Mobile apps for dementia awareness, support, and prevention – review and evaluation

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\textbf{ABSTRACT}

\textbf{Purpose:} This review aimed to document the characteristics and appraise the quality of dementia applications (apps) to support persons living with dementia and their caregivers.

\textbf{Materials and methods:} Systematic searches of the Australian-based Google Play Store, Apple App Store, and relevant websites sought apps with dementia or Alzheimer’s information, support for caregivers and persons living with dementia, or prevention content. Apps were screened and subsequently appraised via the mobile application review system (MARS).

\textbf{Results:} The majority of the final 75 dementia apps were free to download, but were only available on a single platform. Persons involved in caregiving were the primary audience. App content focused on dementia information, practical caregiving, and communication tips. Language options in addition to English were limited and few apps offered ongoing support. MARS appraisal identified few apps with good “Overall Quality” scores. Apps that were more comprehensive trended towards higher MARS scores.

\textbf{Conclusions:} A composite lack of standardised quality indicators and commercial drivers of the marketplace present significant barriers for consumers seeking meaningful dementia information and support. Persons living with dementia and their caregivers would significantly benefit from social and organisational services that assist with navigating the app marketplace.

\textbf{IMPLICATIONS FOR REHABILITATION}

- There is significant opportunity for quality digital innovations, including apps, to support home-based, independent dementia care.
- A composite lack of standardised quality indicators and commercial drivers of the app marketplace present significant barriers for persons living with dementia and their caregivers who seek apps with dementia information and support.
- Social and organisational services can support the dementia community through assistance with navigating the app marketplace for quality dementia information and support.

\textbf{Introduction}

mHealth interventions delivered via wireless devices and modalities, are increasingly used by consumers for information, clinical management, and individual support for health challenges \cite{1-3}. The features of mobile applications (apps), such as internet connectivity, portability, multimedia functionality, and timeliness of access, facilitate user interaction and support the management of health challenges \cite{4,5}, such as dementia \cite{6-8}. With increasing global prevalence of dementia \cite{9}, important policy, research, and social responses are occurring to inform, resource, and support individuals and those in caregiver roles. There is a societal/economic push \cite{10} and an individual preference \cite{6,11} for persons living with dementia to remain in their homes. In Australia, more than 80% of persons living with dementia reside in the community and rely on family members for support \cite{10}. Consequently, there is significant opportunity for digital innovations, including apps, to support home-based, independent dementia care \cite{7,8,12}. However, evidence for cost effectiveness, efficacy, safety, and optimisation of dementia care via mHealth is still emerging \cite{11}, with low-quality evidence for smartphone technologies \cite{13}.

While innovative apps are an avenue of support for individuals and caregivers (dyads) living with dementia, there are challenges regarding technology, literacy, and time \cite{14}. Recent reviews of dementia apps in the USA, Canada, Saudi Arabia, Pakistan, and the global marketplace \cite{6-8,15-17} have varied in scope (with exclusion of apps based on target audience, app cost, etc.) and their application to disability and rehabilitation practice.

The aim of this study was to document the scope, classification, and quality of apps with a dementia-focus available in the Australian marketplace. This study offers health professionals and the dementia research community an insight into mobile apps.
and stimulates critical discussion on the accessibility, quality standards, and funding of apps for persons living with dementia and their caregiving communities.

**Methods**

Systematic searches of the Australian Apple App Store and Google Play Store were conducted to identify relevant apps. Potential apps were screened against pre-defined eligibility criteria for inclusion in the review. Included apps were assessed and rated using the validated mobile application review system (MARS) framework. This study drew on recently applied methods to review and appraise apps for themes such as dementia care [6,8,16], caregiver support and care apps for older adults [18,19] and mindfulness [20].

**Eligibility criteria**

Eligible apps had a primary focus of increasing awareness and understanding of dementia, or helped to address the care needs and considerations for persons living with dementia. Apps with content regarding management or prevention of dementia were also sought for inclusion, where at least two dimensions of health were addressed (e.g., physical, mental, spiritual, and social). Target populations included persons living with dementia, their caregivers, community members, medical staff, and health workers. Both smartphone and tablet computer apps were included. Finally, eligible apps were to be available in English.

