

# **Co-design of an mHealth application for family caregivers of people with dementia to address functional disability care needs**

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## **Abstract**

### ***Objective***

The co-design of a mobile health (mHealth) application for family caregivers of people with dementia to address functional disability care needs is presented.

### ***Participants***

Participants included family caregivers of people with dementia, aged care nurses, physicians, occupational therapists and information technology (IT) experts.

### ***Methods***

The co-design process involved two phases: (1) needs assessment phase (an online survey and in-depth interviews with family caregivers and expert consultation); and (2) development of an mHealth application (content and prototype development). Data triangulation from phase one informed the content of the application.

### ***Results***

Data triangulation resulted in three content modules: “an overview of dementia and care”, “management of daily living activities”, and “caregivers’ health and well-being”. The content was based on contemporary literature, and care guidelines with input from family caregivers and dementia care experts. IT engineers developed the mHealth application.

### ***Conclusion***

An Android-based mHealth application was designed to address the functional care needs of family caregivers. The co-design process ensured the incorporation of end-users’ real-world experiences and the opinions and expertise of key stakeholders in the development of the application prototype. It is to be noted that before releasing the application into the app store, testing its feasibility and effectiveness is essential.

**Keywords:** dementia, family caregivers, functional disability, mHealth application.

## Introduction

Dementia is a global health challenge that is common in an older population. This is also one of the major causes that leads to disability and dependency among older people.<sup>1</sup> Dementia is defined as “a syndrome due to disease of the brain, usually of a chronic or progressive nature, in which there is a disturbance of multiple higher cortical functions, including memory, thinking, orientation, comprehension, calculation, learning capacity, language, and judgement”.<sup>2</sup> This complex syndrome is characterized by the progressive deterioration of cognitive functions, changes in behavior and impairment in activities of daily living (ADLs).<sup>3, 4</sup> An inability to independently carry out ADLs is referred to as functional disability.<sup>5</sup> There are two groups of ADLs: basic ADLs (BADLs) and instrumental ADLs (IADLs). BADLs refer to the fundamental skills needed to manage basic physical needs (e.g., bathing, dressing, toileting, transferring and feeding)<sup>6, 7</sup>, while IADLs refers to more complex activities related to independent living in the community (e.g., using the telephone, handling finance and managing medications).<sup>6, 8</sup> Impairment in ADLs is one of the most common reasons for increased dependency among people with dementia which leads to increased nursing care needs<sup>9, 10</sup>, poor quality of life<sup>9</sup> and institutionalization.<sup>11</sup>

As the majority of people with dementia tend to live in the community<sup>12</sup>, family caregivers are needed to support their ADL needs. Due to the deterioration of ADLs in people with dementia, providing functional care is very complex, and usually, family caregivers need specialized knowledge and skills to assist or provide this care. The requisite skills are similar to those carried out by professional caregivers, for example, when assisting with bathing and toileting. However, family caregivers are often unprepared for the caregiving role<sup>13</sup> as most caregivers provide this care without formal training<sup>13, 14</sup>, and they provide long hours of care.<sup>15</sup> Studies report that providing functional care is a stressful experience for caregivers and leads to distress and burden<sup>16, 17</sup>, and most caregivers are at high risk of experiencing social isolation,

physical and psychological health problems and reduced quality of life.<sup>15, 18-20</sup> Therefore, they need support in providing functional disability care.

The lack of support for caregivers is a significant problem<sup>21</sup>, and family caregivers' demand for education related to functional care is high<sup>22</sup>. Recent systematic reviews show that most caregiver-based interventions focus on managing cognitive impairment and behavioral changes, and providing caregivers with psychological support.<sup>23, 24</sup> However, there are limited interventions focusing on functional care support, and few studies were found to assess caregivers' needs and plan interventions in relation to functional care.<sup>14, 25-28</sup> For example, Ball et al.<sup>25</sup> identified that family caregivers experienced difficulties and challenges in providing feeding and nutrition-related care. Bliss et al.<sup>26</sup> revealed that the main educational needs of family caregivers related to incontinence and skincare and specifically were about skills and strategies related to incontinence care, medications, surgery, diet, fluid intake, incontinence modification behaviors, how to prevent skin damage, and available supportive devices. DiZazzo-Miller et al.<sup>14</sup> tested the feasibility of a family caregiver training program for assisting with BADLs of people with dementia, and this program consisted of three modules: communication and nutritional care, toileting and transferring, as well as bathing and dressing. This study reported a significant improvement in knowledge of family caregivers in the above areas. Furthermore, the literature indicates that most available interventions are not suitable for caregivers as they are time-intensive, costly and burdensome.<sup>21</sup> Consequently, it is essential to introduce user-friendly and time-effective educational and supportive interventions. Recent evidence indicates that the support systems for carers of people with dementia living in the community remain limited.<sup>29, 30</sup> Today, mobile technologies (e.g., mobile phones, smartphones, hand-held computers) are popular<sup>31, 32</sup>, and they provide personalized healthcare, disease management strategies and services to patients and their family members, as well as offer a flexible mode of communication between health workers and their consumers.<sup>33</sup> Furthermore, mobile technologies have many advantages, for example, they are cost-effective, highly personal, intelligent, accessible and

always carried by people.<sup>34, 35</sup> Therefore, these technologies can be used effectively in health educational and supportive activities, particularly in health teaching for diverse groups like caregivers.

