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Review of the content and quality of mobile applications about Alzheimer's disease and related dementias

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Abstract

This study reviewed the content of mobile applications (apps) providing Alzheimer's disease or related dementias (ADRD) information and assessed quality of the apps. Characteristics, content, and technical aspects of 36 apps in the U.S. Google Play Store and App Store were coded and quality of the apps was evaluated using the Mobile Application Rating Scale. Caregiving (62.1%) and disease management (55.6%) content was frequently provided. Few apps had an app community (8.3%) or a reminder function (8.3%). Overall quality of the apps was acceptable; apps by healthcare related developers had higher quality scores than those by non-healthcare related developers. This analysis showed that ADRD related apps provide a range of content and have potential to benefit caregivers, individuals with ADRD, healthcare providers, and the general public. Collaboration of ADRD experts and technology experts is needed to provide evidence-based information using effective technical functions that make apps to meet users' needs.

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Keywords

Mobile application; Alzheimer's disease; Dementia; Content analysis

Introduction

As of 2018, an estimated 5.3 million people are living with Alzheimer's disease or related dementias (ADRD) in the United States, and estimates are projected to 8.8 million people by 2050 (Alzheimer's Association, 2018). As many individuals with ADRD live at home and rely on family members or friends to provide care, these informal caregivers face a significant burden (Alzheimer's Association, 2018). Caregivers are saddled with many responsibilities, such as managing the behavioral symptoms of the disease, helping with personal activities of daily living, such as bathing, dressing, grooming, and feeding, as well as taking over the instrumental activities of daily living, which include household chores, providing transportation, arranging appointments, managing patient finances and legal affairs, and utilizing support services (Alzheimer's Association, 2018). Caregivers of ADRD patients often struggle with a lack of information about disease management and need support for both post-diagnosis and follow up care (De Cola et al., 2017; Laakkonen et al., 2008). In addition, despite the growing number of individuals with ADRD, the public's understanding of ADRD is only fair or moderate (Cahill, Pierce, Werner, Darley, & Bobersky, 2015).

During the last decade, technological advancements have transformed healthcare, empowering people through access to health information that was not as readily available to them in the past. One point of access is through mobile applications (apps) that provide information on disease prevention, management, and treatment (Bender, Yue, To, Deacken, & Jadad, 2013; Brzan, Rotman, Pajnkihar, & Klanjsek, 2016). With this technology at nearly everyone's fingertips, many mobile health apps have been developed to tackle a broad range of health concerns. As of 2017, over 325,000 mobile health apps are available for smartphone users (Research2Guidance, 2017). Patients, caregivers, healthcare professionals, and the general public can use these apps to track and share health status and progress, learn more about diseases and healthy lifestyles, and communicate with other patients, caregivers, or healthcare providers (Bender et al., 2013; Coulon, Monroe, & West, 2016). Previous studies reported that the utility of mobile health apps is variable, with some aiming to raise awareness, while others offering features such as disease self-management or lifestyle modification (Bender et al., 2013; Brzan et al., 2016; Masterson Creber et al., 2016). Mobile health apps could enhance users' understanding of the disease and encourage efficiency in self-management of disease or in caring for others with a disease through various features including monitoring health status, sharing disease management data with a physician, calculating treatment expenses, and providing educational materials (Brzan et al., 2016; Rosser & Eccleston, 2011). User education, social networking, and more automation of features for self-monitoring have been recommended in order to maximize positive health outcomes and encourage long-term use of the apps (Bender et al., 2013; Brzan et al., 2016).

Given that the aging population is growing and larger numbers of adults will be affected by ADRD (Alzheimer's Association, 2018), more patients, caregivers, healthcare professionals, and members of the general public will need ADRD related information. While apps have been developed to provide ADRD information and help older adults manage their daily lives, little is known as to the information being distributed or the quality of these apps. Thus, this study aimed to (1) review the content of apps providing ADRD information; and (2) assess the quality of the apps.