Apps were excluded if their primary purpose or content was not related to dementia awareness, understanding, care, or prevention. Other exclusion factors included a primary focus on intelligent assistive technology (e.g., tracking capabilities), diagnosis/screening, or narrow dementia management/preventative focus (e.g., brain training). Stand-alone apps designed for specific locations and events, or those offering single-focus resources for daily activities (e.g., communication, speech therapy, diary, and clocks) were also excluded. Further details of the inclusion and exclusion criteria are available in Supplementary Appendix 1.

**Scope of study**

While social networking services delivered via platforms such as Facebook can offer a valuable information and peer support to some individuals with dementia and their caregivers [21], this was outside the objectives of this study. A cost limit was not used to exclude apps.

**Search strategy**

The key words “dementia” and “Alzheimer’s” were used to locate apps available in the Google Play Store or Apple App Store within the Australian marketplace during January 2020. Users of both Google Play Store and Apple App Store are constrained to accessing the app store for their geographical region. As the research team were Australian-based the Australian apps stores were searched. This search was extended across relevant professional and non-government organisation (NGO) websites, including Alzheimer’s International, Dementia Australia, Alzheimer’s Queensland, and The Australian Indigenous HealthInfoNet, in order to identify any dementia apps potentially missed in previous searches. Additional keywords were used for website searches depending on the nature of the website and its search function. A full list of sites and keyword searches is available in Supplementary Appendix 1. Search results from the app store listing or websites including: title, description, three screen images were documented. Duplicate apps were removed throughout the screening process.

**App screening, data extraction, and analysis**

**Screening (stage 1)**

Screening of search results was conducted in a two-stage process. Initially, two authors (GC, MN) worked together using the title, description, and images to screen a random selection of 10 apps to ensure inter-rater consistency. Both authors screened the full list independently, and documented exclusion reasons. Analysis for inter-rater agreement of inclusion/exclusion of apps was 91% (748/818) and the agreement for exclusion criteria was 83% (539/648). Discussions ensured consensus was reached for all others. In the second stage, all final apps were downloaded to a smart device for more detailed screening of the full app.

**Mobile application review system**

Analysis of final apps was carried out using the MARS framework [22]. MARS is a 23-item tool with Likert scales for assessing the quality of mHealth apps across aspects of app engagement, functionality, aesthetics, content, and subjective quality. A mean score for each subscale is calculated, together with a mean “Overall Quality” score to provide an overall rating across the quality subscales. The “Subjective Quality” section of the MARS framework covers the assessor’s likelihood of recommending the app, app usage, perceived value, and overall star rating. A mean score for the “Subjective Quality” is then determined. Some items in the framework can be rated as “not applicable”, which is why mean scores (instead of totals) are calculated. The MARS ratings are: 1 = inadequate; 2 = poor; 3 = acceptable; 4 = good; 5 = excellent.

Several adaptations were made to items within the framework to ensure relevance to the context of the dementia apps. For example, in addition to noting the app’s targeted age group, apps were categorised according to intended users, in an adaptation to those outlined by Bradway et al. [1]. In the current context, these were specific to persons impacted by dementia, including person/s living with dementia; primary caregiver/partner/spouse; family or close friends; health and medical professionals or students/formal caregivers; and general public.

**Screening (stage 2), MARS analysis, and classification**

To calibrate the decision-making between two authors (GC, AM), the screening and analysis of a random sample of 20 apps was conducted in collaboration. Discussions were held to synthesise decisions and ensure consistent application of exclusion criteria and the MARS framework in the context of the dementia app. Each author then independently reviewed their allocated apps from the final list. Due to the number of apps retained in stage one (n = 149) and the extensive process of screening and analysis time for each app (x = 30:38min), it was not feasible for both authors to fully review each app individually. These time constraints also limited analysis of cross-platform apps to a single platform and device. The platform and device used for assessment, along with reasons for app exclusion were recorded.

Included apps were also classified according to the focus of the content, in an adaptation to those of Grossman et al. [19], with multiple categories possible. The focus area categories included: (i) information and resources; (ii) practical caregiving and communication; (iii) caregiver information and support; and
Details of each app and the MARS responses were tabulated using Microsoft Forms during the secondary screening stage. Additional information was sought from app developer/organisation websites or scientific publications where available. Data were exported to Microsoft Excel (Redmond, WA) for cleaning and analysis.