### ***mHealth applications***

Due to the popularity of smart-devices (i.e., phones and iPad/tablets) with their user-friendly features, there is a trend for interventions that use mHealth applications to provide healthcare education and support. In a recent review, Zhao et al.<sup>36</sup> reported that less time consumption, user-friendly design, real-time feedback, individualized elements, detailed information and health professional involvement have increased the effectiveness of mHealth applications. Additionally, smart-devices are cost-effective and have distinct features such as ease of availability and accessibility.<sup>34, 35, 37</sup> Accessibility due to transportation, finding convenient time and location are some factors which may negatively affect caregivers in finding educational and supportive services that may lead to stress and burden<sup>38</sup>, and mHealth technologies can support caregivers to study anywhere at any time without class participation and without a physical connection to cable networks.<sup>39, 40</sup> Hence, mHealth application interventions can potentially be used to provide timely education and support for caregivers that may help to reduce their stress and burden.<sup>21, 35, 41</sup> For instance, recent studies have focused on developing mHealth applications for family carers of people with dementia. Brown et al.<sup>37</sup> developed an mHealth application to improve caregiver knowledge of caring for people with dementia and looking after caregiver wellness. Davis et al.<sup>38, 42</sup> developed a storytelling application that focused on improving knowledge and skills of caregivers through learning from the success stories of the provision of care by other caregivers. A recent integrative review reported that there are a limited number of mHealth application interventions for caregivers of people with dementia and although the introduction of these interventions is feasible, literacy-related issues can be a barrier for caregivers.<sup>43</sup> Poorly designed mHealth applications create challenges in accessing health information for users with low health literacy.<sup>31</sup> For example, small fonts used, unclear

instructions and use of complex vocabularies and content that do not match with learners' needs are some literacy-related barriers.<sup>43, 44</sup> Therefore, it is essential to take into consideration the health literacy levels of users when designing mHealth application-based interventions.<sup>45</sup> Consequently, this study aimed to develop a health literate mHealth application that addresses the educational and supportive needs related to functional disability care of family carers of people with dementia.

### ***Co-design process***

In recent times, there has been a shift in the development of new products, firstly from a supplier-centred design (i.e., service providers design a product) to user-centred design (i.e., based on the needs of users), and now to co-design.<sup>46</sup> In co-design, designers, service providers/suppliers and consumers work together to identify the problem and design a solution.<sup>46</sup> To achieve better outcomes, all parties have an active role<sup>47</sup>, and contribute and work together by using their knowledge and resources.<sup>48</sup> Co-design in health interventions involves the equal partnership of the people who engage in a health intervention such as service suppliers (i.e. health staff), end-users (i.e., patients, families and caregivers), and intervention developers (e.g., IT experts).<sup>46</sup> In recent history, this method has been widely used to develop health interventions.<sup>46, 49, 50</sup> This paper reports on the co-design, specifically the development process, of an mHealth application for family caregivers of people with dementia to address functional disability care needs.

## **Methodology and results**

### ***Research design***

In this mixed-method study, an mHealth application for family caregivers of people with dementia to address functional disability care needs was developed based on the co-design process<sup>46</sup> and followed two phases: needs assessment (an online survey with family caregivers,

individual interviews with family caregivers and industry experts) and the development of an mHealth application (content development, content validity checking with caregivers and experts, and the development of application prototype). This paper provides a brief report on the key outcomes of phase one, i.e., needs assessment and focuses on reporting the process of phase two i.e., the development of the mHealth application.

The co-design process incorporated the principles of adult learning theory, i.e., the active participation of adult learners.<sup>51</sup> Based on adult learning theory<sup>51, 52</sup>, mature learners take responsibility for their learning through their inquiry and personal experiences where they are self-directed and motivated to learn. They organize learning around their life problems. Based on these principles, we developed a self-directed learning platform through an mHealth application for family caregivers of people with dementia to address their functional care needs.

### ***Phase I: Needs assessment***

Phase I focused on identifying the needs of family caregivers in relation to functional disability care via an online survey and individual interviews with caregivers as well as healthcare and IT experts. The findings from the survey and interviews informed the content of the mHealth application.

The online survey was conducted to examine the general understanding of the current needs of caregivers in relation to functional care and their use of mHealth applications in health information seeking as reported in (blinded for review).<sup>53</sup> In this online survey, caregivers reported a need for education in relation to functional care, with bathing deemed as the most challenging care activity, and supported the view that education related to functional care could potentially be delivered through an mHealth application.