Method

Search Strategy

The first author (SKC) searched ADRD related apps in the U.S. Google Play Store (Android) and the U.S. App Store (iOS), the top two app markets (Research2Guidance, 2017), on May 22, 2017 using the search terms: "dementia," "Alzheimer," and "Alzheimer's disease." Two research team members (SKC, KK) screened 10% of the initially selected apps using the description of the apps and inclusion/exclusion criteria to check their consistency of app selection. The apps were included for review if they were a smartphone based free app; had an English-language interface; provided ADRD related information; and were categorized as "Health & Fitness," "Medical," "Education," or "Lifestyle." Apps were excluded if they were fee based; not health-related; only providing publications from scientific journals for researchers; focused solely on general health information; games without an education/prevention focus; commercial; explicitly for clinicians/paid caregiver; limited to management of medical schedules, records, or prescriptions; not designed with an English interface. After confirming the reviewers' consistency in app selection, the two reviewers (SKC, KK) independently screened the rest of Android and iOS apps.

Coding

A codebook was developed based on previous research on health-related app reviews (Bender et al., 2013; Pandey, Hasan, Dubey, & Sarangi, 2013). The characteristics of the app (developer, version, number of installations [only available for Android apps], user star rating) and stated target users and purpose were coded based on the app description. To classify developers, we conducted online searches. Coders installed and used the apps to review in-app content and technical aspects. We did not review content that was only available through links to other websites.

The quality of the app was evaluated using the Mobile Application Rating Scale (uMARS) (S. R. Stoyanov, Hides, Kavanagh, & Wilson, 2016), the end user version of the original MARS (S. R. Stoyanov et al., 2015). MARS is a recently developed tool, used to evaluate the quality of health-related apps, and its psychometric properties have been reported as good (S. R. Stoyanov et al., 2016). The uMARS consists of 20 items from four objective subscales - user engagement (5 items: entertainment, interest, customization, interactivity, appropriateness for target group), functionality (4 items: performance, easy to use, navigation, gestural design), aesthetics (3 items: layout, graphics, visual appeal), and information (4 items: quality of information, quantity of information, visual information, credibility of source) – and one subjective quality subscale (4 items). The objective quality

of apps in each subscale was assessed using a 5-point Likert scale from 1=inadequate to 5=excellent. The subjective quality was assessed based on whether the reviewer would recommend the app, expected frequency of use, and overall rating. In this study, we did not include the item "willingness to pay for the app" in the subjective quality subscale because we reviewed only freely available apps.

Before review of the apps, two research team members (KK, a public health master's student; VE, undergraduate computer science student) reviewed the codebook and watched the MARS training video provided by the developers (S. Stoyanov, 2016). The reviewers independently used each app for at least 10 minutes, reviewed the in-app content, and rated the quality of app. They coded the same apps (n=10, all iOS apps) first to compare their coding. Any issues or disagreements were discussed until consensus was reached. Another team member (SKC) was also involved in the discussion process. Each reviewer then assessed half of the rest of the apps. Inter-rater reliability was calculated using Cohen's Kappa (Cohen, 1960) and intraclass correlation coefficient (ICC). The two reviewers had 100% agreement in coding for most variables. Between the two reviewers, Cohen's Kappa statistics ranged from 0.57–1.00, and ICC values ranged from 0.63–0.81, which indicated fair to excellent agreements (Cicchetti, 1994).

Statistical Analysis

Descriptive statistics were conducted on app characteristics and content. Mean MARS scores were calculated by each subscale as well as overall objective quality subscales. Student ttests were used to compare MARS scores by app characteristics. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC) and statistical significance was set at $p<0.05$.

Results

Figure 1 presents the process of identification of apps. A total of 517 Android apps and 359 iOS apps were found from the initial search. About 89.7% of apps (n=786) were excluded after review of app description because they did not meet the inclusion criteria. Among the 90 apps reviewed, 22 apps that did not meet inclusion criteria were excluded. We further excluded 20 apps that had restricted access, did not function well, or without in-app content. Twelve apps among the 48 apps left were available in both Android and iOS. Thus, a total of 36 apps (9 apps were only available in Android; 15 apps were only available in iOS; 12 apps were available in both platforms) was included for analysis. For coding, we used 25 iOS apps and 11 Android apps).