Data synthesis

The dataset of app characteristics and MARS framework responses was exported from Microsoft Forms into spreadsheet format. Descriptive analysis was used to generate summary data of the characteristics and quality of dementia apps available in the Australian marketplace, including platform availability, cost, focus of content, and target users. The text-based MARS responses were converted to their numerical counterparts and the mean quality and subjective scores for each app were calculated. This summary data were used to explore the relationship between MARS results to app variables including cost, comprehensiveness, affiliation, and recency of update.

Results

Screening results

A total of 821 unique apps were identified from app store and website searches. The two-phase screening process retained 75 final apps for appraisal via the MARS framework (see Figure 1).

It was noted that when identical search terms were used on different days or devices, the app stores presented the search results in varying order. This could be attributed to a number of factors, including non-deterministic search algorithms, app popularity variations, and personalised search results. The dynamic nature of the app marketplace was also observed in changes to availability between screening stages. A proportion of apps (n = 15) identified in initial searches and retained were no longer available to download at the time of analysis. Several apps associated with NGOs and university research programs were included in these losses.

App characteristics

Table 1 of Supplementary Appendix 2 presents the characteristics and availability of the final 75 apps.

Availability and cost

While a proportion of the final dementia apps were available cross platform (i.e., iOS and Android) (n = 30, 40%), the majority were limited to a single platform (n = 45, 60%).

More than 90% of apps were free to download (n = 68, 91%), although many of these featured prominent advertising. Only one app had a cost that was likely to be prohibitive to users (Dementia, Indextra AB; AU$65.99). However, this app is specifically designed for medical practitioners and students, who are likely to invest in a comprehensive resource. Seven apps (9%) had in-app purchases or upgrade options such as monthly subscriptions (ranging from $1.49/month to $14.99/month), to access full content. One of the apps, which generally requires a purchase, was made available free during the COVID-19 pandemic.

Focus of app content

App content with regard to dementia care was used to classify apps. Table 1 outlines further detail and examples of the non-mutually exclusive categories.

Apps with more than two focus areas were considered comprehensive, and this was true for almost half of the included apps (n = 35, 47%). The majority of final apps (n = 53, 71%) were designed to provide information and resources to increase awareness and understanding of dementia, and half of them offered practical caregiving tips and communication aids (n = 40, 53%) to assist quality of life and care for persons living with dementia. A smaller proportion of apps were intended to offer content regarding caregiver resources and support (n = 15, 20%), or prevention (n = 12, 16%).

Target user/audience

A review of the intended user/target audience of the apps (Figure 2) showed a significant proportion of apps were designed for the primary caregiver/partner/spouse (n = 56, 75%), health and medical professionals or students/formal caregivers (n = 38, 51%), and family or close friends (n = 36, 48%). A smaller selection (n = 28, 37%) was designed for persons living with dementia; and a few would be of use to a broad audience (n = 11, 15%).

Culturally sensitive apps

No apps in the final sample were identified as intended for dementia awareness and support with non-dominant cultures in Australia. While many apps advertised availability in multiple languages, only four apps (5%) included language options other than English within the downloaded app, including those with a user login and profile. Language options included French (n = 2), Spanish (n = 1), German (n = 1), Swedish (n = 1), and Chinese (n = 1). This is likely due to the same app store listings used internationally, but final download being specific to the location of download.

Interactivity/community

A number of apps offer users interactive features such as gamification and virtual reality to raise understanding of dementia (e.g., A Walk Through Dementia (Alzheimer’s Research U.K.) and G30 – A Memory Maze (Kovalov Ivan)), or to enhance quality of life for persons living with dementia and their caregivers, e.g., DevaWorld (Mentia, Inc., San Francisco, CA). Other apps, such as Alzheimer’s Support (MyHealthTeams Inc., San Francisco, CA) offer connection through social networking to support for caregivers of persons living with dementia through online message boards, information, and resources plus email messages from the organisation. MemorC (Topos Productions, Berlin, Germany) emails regular updates regarding practical dementia caregiving during the impacts COVID-19. Another app called MindMate (MindMate Ltd., Glasgow, UK), focused on dementia prevention, sends email prompts, and encouragement to participate in health and well-being habits.