Individual interviews with family caregivers aimed to: (a) gain an in-depth understanding of family caregivers' perceptions toward the needs, barriers and challenges faced when managing functional disabilities of their care recipients; and (b) identify the experiences of and opinions for using mHealth applications in health information seeking as reported in (blinded for review).<sup>54</sup>

This study found that the provision of functional care was found to lead to the development of caregiver distress and burden, and performing ADLs was regarded by caregivers to be difficult. Caregivers held a positive attitude toward mHealth applications for education and support. The main suggested areas for the content for the application and features can be found in Table 1.

[Insert Table 1 here]

Expert interviews aimed to identify healthcare and IT experts' opinions on the provision of care, especially the management of functional disabilities of people with dementia and the development of an mHealth application for caregivers. A summary report, based on the results of the online survey and individual interviews with caregivers was provided to the experts prior to the interviews. The report also included content and features proposed for the potential mHealth application as follows:

- Overview of dementia and management of behavior and symptoms of dementia.
- Information on ADL with a focus on self-care activities (i.e., bathing, dressing, toileting, transferring, feeding); medication management; using public transport; running simple errands).
- Information on available care equipment and support services.
- Discussion board/chat room to connect with other family caregivers of people with dementia.
- Caregivers' Corner.
  - Importance of caregiving for the caregivers.
  - Strategies to support the health and well-being of caregivers.
  - Task reminder and calendar features.

The findings and opinions of caregivers from the online survey and qualitative interviews were validated in the expert interviews. Healthcare experts agreed that managing needs related to functional disabilities were very challenging for caregivers, while barriers, challenges and difficulties that were highlighted by caregivers were common for family caregivers who provided



care in the community. Experts highly regarded mHealth applications as a solution for providing demand-driven education as well as an important educational and supportive resource for family caregivers of people with dementia with the ability to organize and manage information and tasks. They identified the calendar and reminder functions as a very useful application feature for caregivers.

Experts further commented on issues that may be impacted by creating an mHealth application. These included the need for individualized information, difficulties in receiving accurate information and using or comprehending of available information, the lack of time to access information, navigation issues related to the availability of a number of sources, and difficulties in making decisions about equipment.

They further agreed that the proposed application content was appropriate to address caregivers' needs related to functional care except for the concept of a 'chat-board' due to the need for a moderator for this feature. The IT expert agreed that the proposed content and features were not difficult to include in the design and development of an application prototype. Experts further raised that maintaining up-to-date information is essential, and the application should be very simple and easy to use. The use of positive and supportive language was highlighted to increase the readability of application content. Other suggestions included the use of videos and cartoons to help caregivers to understand the provision of providing functional disability care. In addition to the caregivers' opinions<sup>54</sup>, experts suggested including the importance of physical exercise and information on where to access general practitioners. They further emphasized that the prototype needed to be checked with caregivers before releasing the application.