General characteristics of apps

Table 1 shows characteristics of apps. More than half of the apps reviewed were developed by healthcare-related developers (58.6%), including non-profit organizations (13.9%; e.g., Alzheimer's Association), for-profit organizations (e.g., health consulting firm), universities (8.3%), care service organizations (8.3%), hospitals (5.6%), government organizations (5.6%), and pharmaceutical companies (5.6%). Non-healthcare related developers (41.7%) were information technology (IT) companies (36.1%), and non-profit organizations (5.6%;

e.g., charity). The installation numbers among Android apps varied. About 14.3% of apps were installed fewer than 100 times, while one third of apps were installed more than 1,000 times. Among the Android apps by non-healthcare related developers (n=9), none of them were installed more than 1,000 times; while 8 apps out of 12 Android apps by healthcare related developers were installed more than 1,000 times (data not shown).

Target user, purpose, and content of apps

Most ADRD related apps stated that they were designed for caregivers of individuals with ADRD (63.9%) or for the general population (44.4%). Few apps were specifically for healthcare professionals (16.7%), individuals with ADRD (16.7%), or older adults (13.9%). Most apps aimed to aid disease management (55.6%), offer skills training (44.4%), provide disease and treatment information (36.1%), or increase awareness (30.6%). Apps aiming at prevention (8.3%), early detection of ADRD (8.3%), organization promotion (5.6%), or disease/condition monitoring/tracking (2.8%) were less common.

All apps reviewed provided ADRD related information. The most frequently featured inapp content was caregiving (62.1%), followed by disease management (55.6%), early signs and symptoms of ADRD (38.9%), types of ADRD (36.1%), financial and legal matters (33.3%), and lifestyle for ADRD prevention (30.6%).

Technical aspects of apps

One third of the apps reviewed (33.3%) required Internet connection to function. One fourth of the apps (25.0%) provided video lectures/tutorials, while only 1 app (2.5%) provided audio lectures/tutorials. About 16.7% of the apps allowed information sharing (e.g., email to others, share to social media, etc.), 8.3% of the apps had a community feature, and 8.3% of the apps had a reminder function. Only 1 app required login and another 1 app had a password protection function.

App quality

Quality of apps varied as measured by MARS (Table 2). The mean overall objective quality score was 3.7, ranging from 2.3–4.6. Functionality had the highest MARS score (mean: 4.3; range: 3.5–5.0) which was considered acceptable to good, followed by information (mean: 3.9; range: 1.5–5.0), and aesthetics (mean: 3.8; range: 2.7–5.0). Engagement received the lowest MARS score (mean: 2.9; range: 1.4–4.2) which was lower than acceptable quality. The mean subjective quality score was 3.1, ranging from 1.0–5.0.

MARS scores differed by developers. Apps developed by healthcare related developers had significantly higher MARS scores in overall ($p=0.017$), aesthetics ($p=0.025$), and information ($p=0.008$) than those developed by non-healthcare related developers.

MARS scores did not differ by intended users, except apps for individuals with ADRD had a significantly lower functionality MARS score than those not intended for individuals with ADRD ($p=0.023$). Apps stating that their purpose was ADRD assessment had a significantly higher MARS score in functionality ($p=0.010$) and a significantly lower MARS score in information ($p=0.003$) than those without assessment as their stated purpose. Significantly

lower MARS scores in functionality were shown in the apps whose stated purpose was awareness (p=0.014), disease management (p=0.015), or connecting to other services (p<0.001) than apps with other purposes. Apps for skills training had significantly higher MARS scores in overall (p=0.001), engagement (p<0.001), and information (p=0.001) subscales than apps not for skills training (data not shown).

Discussion

The use of mobile health apps continues to grow (Research2Guidance, 2017). As the population ages and ADRD diagnoses increase, apps providing ADRD information may benefit individuals and caregivers by offering preparation and management strategies. This review assessed the content and quality of these apps. The apps addressed a range of ADRD information with varied technical aspects and while the overall quality of the apps was acceptable, it differed by developer.

More than half of the apps reviewed were developed by healthcare related developers. About 41.7% of the apps were developed by non-healthcare related developers, the majority being IT companies. This is understandable, given the expertise of IT companies in technology; however, their expertise in ADRD is questionable. A lack of ADRD expertise among nonhealthcare related developers might have contributed to the significantly lower information quality of the apps from non-healthcare related developers versus those from healthcare related developers. Some of the apps that scored low on information quality provided either limited or an overwhelming amount of information. Others scored low due to a lack of credible information. Although the number of app installations does not necessarily reflect the quality of the apps, Android apps developed by healthcare developers had more installations than those developed by non-healthcare developers. This may indicate that users prefer information from healthcare related entities to ensure content credibility. When people look for health-related information, they may experience difficulty in finding or recognizing information that they can trust (Sillence, Briggs, Harris, & Fishwick, 2007). Apps need to provide evidence-based, credible information to users (Collado-Borrell et al., 2016; Zapata, Fernandez-Aleman, Idri, & Toval, 2015). In developing mobile health apps, effective communication and collaboration between health researchers and technology experts is recommended in order to fulfill both technical and medical expertise and ensure credibility of the content (Collado-Borrell et al., 2016; Schoeppe et al., 2017).