MARS results

“Overall quality” and “subjective quality” of apps

The mean subscale scores and overall MARS scores for each dementia app are included in (Table 1 of Supplementary Appendix 2). A scatterplot of the “Overall Quality” and “Subjective Quality” MARS scores of each dementia app (N = 75) is displayed in Figure 3, along with the means and standard deviation (SD) of the app cohort for the MARS subscales and overall scores.
The mean scores for "Overall Quality" of the dementia apps reviewed in the study were mostly "Acceptable" ranging from 1.68 to 4.26 (\(\bar{x} = 3.16;\ SD\ 0.65\)) out of a maximum of five. There were very few apps (\(n = 5,\ 7\%\)) with an "Overall Quality" of four ("good") or more. These included Balance – Alzheimer’s Caregiving (National Alzheimer Center, Riverspring Health, Bronx, NY), Verily Connect (La Trobe University; John Richards Centre, Wodonga, Australia), Much Too Young – Virtual Reality (The Digital Generals Media Inc., Toronto, Canada), Healthy Brains by Cleveland (Cleveland Clinic Innovations, Cleveland, OH), and MindMate – For a Healthy Brain (Mindmate Ltd., Glasgow, UK).

There were no particular subscales such as functionality or information that particularly influenced the higher scores for the top five apps (see Figure 4). Rather, the apps rated consistently better across all four subscales when compared to the mean for the remainder of the dementia apps (\(n = 70\)). The “Subjective Quality” of the app cohort were largely viewed as "Inadequate" (\(\bar{x} = 2.37;\ SD\ 0.93\)). This is clear in the scatterplot (Figure 3), where the “Subjective Quality” scores are consistently lower than the “Overall Quality”.

Contributors to the “Subjective Quality” score reflected the reviewers’ likelihood to recommend the app, use the app, pay for
the app, and an overall star rating (see Figure 5). The mean score for the star rating was slightly higher than the other dimensions, but all means rated consistently lower than those for “Overall Quality”.

**Comprehensive apps**
A comparison of the comprehensiveness of the app (number of focus areas for content out of possible four) versus the MARS “Quality” and “Subjective” scores revealed positive trends (Figure 6). That is, more comprehensive apps were more likely to have slightly higher MARS “Overall Quality” scores, and modestly higher “Subjective Quality” scores.

**Engagement dimension**
A proportion of final apps (n = 11, 15%) were rated as “good” (mean of four or higher) for engagement by offering interactive features (e.g., login, feedback, customisation, and prompts) and/or ongoing user support through forums and email. Higher “Engagement” mean scores positively correlated with “Overall Quality” means. Four apps with higher engagement mean scores were also four of the top-rated “Overall Quality” apps. These were Balance – Alzheimer’s Caregiving (National Alzheimer Center, Riverspring Health, Bronx, NY), Verily Connect (La Trobe University; John Richards Centre, Wodonga, Australia), Healthy Brains by Cleveland (Cleveland Clinic Innovations, Cleveland, OH), and MindMate – For a Healthy Brain (Mindmate Ltd., Glasgow, UK).

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Table 1. Categories and examples of dementia app content.

| Category                        | Examples                                                                 |
|---------------------------------|--------------------------------------------------------------------------|
| **Information and resources**   | Facts on dementia (causes, stages, description, treatment, etc.)          |
| To increase knowledge and understanding of dementia | Links to resources for further information from expert organisations such as Alzheimer's Association |
|                                 | Detailed medical information and study resources for health professionals, students | |
| **Practical caregiving and communication aids** | Ideas to assist decision-making and manage difficult situations. For example, suggestions as to how to understand and support a person living with dementia who is distressed |
| To facilitate quality of life and care for person living with dementia | Practical ideas about engaging with persons living with dementia and building quality of life experiences |
|                                 | Interactive functions to document important information, memories and preferences of the person living with dementia to assist caregiving dyad |
|                                 | Links to community resources for support and ideas |
| **Caregiver resources and support** | Information and resources to support the role of the caregiver who fulfils a complex and necessary role. For example, managing health and wellbeing through lifestyle tips |
| To support the carer in their role and their own wellbeing | Links to finding caregiver support groups/on-line communities, in-home care services in local area |
| **Prevention**                  | Facts about healthy lifestyle choices to prevent dementia                |
| To inform and resource prevention of dementia with a multi-dimensional approach (i.e., targeting at least two dimensions of health) | Interactive functions to stimulate healthy lifestyle practices. For example, five small challenges each day to support mental, physical, social, and spiritual dimensions of health |
|                                 | Links to further information and resources for prevention of dementia |

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Figure 2. Target group/user of apps.
The authors planned to explore the relationship between apps that required payment with their MARS scores. However, given the low number of data points for paid apps \( n = 7 \) or those with upgrade/in-app purchases \( n = 7 \) this analysis was not feasible.