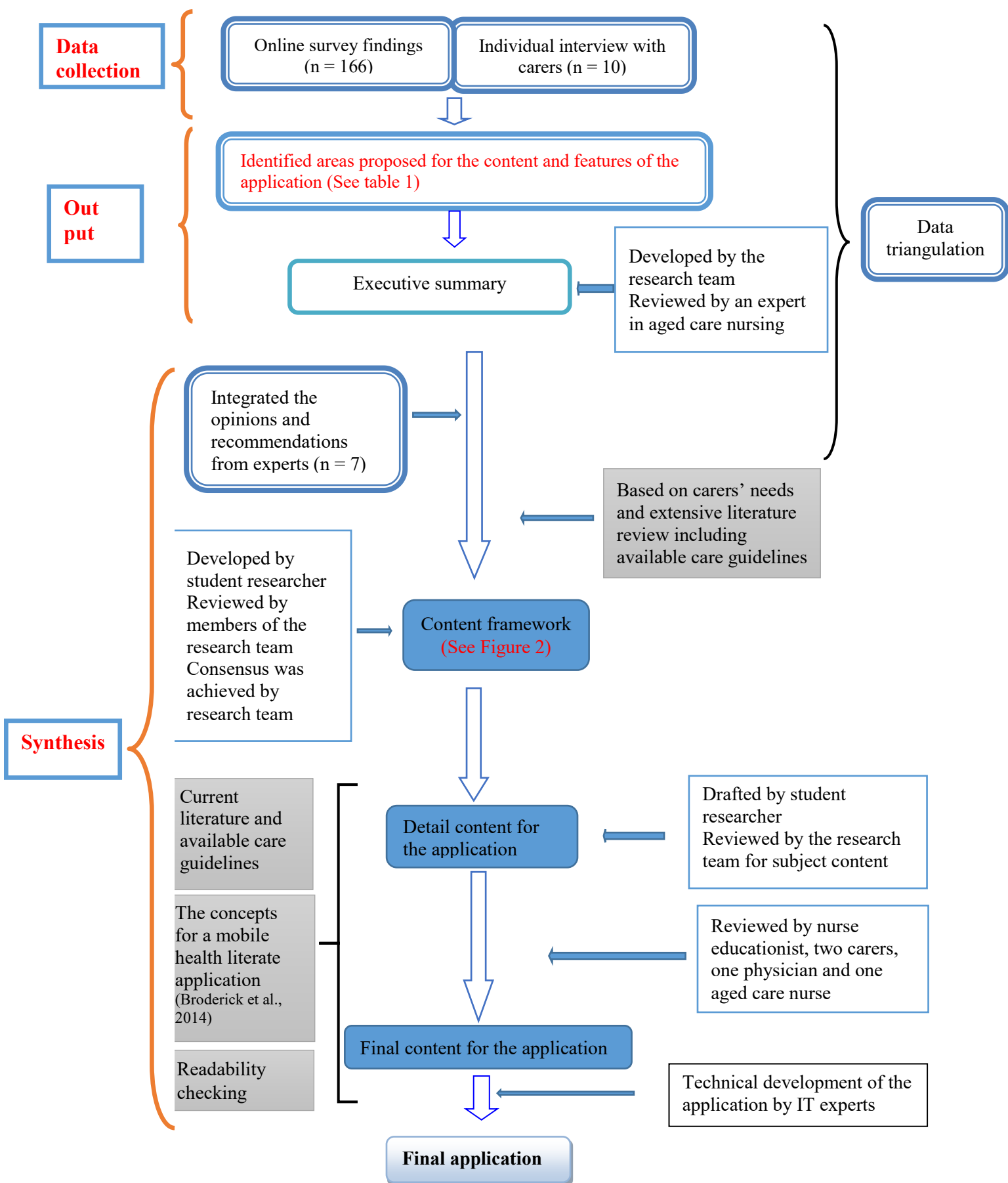
Experts identified possible challenges and barriers in relation to the application use. They stated that some caregivers may not find an mHealth application a useful resource and that they should have the appropriate emotional capacity to make the best use of the applications. As most caregivers are older people, they may have limited knowledge about how to use the mHealth application, and experts stated that younger caregivers are more likely to access mHealth

application compared with older caregivers. Other barriers stated by experts were the need for technical skills in application usage, affordability of smartphone and size of the phone.

Based on the experts' views, except the chat-room feature, other suggested content areas by caregivers were included in the final application. The features of a calendar with appointment scheduling and task reminders, and linking online videos to application content were included. Moreover, the importance of exercises were included in supporting and managing the health and well-being of caregivers.

### ***Phase II: Development of the application***

A user-centric preliminary mHealth application was designed and developed following an iterative co-design process.<sup>31, 46, 47</sup> This process incorporated the concepts related to developing a health literate application proposed by Broderick et al.,<sup>31</sup> which consisted of two stages: content development and prototype development. This process followed a series of steps (See Figure 1).



**Figure 1: The process of content development**

### ***Development and validation of the application content***

Aligned with the co-design process, triangulation of data from the online survey and qualitative interviews with caregivers and opinions from the experts informed the content framework consisting of three modules: (a) an overview of dementia and care; (b) managing daily living activities, and (c) carers' health and well-being (see Figure 2). Consensus on the framework was reached by members of the research group, all of whom have extensive experience in dementia care practice, research and/or education. "Carers' corner" in the preliminarily proposed content was re-named as "Carers' health and well-being". The chat-board feature was removed following the experts' view of the need for continuous moderation by health professionals. This was replaced by the inclusion of links to caregiver support groups (e.g., social media support groups) into the application as the importance of available peer groups in caregivers' well-being was identified during interviews with caregivers and experts.

