causing disorientation associated with a pleasurable sense of fullness and liveliness that charges attention and concentration
Frustration	Focuses on the frustration induced by using the product

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Table 3. Classification Examples based on the Usability and User Experience Dimensions.

Comment	Dimensions
"I just tried to use it for pill reminder. Not user friendly. I could not find where to list the quantity or evening as the time of day to take trazodone."	Learnability, Overall Usability, Efficiency
"They completely ruined the game. There is so much going on it is very difficult to keep up and understand what is happening. There is a lot of flashy visuals, but it is not user-friendly anymore. Also, now to replay the games you have to play. Was once great but not anymore."	Memorability, Aesthetics, Overall Usability, Emotion
"The app kept freezing and was not very exciting. The brain games weren't as challenging as I'd really hoped for."	Error, Enjoyment
"I absolutely love this app. I've used it for years, but sometimes 3 days ago, it stopped working for me completely and now loads ONLY a solid orange screen. Is there tech support available?"	Support
"Yes, I did love it when I first got it, but then the memberships came in, and I don't use the money on this stuff, so I started disliking the app because it was amazing at first, but it went downhill with money."	Satisfaction, Emotion
"For a recovery app that is intended for adults that have had a stroke or other brain injury, it is very juvenile, same set up as the kid's games. Make it friendly for all age groups. The encouraging voice is too childish, and the whole word it says is very annoying. Please make this, so it is geared for adults. Thank you."	Efficiency, Emotion, Enjoyment, Aesthetics, Support
"So the app seems pretty great. I've been trying it out for about a week, and the games that I'm able to play are fun. Plus, they seem to really work my mind. However, I hate that you can only play 5 different games once a day. I feel that it is misleading by saying it's FREE, but having EVERYTHING but 1% of the app is on PRO and must be paid for. I wouldn't even mind if I could play the 5 games. I'm able to more than once a day. Just pretty disappointed in being cornered into paying."	Engagement, Enchantment, Emotion
"Frozen. I was enjoying the fit games at the beginning g until the trains froze and started going where I didn't want or tell them to go. Too bad. I really wanted to try their games."	Efficiency, Error, Anticipation, Emotion
"I've been with Elevate for 2 or 3 years now. I've passed all the games and challenges and would like some new content and games. I'm thinking of dropping the subscription at this point and look for something else. It's been enjoyable and became a part of my daily routine, but now I find myself opening it less and less. There haven't been any updates or game additions for quite a while... :("	Enjoyment, Emotion, Motivation
"Maybe it's better than it looks, maybe it isn't. Who can tell? I'll never know because the full version is prohibitively, outrageously expensive, and the free version is nothing but a tiny, useless preview."	Hedonic, Emotion
"Good concept, but poorly implemented. The pillbox analogy is screwy, and I can't get it to show one day only. I already missed dose with the confusing schedule. It looks like it's back to the Apple reminder app. Simple but works. The colours of pills and background make pills impossible to see in a pillbox. App has been deleted; unfortunately, I don't see a way to delete my personal information from the company servers."	Efficiency, Detailed Usability, Impact, Aesthetics, Support
"We have used this app for several years. It used to be great. Now, it frequently freezes and crashes, opens ads or sections I didn't click and generally moves slowly. I will be exploring alternatives to this app. Can't stand it anymore."	Efficiency, Error, Detailed Usability, Frustration
"I've been playing on my computer for years, but I don't play on my phone much because the sounds drive me crazy. I need the volume up for pathetic reasons. Please fix this soon."	User Differences, Aesthetics, Support

3. Results

Out of 1,385,337 user reviews available, the python-based scraper extracted only 162,095 due to the limitations of both app stores (i.e. Google Play Store and Apple App Store), which formed the initial dataset for this study. The dataset was categorized based on user sentiments into positive (146,221/162,095), neutral (8,465/162,095) and negative (7,409/162,095) user reviews. Positive reviews (146,221/162,095), false neutral/negative reviews from the sentiment analysis (41/162,095) and reviews not published in English (15/162,095) were excluded from the study forming a corpus of 15,818 reviews that were

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classified based on the usability and user experience dimensions (Table 1). Examples of the classification scheme used in this study are shown in Table 3.

3.1. Usability and User Experience Issues

Forty-two out of the 47 apps extracted had one or more usability or usability design issues identified by user comments (or reviews). Figure 2 presents the number of reviews that satisfy each dimension (Table 1) based on the examples in Table 3 to highlight usability and user experience issues within the stroke caregiving mobile apps. The reviews highlight critical issues related to the errors/effectiveness, efficiency and support that contribute to decreased satisfaction, affect and emotion and frustration in using the app.