Consumer rating of apps
A proportion of apps included a listing of consumer rating scores in the Google Play App Store and the Apple App Store. However, there were not sufficient data points to make a meaningful exploration of the consumer rating and the MARS scores. More than 75\% \( n = 57 \) did not have any reviews recorded in at least one of the online stores in which they were listed. Further, analysis of "total download" statistics was limited due to these data solely available in Google Play App Store.

App updates
Review of the app version histories showed that only a minority of the final sample were updated regularly, with 19\% \( n = 14 \) updated in the previous six months and 37\% \( n = 28 \) in the previous 12 months. Furthermore, three quarters \( n = 10/13 \) of the apps excluded after download on account of malfunction or incompatibility with current operating systems, had not been updated for more than 18 months. A comparison of the MARS "Overall Quality" scores for apps that had been recently updated (since January 2020), revealed a modest but not significant trend to higher MARS means \( \bar{x} = 3.28; \ SD = 0.64 \) versus \( \bar{x} = 3.14; \ SD = 0.65 \).

Developer/affiliations
A significant proportion of apps \( n = 28; 37\% \) had trusted organisations as affiliations or as development partners. These affiliations included universities, government, or NGOs such as Alzheimer’s Association or Dementia Australia.

A comparison of the MARS "Overall Quality" scores for apps with trusted affiliations, shows moderately higher MARS mean scores \( \bar{x} = 3.53; \ SD = 0.33 \) versus \( \bar{x} = 2.95; \ SD = 0.69 \).

The MARS review considered trustworthy affiliations and scientific evidence from publications; however, this was a limited assessment of credibility or efficacy. None of the top five rated apps (for "Overall Quality") included publication statements regarding evaluation in their app store profiles. Searches of the

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\begin{array}{ccccccc}
\text{Mean scores and SD for MARS quality subscales, ‘Overall Quality’ and ‘Subjective Quality’} \\
\hline
\text{Subscale} & \text{Engagement} & \text{Functionality} & \text{Aesthetics} & \text{Information} & \text{Overall Quality} & \text{Subjective Quality} \\
\hline
\text{Mean} & 2.97 & 3.42 & 3.20 & 3.07 & 3.16 & 2.37 \\
\text{SD} & 0.80 & 0.56 & 0.84 & 0.97 & 0.65 & 0.93 \\
\hline
\end{array}
\]

The MARS ratings are: 1=inadequate; 2=poor; 3=acceptable; 4=good; 5=excellent.

Figure 3. Quality of apps rated using the MARS subscales.
National Library of Medicine (Pubmed.gov) for apps with trusted affiliations (university, NGO, and government) confirmed a lack of evaluation evidence in the scientific literature.

**Discussion**

**Principal findings**

The authors highlight that while the study documents the characteristics and quality of 75 apps with a dementia-focus available in the Australian app marketplace, a proportion of the final apps are available through Google Play Store and Apple App Stores in other countries. Therefore, this review has relevance for clinicians and dementia care organisations internationally.

The majority of apps were free to download but only available on a single platform. Persons involved in caregiving were the primary audience, with app content focused on dementia information and practical tips for caregiving and communication. Approximately, half the apps were deemed comprehensive. Language options in addition to English were limited and few apps had ongoing support mechanisms. MARS appraisal [22] found only five apps with good “Overall Quality” scores and few recommended apps within the “Subjective Quality” subscale. Apps from trusted affiliations were more comprehensive and trended towards higher MARS “Overall Quality” scores.

Recent research substantiates the value of mobile app characteristics of connectivity, multimedia functionality, and on-demand access to enable dementia information sharing, caregiving tips,
management of symptoms, and support to maintain independence [6–8,23]. However, the challenges of navigating the app marketplace are a common theme. This review further demonstrates the difficulties faced by users in identifying meaningful apps for dementia caregiving, amongst the copious quantity and generally poor quality of the marketplace. The attrition of dementia apps during the six-month period of this study, including those created with trusted affiliates, highlights sustainability issues. Three key factors that contribute to these challenges are discussed.