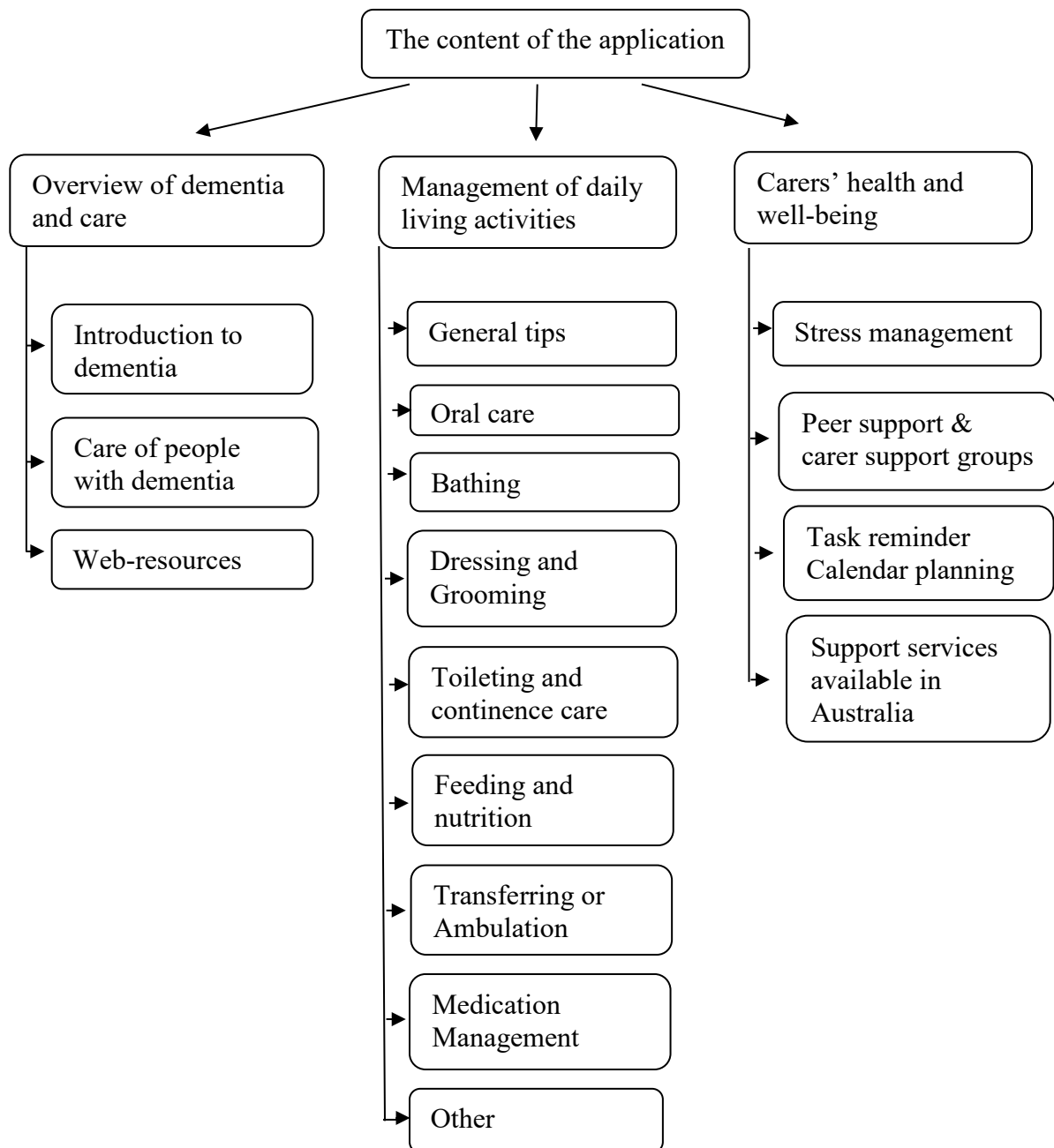


Figure 2: The content framework

Based on the current relevant literature and evidence-based guidelines, detailed content was drafted by the first author (blinded for review). The research team who have extensive expertise in dementia care practice and research (blinded for review), reviewed the content over several sessions until consensus was achieved. In addition to text information, links to currently available evidence-based online resources such as websites, articles and videos were included in the educational content. Images were also included wherever necessary.

After finalizing the application content by the research team, the application content was further reviewed by: (a) a nurse educator who has extensive experience in educational methodology and research, to meet the educational requirements; (b) an experienced geriatric nurse and a physician who both have extensive experience in dementia care; and (c) two caregivers who participated in the online survey and qualitative interviews. Firstly, they were invited through email or telephone contact and upon agreement to participate in the content validation process, they received the content modules finalized by the research team via email. They were asked to rate the content for its appropriateness and clarity based on a four-point Likert scale from strongly agree (1) to strongly disagree (4) and to make any suggestions for further improvement. An overall rating of “disagree” or “strongly disagree” indicated a need for a major revision of the content while an overall rating of “agree” or “strongly agree” reflected appropriateness and clarity of the content; with no changes required for the developed application content. After reviewing the content, they sent their rating and comments through email. Additionally, based on the rating of five assessors, a content validity index (CVI) was computed (see Table 1).  $CVI > 0.80$  was considered as adequate for content validity.<sup>55</sup> In the present study, the CVI for the given criteria (appropriateness and clarity) reported an accepted level for the three modules (see Table 2).

[Insert Table 2 here]

### ***Content overview of the application***

***Module 1: Overview of dementia and care.*** This module consists of three sections that introduce dementia and its management. The section “Introduction to dementia” briefly provided basic information about dementia with its signs and symptoms, types, stages and progression. The section “Care of people with dementia” included basic information about care strategies for dementia including, person-centred care, effective communication, pharmacological and non-pharmacological management, pain management as well as the

management of behavioral and psychological symptoms of dementia. Users can access detailed information through online resources linked to the above topic areas. Under the “Websites” section, we included links to credible national and international dementia organizations, for example, Dementia Australia and Alzheimer’s Disease International.