The ADRD related apps reviewed provide various in-app content; however, it is unclear whether this content meets the users' needs. More than half of the apps stated that their intended users are caregivers of individuals with ADRD. Due to the progressive nature of ADRD, patient dependency increases caregiver burden over time, taking a personal, physical, financial, and social toll (Alzheimer's Association, 2018; Haro et al., 2014). Increased demands can cause significant health effects on caregivers, such as mental and physical health deterioration and decreased quality of life (Sorensen & Conwell, 2011). Thus, caregivers need information on how to manage the care of their loved ones while tending to their own healthcare needs (Hepworth, 2004). Most ADRD related apps with caregiving content provided information about resources for caregiver support and dealing with patients' issues; however, few apps provided information on other issues that caregivers

may confront such as financial and legal issues, caregivers' health problems, and alternative care options. If apps do not provide relevant information, it compromises their purpose. In addition, app sustainability relies on user continuity, as users will continue to use apps that meet their needs. Evaluation of the apps by different user groups is recommended to help developers understand users' needs and satisfaction and design more appropriate apps for their target users. Future studies and those who plan to develop ADRD apps need to focus on users' needs and experience of apps by different groups.

Mobile health apps offer many advantages, such as ease of use, portability, continual access, variety of health information delivery modes, user customization, disease management features, and social networking opportunities with other patients, caregivers, or healthcare professionals (Klasnja & Pratt, 2012). Similar to previous studies using MARS (Brown et al., 2017; Reyes, Qin, & Brown, 2018; Schoeppe et al., 2017), functionality quality of the reviewed apps ranked highest among the four app quality subscales. Nonetheless, most apps reviewed did not fully utilize the capacity of apps, which was reflected in the low engagement quality scores as rated by MARS. While apps might provide a platform for interaction among users, which could motivate users to engage more in health promoting behaviors, to exchange supports, and to encourage sustained use of the apps (Ba & Wang, 2013; Bender, O'Grady, & Jadad, 2008), most apps reviewed had limited community and sharing functions. In addition, only three apps reviewed had a reminder function, which is potentially helpful as an external memory cue for both caregivers and individuals with ADRD (Navarro & Favela, 2011). The lack of reminder functions may be due in part to our exclusion of apps that did not provide ADRD information. Some of the excluded apps for management of medical schedules might have reminder functions; however, a recent review also showed that only one thirds of apps for AD caregiving had reminder functions (Brown et al., 2017) Given that ADRD patients present amnesic behaviors, reminder functions could be used to reorient patients to their daily routine and to help caregivers manage patients' medical issues and schedules. In addition, information delivery was mostly limited to text and graphics. The use of video and audio to deliver information might be more attractive to users and may enhance comprehension (Bouton et al., 2012; Kang, Fields, Kiyak, Beck, & Firestone, 2009). Moreover, about one third of the apps reviewed required an Internet connection to function, which may reduce the accessibility of the apps. Most apps did not have password protection or require login. One common concern of mobile health apps is that of privacy, given that users often enter their health information into the apps (Eng & Lee, 2013). ADRD related apps need to have ways to protect users' private information.

This study has some limitations. First, developer information could be misclassified, as we relied on information as stated in the app descriptions. It is possible that some of the apps developed by IT companies in collaboration with healthcare professionals might be coded as non-healthcare related developers. Second, we do not know what content are provided to users through links to external websites. We considered that in-app content is more accessible to users, thus we did not review information provided outside of the apps. Third, some relevant apps might have been overlooked given our inclusion and exclusion criteria. Finally, we recognize that caregivers and individuals with ADRD, as the primary target users, may rate the apps differently than our reviewers.