1. Accessibility and navigation of complex marketplace
Caregivers’ daily responsibilities are demanding and complex, leaving little space in daily schedules for accessing support [14,24]. Optimised access to helpful information or support for dementia via mobile apps offers a plausible solution. This review identified many (n = 821) unique apps asserting their relevance to dementia. However, systematic screening revealed a significant proportion (n = 672) had little or no value for dementia understanding or caregiving and were not always available cross-platform. Similarly, Choi et al. [7] identified a host of dementia apps (n = 876) in the US’ marketplace, where a majority were again, of low relevance to the review. Consumer identification and access to quality digital solutions for dementia can be challenging [16].

The abundance of low relevance dementia apps (n = 672) reflects the broader, commercial drivers of the marketplace, where app developers and resellers benefit from direct sales (download cost) or embedded advertisements [25]. In this review, examples of poor quality apps with clear commercial interest were free to download with some useful dementia content, but advertising banners and pop-ups dominated the screen and attention of the user, offering limited value to consumers. These products clutter the marketplace, wasting valuable time, and potentially diverting a user’s finances elsewhere. Adding further complexity to a user’s experience are the invisible and fluctuating algorithms behind App Store Optimisation (ASO) – which is crucial to an app’s commercial success [26]. Results generated from app store searches can be inconsistent (even on the same day and the same device) and higher-ranking apps are not necessarily higher in quality, but rather, a reflection of the developer’s marketing and financial investment in ASO [27] (D McKay, personal communication, 18 February 2020).

This review did not identify any active dementia apps designed with, and for non-dominant cultures. Loss of the Cultura app from the marketplace during the timeline of this study is a setback for the dementia community in Australia. Developed by Alzheimer’s Australia South Australia (2017), the app provided cultural insights about language, food, traditions, practices, etc. to enhance caregiving (informal and formal) for individuals living with dementia. Dementia Australia (T Petrovich, personal communication, 13 March 2020) confirmed that financial aspects, including cost of app maintenance and hosting, were the main contributor to non-renewal. Culture, language, and autonomy considerations are central to health care and support for persons living with dementia [28–31]. Without representation in the marketplace, non-dominant cultures already facing health disparities may be under-resourced in their understanding of dementia and access to support for dementia caregiving. In Australia, Aboriginal and Torres Strait Islander people face a three- to five-fold higher risk and earlier presentation of dementia than non-Indigenous people [32–34]. It is imperative that any work to support persons living with dementia address the needs of persons from non-dominant culture in Australia with specific attention to the unique cultural identities of Aboriginal and Torres Strait Islander people [28,35]. There are also international calls for contextualisation of apps to enable cultural safety in dementia support [6,8].

2. Quality of available dementia apps
The mean “Overall Quality” of the dementia apps was “acceptable”, as assessed via the MARS framework (x = 3.16/5). Very few individual apps were rated as “good” (n = 5) and none as “excellent”. The trend towards higher MARS results for apps developed with trusted affiliations corresponds to similar research in the US [7], highlighting the importance of collaboration between trusted dementia experts and technology specialists. The few apps considered more comprehensive and engaging [14,24] correspond to similar research in the US [7], highlighting the importance of collaboration between trusted dementia experts and technology specialists. The few apps considered more comprehensive and engaging [14,24] correspond to similar research in the US [7], highlighting the importance of collaboration between trusted dementia experts and technology specialists.
that may not be relevant to all dementia dyads. Consumers (particularly caregivers), seek functional, interactive dementia support beyond extensive didactic material that can be overwhelming [16]. Additionally, caregiving information needs can be complex and evolving along the care pathway of dementia [16]. The Verily Connect virtual platform (John Richards Centre for Rural Ageing Research, La Trobe University, Wodonga, Australia) is a good example of a comprehensive resource for caregivers that includes: quality information in helpful bite-size sections as “cards”, peer support through chat and video functions, links to local services and further information. The Verily Connect project (2017–2019) sought to provide innovative support for carers of persons living with dementia living in rural communities of Victoria, New South Wales, and South Australia [36].

The “Information Quality” of the 75 apps reviewed was rated as “acceptable” (k = 3.07/5) based on items of accuracy, credibility, relevance, sufficiency, and advertised content. This outcome highlights a potential mismatch between a consumer’s high expectations from the app store listing, versus the “average” content of many apps in reality. Results from this study reinforce statements from previous studies that health professionals may experience difficulty identifying trustworthy apps they can use for direct caregiving, or endorse in their role to support and guide dementia–caregiver dyads [19] or other health conditions [37].