***Module 2: Management of daily living activities.*** Module 2 is the primary focus of this application. It includes caregiving strategies for six activities related to ADLs (i.e., oral care, bathing, dressing and grooming, toileting and continence, transferring and mobilizing) and four IADLs (i.e., medication management, driving, using telephone and shopping). In addition to general care tips for managing ADL and IADLs, we included caregiving tips or interventions for common problems or questions that can arise during the provision of functional disability care. Aligned with the concepts of andragogy (i.e., problems of caregivers rather than content)<sup>51</sup>, an example of common problem areas related to the activity of “oral care” included: (1) my care recipient forgets to brush his or her teeth, (2) my care recipient needs assistance to brush his or her teeth, (3) my care recipient is unable to brush his or her teeth, (4) my care recipient has dentures, (5) my care recipient is complaining of pain in his/her teeth, and (6) I notice bleeding when providing oral care.

Additionally, this module focused on a brief introduction to the three important concepts related to functional disability care: “assessment of ADLs”, “positive care approach” and “dementia-friendly environment”. The concept of “assessment of ADLs” briefly describes the importance of the assessment of care needs related to ADLs. The concept of a “positive care approach” focuses on using existing skills and abilities in care rather than what the person with dementia is no longer able to do. The concept of a “dementia-friendly environment” briefly describes making a safe and secure environment at home to promote ADLs of the care recipient.

***Module 3: Carers' health and well-being.*** To address the reported distress and burden to functional care, this module focused on the health and well-being of caregivers and consists of three sections. The section "Stress management" includes basic information related to the management of caregivers' stress, including the importance of exercise, meditation and music. In the section "Peer support and carer support groups", we included information for and links to currently available peer support groups and social media support groups. Features such as "calendar" and "reminders to appointments" and "events" were included under the section of "Task reminder and calendar planning". Under the section "Support services available in Australia", web links and contact information of local, state and national caregiver resources and services were included.

### ***Formatting the content***

In line with the framework proposed for a health literate application by Broderick et al.<sup>31</sup>, the concepts of "write actionable content" and "plain language with everyday words" were used in the application. For all medical terms and concepts that may be difficult to understand, a glossary of these terms was included. Broderick et al.<sup>31</sup> recommend short sentences of 15-20 words. In the application content, the average words per sentence were 5.56, 7.14, and 7.15 for modules 1, 2 and 3, respectively. Furthermore, bullet points were used rather than a paragraph structure. The recommended minimum font size was 12. In our application, we used the dynamic font size that facilitates re-sizing the font size based on the device. Images were used where necessary, and links were labelled clearly.<sup>31</sup> Additionally, black text and white background<sup>31, 56</sup> with Arial font were used. Arial font style is one of the popular mobile web-safe sans-serif fonts which is highly readable even on mobile surfaces.<sup>31</sup> The content of the application was organized under three modules, and British English was used.



### ***Readability***

Readability for the application content was checked using the Flesch-Kincaid Readability Formula<sup>57</sup> via the online-utility.org website ([https://www.online-utility.org/english/readability\\_test\\_and\\_improve.jsp](https://www.online-utility.org/english/readability_test_and_improve.jsp)). This formula assesses text readability that is based on the word and sentence lengths found in the text.<sup>58</sup> The desired readability was maintained around the level of eight as the average Australian reading level is at grade eight.<sup>44</sup> Readability index was 9.33, 6.36 and 8.23 for modules 1, 2, and 3, respectively.

### ***Development of the application prototype***

Professional IT engineers (i.e., app developers) were employed to develop the application using an Android system. After an initial discussion via telephone between the first author and the application developers, three face-to-face meetings took place with ongoing discussions occurring over the phone or via texts or email correspondences until the completion of the application development. The application was named “Dementia Support for Carers” as the primary function of the application was to provide education and support for caregivers of people living with dementia.

### ***Logo of the application***

The first author (blinded for review) designed the application logo under the direction of the research team (see Figure 3) and then the application developers digitally developed it. The logo depicts the caregivers receiving information and support from health professionals to look after their care recipients through a smartphone device in the community (i.e., home). The symbol of a heart represents love and compassion as required in dementia care. The color red was used as it denotes energy and love as well as it being an eye-catching color that helps to draw attention.<sup>59</sup>



Figure 3: mHealth application logo

### *Sign-in or log-in page*

Users can log into the application via Google or Facebook (see Figure 4). The user profile includes the following details: name, email address, gender, country, age group and the role of the user (i.e., family caregiver, health worker/professional, a person with dementia, student, researcher and others). The first time use of the application requires the user to register by entering their profile details.