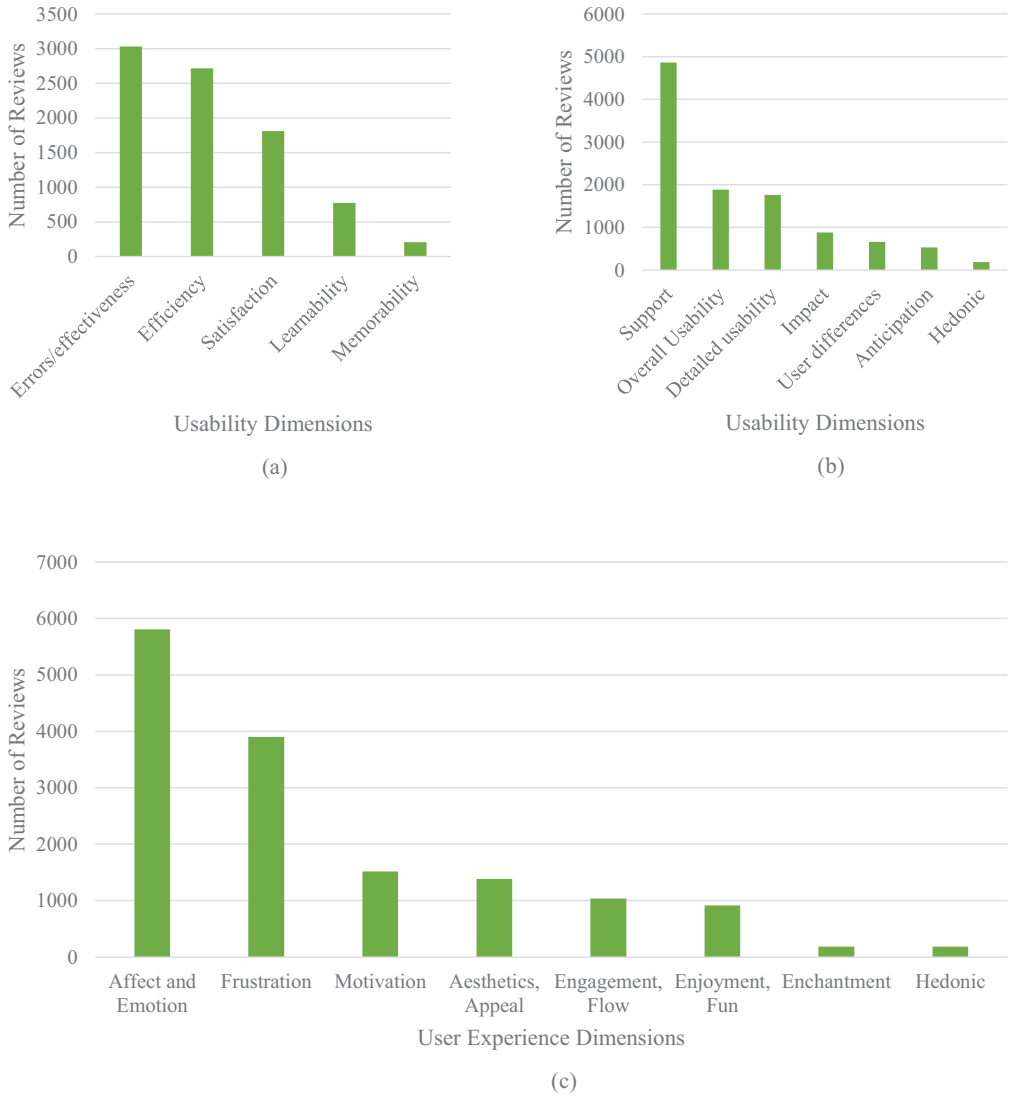

Figure 2. Usability and User Experience Issues in Stroke Caregiving Apps based on the Usability Dimensions by (a) Nielsen [30] and (b) Bevan [24], and User Experience Dimensions by (c) Bargas-Avila and Hornbæk [31].

4. Discussion

4.1. Principal Findings

The purpose of this study was to identify the usability and user experience issues faced by users of stroke caregiving apps based on a theoretical framework that identified the perceptions and responses of the users of a product, service and/or system. The study included 47 apps on Android and iOS platforms, with over 1,385,337 user comments and

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a high average user rating (i.e. 4.2) on a scale of 1 to 5. On extraction of user comments, however, only 162,095 user comments were extracted due to app store restrictions with similar issues faced in the study by Maalej and Nabil [32]. After filtration, 15,818 neutral and negative user comments in 42 apps were classified based on usability and user experience issues.

Understanding factors such as usability and user experience is critical as it creates a positive relationship between the product, the user, and the organization [33] while also ensuring the system's long-term success [21,34]. This relationship was evident in this study, where several users reported the need to withdraw from the app due to issues with the app usability and user experience. The main issues were support, errors/effectiveness, efficiency, usability, motivation, aesthetics and engagement. However, these issues could be expected as most apps were published by small and medium-sized organizations with limited evaluations [25].