For “Subjective Quality”, the consistently lower scores (versus “Overall Quality”) applied by the authors were made within the context of the broader app marketplace. While the “Overall Quality” subscales related more specifically to app characteristics, the components of “Subjective” score (recommendation, usefulness, usage, and star rating) reflected the authors’ (Author Initials, Author Initials) exposure and experiences with the breadth of apps in the marketplace featuring superior designs and optimised functionality. The authors acknowledge the subjectivity associated with these decisions.

In terms of understanding consumer perspective, the current metrics from online stores were not a reliable source of information. As stated, the majority (75%) of the final apps did not include any user ratings. Prior research indicates this metric is a poor indicator of the apps’ clinical value or usability [27]. Further, total app download data were only available in Google Play App Store, is often non-specific (e.g., “less than 100”) and is not reflective of user engagement. In fact, commercial analysis shows that up to 25% of consumers may only use an app once after download [38,39]. App selection by a majority of users is often based on community recommendations via social media, testimonials, or simply selection of the first relevant app with adequate reviews or ranking [16].

This review echoes themes of broader health app research regarding the lack of industry-standard quality indicators [40]. Without consistent quality markers, it is impossible to establish the validity and real-world transferability of apps [41,42]. While trustworthy affiliations lift app credibility, these are not always obvious, nor information sources stated [42]. The overall process remains a user-tested experience, heavy with advertising, inconsistent functionality, and a sense that commercial interest is the driver for app creation. Users may also discover that there may not be any association between payment for apps and their quality or evidence-base [42].

Application of the MARS framework in this review was in line with the intent of MARS as a “brief tool for classifying and assessing the quality of mHealth apps” [43,p.1–2] not intended for deeper analysis of efficacy. While this provided useful insights into dementia apps for the purposes of this review, the authors support a continued push to establish framework/s that enable consistency in quality indicators. A concurrent proliferation of apps in the marketplace claiming effectiveness, and academic literature endeavouring to validate apps, has minimal crossover of content [16,41], leaving consumers in the gap. In the context of dementia, there is significant community fear associated with the growing presence of the condition, fed by media messages [44] and it is likely developers see opportunity to enter the marketplace with apps that meet consumer fact-finding behaviour. Unfortunately, consumers are vulnerable to the commercially driven non-validated products. Clarification and transparency of evidence-based content is needed for health apps [4,37], particularly those claiming clinical efficacy [2,40,42]. Several collaborative groups are developing prospective tools in Australia [42] and the US [41]. Furthermore, regulation processes and international guidelines are also being established [2].

3. Sustainability of apps in health care

Outcomes noted during the six-month timeline of this review demonstrate the fluctuating nature of the app marketplace. First, 15 dementia apps retained for analysis were no longer available during secondary screening. Nine of these were developed with “trusted affiliations”, highlighting the loss of quality products from the pool of dementia apps. A further exclusion of 13 downloaded apps was due to technical issues that prevented any meaningful use of the app. Both these factors further complicate consumers’ experience of finding reliable, quality products to support their needs.

Funding streams are a key consideration for app sustainability. For example, a university research group or NGO may develop and trial a health care app – based on short-term government grants. Unless the app successfully attracts further funding through metrics for downloads and user-engagement, the costs of hosting and maintenance become unviable. Examples of non-renewal for these reasons in this review included the Cultura app and Brainy App, both by Dementia Australia (T Petrovich, personal communication, 13 March 2020). Another aspect of funding streams affecting app sustainability is the “fail fast, fall often” approach of technology start-ups [41], that push for product launch without investment of time and quality content. This type of “set and forget” activity was observed in the exclusion of 13 faulty apps. Many of these substandard products had not undergone updates in several years, demonstrating lack of developer management following app launch, and consequently lack of use by consumers.

A broader aspect to sustainability that warrants further research is whether apps are stand-alone products or embedded in models of care. Without ongoing engagement, an app by itself may not really provide a “solution”, but rather become a static source of information that may be sourced elsewhere [42], gradually becoming irrelevant. Practical support for early use and ongoing enquiries or problem solving is necessary for app integration with health systems [2]. In this review, several apps that obtained higher MARS results were associated with health organisations and tied into existing health services systems, thus supporting the concept that a wider network may enhance app quality, relevance and engagement.