This review demonstrated that ADRD related apps provide a range of content and functions, highlighting areas for improvement in both technical aspects and information quality. In order to help ease the burden of ADRD for caregivers, individuals with ADRD, and the general public, apps designed for this purpose should provide evidence-based information that meets the range of user needs from prevention to disease management. ADRD related apps will be the most useful when they reflect the users' needs and provide appropriate information in user-friendly ways. In addition, perceived quality and effectiveness of the apps may differ by user group. Caregivers and individuals with ADRD are often older adults who may be less familiar with clinical terminology and technology use. Previous studies stress the need for technology training among older adults (Betts, Hill, & Gardner, 2017; Yoon, Jang, Vaughan, & Garcia, 2018) given the potential benefits from technology including mobile health apps. Thus, future efforts should examine users' characteristics (e.g., demographics, level of health and technology literacy, etc.) and needs in order to maximize app functionality. This can be addressed through the collaboration of ADRD experts and technology experts as well as involvement of target users during app development. In addition, ADRD related apps could assist with effective information sharing between patients, caregivers, and healthcare providers. Providers may recommend apps that contain helpful and evidence-based information for patients and caregivers. Future research should also explore how individuals utilize ADRD related apps and the effectiveness of these apps on reducing caregiver burden and improving patient health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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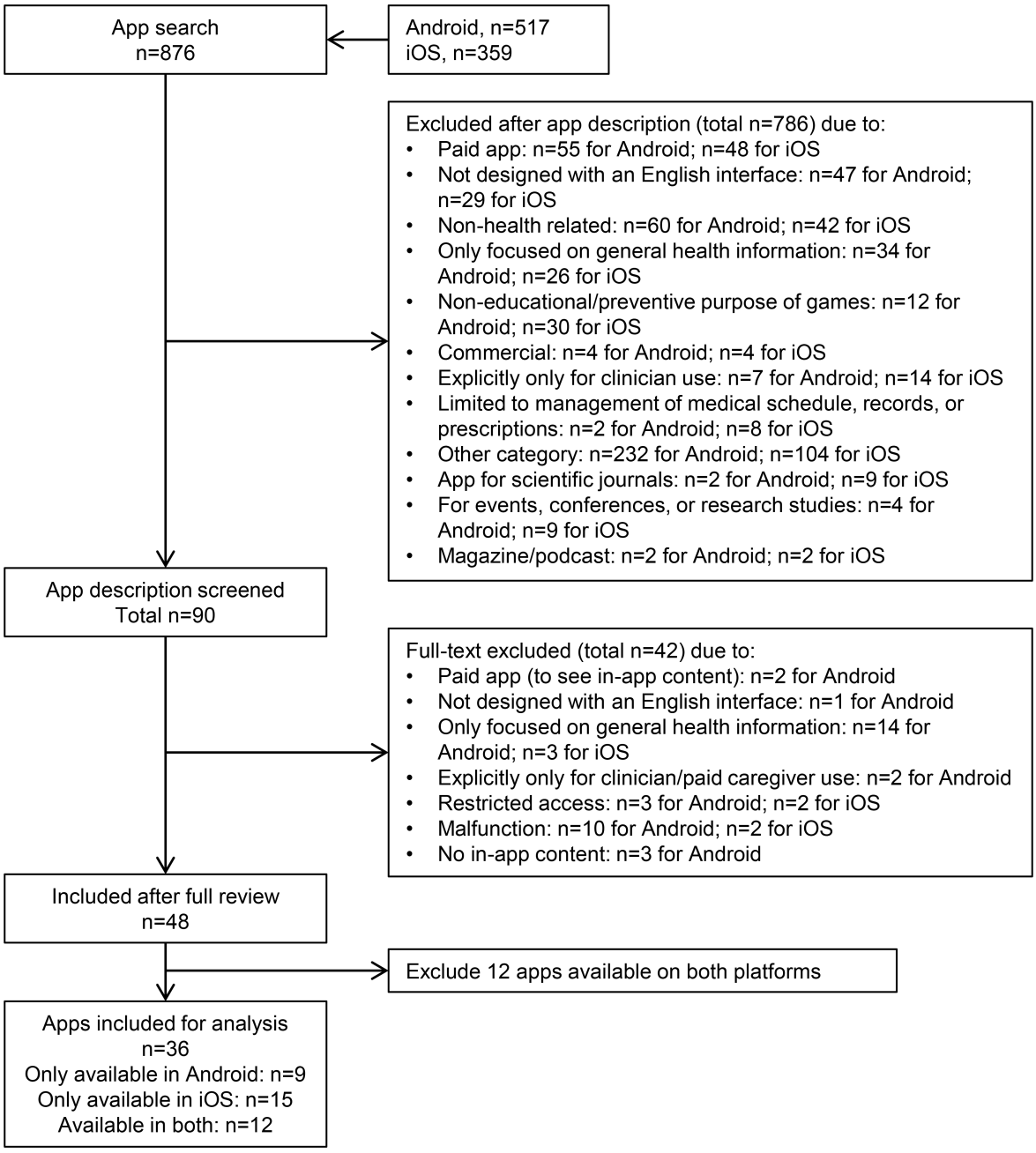