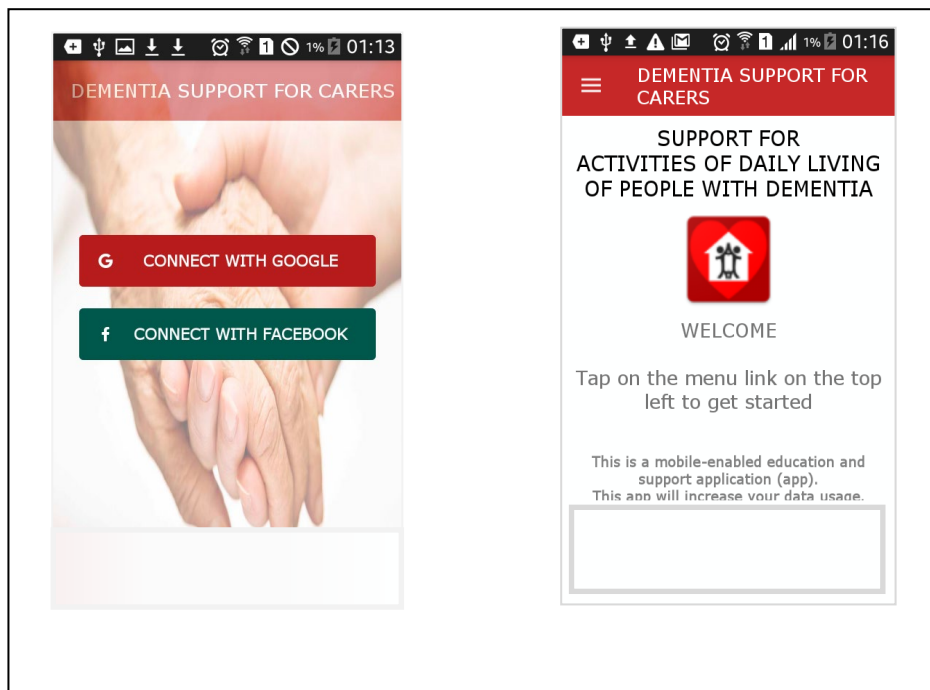




Figure 4: Login and home pages (for the blind review process, logos of the affiliated institutions of application developers were removed in the above figures.)

### ***User interface and content organization***

Based on the Broderick et al.<sup>31</sup> framework for health literacy applications, a simple and engaging home page was created. User-friendly navigation features, such as touch and slide options were included. Users can access relevant text information and links through either touching or sliding the menu, sub-menu, icons or links. The home page consists of a “Home” (line menu) icon (  ) on the top left corner, and the user can easily access the home page or menu pages using this icon. Users can shuffle from the current page to the previous page using the back icon (  ). Additionally, permission was sought and granted to use the logos of (blinded for review) and (blinded for review) in the application interface (see Figure 4).

The organization of the application main content menus (i.e., “Home page”, “Dementia and care”, “Management of daily living”, “Carer health and well-being”, “About this app”, “Instructions” and “Glossary”) and the organization of sub-menu “Dementia and Care” are reflected in Figure 5.

[Insert Figure 5 here]

Additionally, the application included a feature that focuses on sending reminders through notification. Caregivers can set a notification/reminder for a particular task (e.g., time for giving medication), an appointment date or any events using the year calendar and 24-hour clock. There is also a snooze function to reset the alarm based on the given time gap (i.e., minute, hour, day, week or month) (See Figure 6).

[Insert Figure 6 here]

### ***Technical description of the application***

The application was developed in Android using Java and Android Studio. The Android software development kit (SDK) provides a variety of user interface elements and modules to plug into the application that helps users to use it easily and in a flexible way.

Firestore was used to store data in the backend real-time database as it seamlessly integrates into the SDK. Using Google Sheet, the script was run to add all the formatted data into the database. Login was achieved using Google and Facebook. Background services provided by Android SDK platform were used to add and run reminders through notification at particular times along with snooze. Hypertext markup language (HTML) was used to display the content of the application. As indicated earlier, we have developed an Android-based application. The authors are working with the developers toward developing the application on an iOS-based platform to increase its accessibility and wider distribution.

### **Ethical considerations**

Ethical approval for the online survey was obtained from the Human Research Ethics Committee, (blinded for review). Prior to commencement of the individual interviews with carers and experts, ethical approval for the main study, including interviews with carers and experts and the application development process, was obtained from the Human Research Ethics Committee, (blinded for review). In each phase, written information about the study was distributed and informed consent was sorted before data collection. Information collected in this study was confidential and anonymous and participation was voluntary. Participants were informed that there was no penalty for refusing participation and they could refuse to continue participation at any stage of the data collection period.

### **Discussion**

This paper describes the process of developing a mobile-enabled mHealth application for family caregivers of people with dementia to address needs related to functional disability care. Consistent with the previous health intervention studies<sup>46, 49, 50, 60</sup>, a co-design process guided the development of the application. To our knowledge, this is the first reported mHealth application development study based on the co-design process that addresses the functional disability care needs of family caregivers of people with dementia. Co-design is a

recent method used in designing health interventions.<sup>46</sup> Assessment of the needs of primary users is an essential strategy to increase the effectiveness of the intervention.<sup>31, 61</sup> The needs assessment enabled us to obtain in-depth views of caregivers' needs concerning functional care and mHealth application use. Additionally, it helped us to integrate other stakeholders' (i.e., service providers and designers) views and expertise into the application development process. This is the main advantage of the co-design process compared with the user-centric design because, in user-centric approaches, the product is only based on the needs of primary users and, they do not engage in the further development of the intervention.<sup>46</sup>