An approach taken by Health and Social Care – Northern Ireland (HSCNI) [45] to develop an app library for dementia, poses a valuable solution to a combination of the challenges outlined in this review. Collaboration with an expert evaluation partner – Organisation for the Review of Care & Health Applications [46], enabled screening and identification of potential apps to support
dementia awareness and support for caregiving, with subsequent participatory review by consumers and health professionals. Furthermore, apps are classified along a dementia care pathway, to maximise user relevance. The multi-stage evaluation model of ORCHA ensures aspects of app quality including content, function, affiliations, and regulatory are assessed. The creation of a single portal for consumers and health professionals assists accessibility and provides confidence that products are endorsed.

Limitations

The authors acknowledge the cross-sectional nature of this review is a key limitation. The results represent a snapshot of the dementia apps available in Australian app stores. The fluctuating nature of app availability and search results driven by ASO meant the search results are unique to the timeline of this review. A high yield of apps retained for the second stage (n = 149) was managed by collaborative screening and analysis of a sample of apps (10%) to optimise consistency in decision making, prior to both authors screening half the remaining apps. While independent screening and analysis of all final apps by both authors would have been optimal, time constraints meant this was not feasible.

Researchers with personal and professional relationships with persons living with dementia conducted this review. App searches, screening, and assessments were led by the first-author who has lived experience of dementia caregiving as well as research-related knowledge of Alzheimer’s and other forms of dementia. However, it is important to note that the review does not directly represent the perspectives of individuals living with dementia or their caregivers. Use of the original MARS [22] versus the uMARS [43] was the appropriate framework for this context. While the MARS framework makes some reference to app privacy and security, a deeper assessment of these aspects is an important consideration for further research for the use of mobile apps to support dementia caregiving [37].

Conclusions

Challenges remain in building access to quality dementia apps that are available and meet the diversity of conditions and individual-caregiver dyad experiences. A majority of apps in this review were unlikely to be recommended by the reviewer team because of their limited relevance, poor dementia information quality, and commercial overtones. Future work in dementia apps must encompass true co-design partnerships to build engaging apps [12,16,47], with regulations to ensure evidence-based content [40]. There is a need for contextualisation of dementia apps to enable cultural safety for non-dominant cultures internationally [6,8], and in Australia for Aboriginal and Torres Strait Islander people [35]. Integration of apps into models of care for persons living with dementia is a prospective way to enhance sustainability and increase impact. While development of broader mobile app guidelines and regulation processes continue, Northern Ireland’s Apps 4 Dementia is a valuable avenue of consumer support in marketplace navigation [45].

The authors acknowledge the challenges regarding the time-sensitive nature of the app marketplace and the reviewers’ bias embedded in the study. However, insights into the challenges of navigating the marketplace and identification of quality app products provides an opportunity for further discussion between health professionals and the dementia research community. Persons living with dementia and their caregivers would significantly benefit from social and organisational services to navigate the app marketplace and source quality dementia information and support.

Acknowledgements

The authors have endeavoured to use respectful language throughout this review by referring to the Dementia Australia Language Guidelines, available at http://www.dementia.org.au/.

Ethical statement

This research has been reviewed by the Office of Research Ethics and is deemed to be exempt from ethics review under the National Statement on Ethical Conduct in Human Research and University of Queensland policy. The research uses only existing collections of data that contain only non-identifiable data about human beings AND is of negligible risk, and is exempt from review; OR is audit or quality assurance activity Human Ethics Research Office, The University of Queensland, Australia. Clearance number: 2020002320.

Author contributions

Conception and design: Georgina Chelberg, Liam Caffery. Acquisition of data, analysis, and interpretation of data: Georgina Chelberg, Maike Neuhaus, Adam Mothershaw. Manuscript preparation and first draft: Georgina Chelberg. Critical review and editing of the manuscript: Maike Neuhaus, Adam Mothershaw, Liam Caffery, Ray Mahoney. All authors have read and approved the final manuscript.

Disclosure statement

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

This review is being conducted as part of “Georgina Chelberg’s” PhD, and the authors acknowledge the funding and support provided by The University of Queensland (PhD Scholarship – stipend) and the Australian E-Health Research Centre, Commonwealth Scientific and Industrial Research Organisation (Research Plus Top Up Scholarship).

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