Figure 1.

Flow chart of mobile applications (apps) providing Alzheimer's disease and related dementias (ADRD) search

Table 1.

Characteristics of ADRD related mobile applications

	Frequency	Percent
Developer Affiliation		
Healthcare-related	21	58.3
Non-profit organization	5	13.9
For-profit organization	4	11.1
University	3	8.3
Care service organization	3	8.3
Hospital	2	5.6
Government organization	2	5.6
Pharmaceutical company	2	5.6
Non-healthcare related	15	41.7
Information technology company	13	36.1
Non-profit organization	2	5.6
Installation (among Android app)		
10–100	3	14.3
100–500	7	31.3
500–1,000	3	14.3
1,000–5,000	6	28.6
5,000+	2	9.5
Stated intended users		
Caregivers of individuals with ADRD	23	63.9
General public	16	44.4
Healthcare professionals	6	16.7
Individuals with ADRD	6	16.7
Older adults	5	13.9
Stated purpose		
Disease management	20	55.6
Skills training	16	44.4
Disease and treatment information	13	36.1
Awareness	11	30.6
Connect to other services	8	22.2
Assessment	8	22.2
Prevention	3	8.3
Early detection	3	8.3
Promote an organization	2	5.6
Monitoring/tracking	1	2.8
Content		
Caregiving	24	66.7
Resources for support for caregivers	17	47.2
Patients' behavioral issues	14	38.9

	Frequency	Percent
Emotional support for patients	12	33.3
Financial and legal matters	12	33.3
Caregivers' health problems	7	19.4
Care options (e.g., long term care, assisted living, adult day care)	4	11.1
Disease management	20	55.6
Disease information	20	55.6
Early signs and symptoms of ADRD	14	38.9
Types of ADRD	13	36.1
Lifestyle for ADRD prevention	11	30.6
Causes of ADRD	10	27.8
Early detection of ADRD	9	25.0
ADRD risk factors	9	25.0
Stage of ADRD	9	25.0
ADRD statistics	6	16.7
Comparison between AD symptoms and typical aging related changes	6	16.7
Resource for support for patients	10	27.8
Quality of life of individuals with ADRD	8	22.2
Introduction of ADRD related organizations	7	19.4
Health insurance	4	11.1
Alternative medicine	2	5.6
New research findings	2	5.6
Technical aspect		
Needs Internet connection to function	12	33.3
Video lecture/tutorial	9	25.0
Allows sharing	6	16.7
Has an app community	3	8.3
Sends reminders	3	8.3
Requires login	1	2.8
Allows password-protection	1	2.8
Audio lecture/tutorial	1	2.8

Table 2.

Quality of ADRD applications measured by the Mobile Application Rating Scale (MARS)

	All apps	Healthcare related developer (n=21)	Non-healthcare related developer (n=15)	
Subscale	**Mean±SD**	**Mean±SD**	**Mean±SD**	**p**
Overall	3.7±0.5	3.9±0.3	3.5±0.6	0.017
Engagement	2.9±0.7	3.1±0.5	2.7±0.9	0.109
Functionality	4.3±0.5	4.4±0.5	4.2±0.4	0.282
Aesthetics	3.8±0.6	4.0±0.5	3.5±0.6	0.025
Information	3.9±0.9	4.2±0.7	3.4±0.9	0.008
Subjective quality	3.1±1.1	3.3±1.0	2.7±1.2	0.067

MARS rating: 1 = inadequate; 2 = poor; 3 = acceptable; 4 = good; 5 = excellent