The main areas of needs highlighted by family caregivers of people with dementia in the need assessment phase were knowledge about dementia and its management, needs related to the management of functional disability care, information on available care equipment, support services and training opportunities, as well as how to manage caregiver's health and well-being. Recent studies also reported similar findings<sup>26, 62-64</sup>, and these broad areas of needs could be addressed through this mHealth application consisting of four modules. Further links to many available resources, for example, dementia-related websites, online articles and videos are provided. Therefore, the mHealth application can be identified as a resource collection and gives caregivers more opportunities in accessing information in relation to providing dementia care, especially managing daily living activities and looking after their health and well-being. Moreover, this app includes the feature of connecting to the available peer support groups including social media groups (i.e., Facebook groups). Peer support has an essential role in dementia care. It helps to enhance feelings of emotional support and psychological well-being, as well as reduce social isolation, stress and risk of depression in caregivers.<sup>65, 66</sup>

To date, most of the available interventions for caregivers are time-intensive and costly.<sup>21</sup> Our mHealth application intervention uses a technology-based approach that is less

time-consuming.<sup>36</sup> Technology-based interventions facilitate caregivers to access support at all times of the day, at their convenience.<sup>15</sup> Furthermore, it can serve a larger population in a mobile form compared with traditional forms<sup>41</sup> because any person from urban, rural or remote areas can access mHealth applications if they have smartphone access and data. Moreover, modern technology supports more informal and self-directive learning with help from new technologies<sup>67</sup>. Self-directed learning is a central concept of adult learning<sup>51, 52, 68</sup> used in this study. mHealth applications are widely recognized as self-directive learning platforms<sup>69</sup> that allow the users to take in as much or as little as is needed at the time, reducing learning overload. Therefore, this mHealth application-based platform might be helpful as a self-directed learning resource for family caregivers of people with dementia.

This application aims to be a user-friendly application for family caregivers. We used a user-friendly interface<sup>36</sup> with many features, for example, line menu icon (home icon), touch, and slide options to increase the usability of the application. Additionally, we integrated health literacy concepts related to developing an mHealth application<sup>31</sup> and checked the readability of the content. Boulos et al.<sup>45</sup> argue that there is often a poor focus on including those concepts into mHealth application development. Therefore, we expect the application of these concepts will further increase usability. This caregiver-focused mHealth application was designed by health professionals who were experts in dementia care. Zhao et al.<sup>36</sup> state that the engagement of health professionals in developing mHealth applications increases the credibility and efficacy of applications.

The researchers faced several challenges during this mHealth application development study. Initial cost relevant to the development of the application is one of the main drawbacks of mHealth application-based interventions.<sup>45</sup> The co-design process is time-intensive.<sup>70</sup> In this study, caregivers and key stakeholders participated and engaged with a number of research activities in several stages; therefore, this process took 16 months to

complete. Additionally, during the interviews, caregivers often wanted to discuss and explore issues around caregiving other than functional disability care needs. It was also challenging to arrange interviews with experts due to their workload. The researchers' inexperience with the technical development of the application, for example, organizing content to suit the application interface, technical vocabulary and technical methods used in designing, and application developers' inexperience with integrating health literacy concepts in the application were other challenges.

During the interviews, caregivers stated that including a feature or facility to include favorite music into the application would be very helpful<sup>54</sup>; however, as our major focus was functional disability care, we did not include the above feature in the application. Future investigations might focus on introducing music-related interventions through smart-technologies for caregivers of people with dementia. Initially, we intended to include a discussion board/chat room for caregivers as they highlighted the need for timely information, notably receiving a timely response from health professionals for their problems related to caring in the need's assessment phase. However, the inclusion of such a platform requires moderation by health professionals and can be laborious and time-consuming. It is acknowledged that skills training via video demonstration would be ideal for educating caregivers; the application development was limited by the time and cost required to develop and produce these training videos. Therefore, there is room for improvement to the current application to include skill training videos concerning functional disability care, and a chat room with professional moderation and entertainment features for caregivers.

Additionally, once-time only feedback on the application content was solicited from a small sample of caregivers and experts. While the CVI was computed and strong agreement obtained for both appropriateness and clarity of the application content, further validation of

the application in its entirety (i.e., user testing) is required before the application is introduced and distributed widely to caregivers.

## **Conclusion**

We have developed an Android-based mHealth application for family caregivers of people with dementia to address needs related to managing functional disabilities of their care recipients. The application can be accessed through an Android-based smartphone or tablet. The co-design process helped to design and develop a new application for caregivers based on their real-world experiences and the opinions as well as the expertise of the key stakeholders, including healthcare and IT professionals. Before the release of the application to the public, testing of this application with caregivers of people with dementia for its feasibility and effectiveness is essential.

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The authors report no conflict of interest.

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