Beyond the usability and user experience issues, several users described the app's inability to support their needs, which contributed to support, efficiency, motivation, engagement, and enjoyment. Moreover, Torous *et al.* [21] suggests that the inability to align the app functionalities with the preferences and goals of the intended users may lead to a lack of adherence that may eventually influence the app usability. For example, one user mentioned that the paid app prices are incredibly high, especially for people assisting those with special needs that would require lifestyle adjustment and unavoidable financial responsibilities, which may affect their ability to engage with the app. Another user mentioned the need to include other useful aspects such as health and safety information, user info, photo, allergies and notes in a medication management app to allow better support.

The design of any commercially available mHealth app ultimately depends upon the uptake and success of the app, which is found to be linked with the need to design the system based on user preferences and goals. Moreover, the app needs to function in a way to promote improved usability and user experience. Hence, developers need to consider an approach that can understand the needs, engage the end-user and priorities the requirements to ensure effective outcomes. User-centered design is one such approach.

The user-centered design had been endorsed by the World Health Organization (WHO) as an effective approach to ensure improved outcomes in terms of usability and functionality [35]. This approach provides the better inclusion of target end-users during the design and development of the app based on a clear understanding of the processes involved in the planning of care and recovery [36]. Furthermore, if methods such as participatory design are implemented, it can create meaningful, actionable and feasible strategies [37].

Participatory design has been used to align the concerns of users with health technologies [37]. This is because the traditional design approaches fail to engage users in the design process, which eventually compromises the commercial opportunity and interactional experience of the users [38]. Kushniruk and Nøhr [39] reported benefits of user involvement, particularly in participatory design, including (i) improving system quality as a result of more accurate understanding of user needs and preferences, (ii) greater likelihood of inclusion of features that are required by the user, (iii) higher levels of user acceptance as the system was developed based on user input, (iv) improved understanding of the usage issues, training needs and user engagement, and (v) higher level of participation in the user decision making processes. Hence, making it an ideal approach in the design of mHealth technologies, especially in stroke caregiving.

Despite the numerous usability and user experience issues, it is essential to note the high level of satisfaction amongst the user of the extracted app, with an average rating of 4.2 on a scale from 1 to 5.25. Some users have discussed the presence of fake reviews in their user comments. For example, one caregiver mentioned 'many five star ratings' without any 'meaningful' comments. In contrast, another caregiver discussed the feeling that most fake positive reviews were posted by the developer for an 'obviously subpar product'. The increase in counterfeit review apps could be due to the rise in the illegal market for fake

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reviews to help app developers improve their rankings and ratings [40]. These fake reviews have not only misled many customers into making poor decisions but also affect the users' trust in online reviews [41] as seen in several published user comments.

4.2. Strengths and Limitations

This study has several notable strengths. The primary being the novelty. To the best of our knowledge, the analysis of user feedback in apps that support stroke caregivers has not been addressed. As a result, addressing a key gap in the literature. It also provides a voice to a large sample of users, highlighting their needs and expectations from the app. This feedback can be used to establish support for user inclusion in the design and development processes of the app. Moreover, it can provide future developers with the necessary guidelines in app design. In addition to providing a novelty and providing a voice to app users, the study is comprehensive. It gives a precise classification of usability and user experience issues based on a well-defined theoretical framework with high interrater reliability for each dimension.

Despite the strengths, the study includes a few limitations. First, the comments extracted were less than 12% than those published due to app store limitations. Another downside is the sensitivity of sentiment analysis used in this study. While sentiment analysis has been successfully applied to numerous different applications to understand user opinion, a few neutral or negative reviews may have been falsely classified as positive, which would have resulted in its exclusion from this study. The inclusion of more comments may have painted a different picture of the usability and user experience issues and may have uncovered other problems within the app.

5. Conclusions

The study explores the usability and user experiences issues of apps that support stroke caregivers in their daily activities and considerations for future app development. The implication is to inform the development of apps by considering users using user-centred design approaches such as participatory design. Most apps have demonstrated a lack of understanding of user needs that contribute to usability and user experience issues. Therefore, contributing to the lack of adherence and affecting user satisfaction. Hence, the collaboration with necessary stakeholders could contribute to the design of an app that is meaningful, actionable and feasible to the user preferences and goals.

Author Contributions: EL, MA and JG designed and conceptualized the study. EL coordinated the classification process between the three coders and analyzed the data under the supervision of MA. Further, EL drafted the manuscript based on the findings, which were reviewed, modified and approved by all the authors involved in the study.

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

mHealth	Mobile Health
NLTK	Natural Language Toolkit
LDA	Latent Dirichlet Allocation
CSV	Comma Separated Values
App	Application

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