

Supporting healthy aging through technology: A case study of integrated health features in a mobile app for older adult users

Samina Rahman MS^a, Catherine Luna MS^a, Catherine Van Son PhD^b, Maureen Schmitter-Edgecombe PhD^a, Ron Kim Johnson MBA^c

^aDepartment of Psychology, Washington State University, Pullman, WA USA; ^bDepartment of Nursing, Washington State University, Vancouver, WA USA; ^cManaged Health Connections, Inc, Spokane, WA, USA

*Corresponding author: schmitter-e@wsu.edu

Abstract

Background: Digital technologies are increasingly used to support health monitoring and behavior change; however, few are designed with the needs of older adults experiencing cognitive challenges in mind. Given the importance of healthy lifestyle behaviors for maintaining cognitive function, digital tracking systems may offer a valuable means for supporting engagement in positive health-promoting activities.

Research aim: This paper presents a case study of the Electronic Memory and Management Aid (EMMA), a prototype digital cognitive compensatory application developed for older adults experiencing cognitive challenges. Specifically, it reports findings from three exploratory studies that chronicle the user-informed development, usability testing, and long-term engagement with a health behavior tracking and medical information system integrated into the application (app).

Methods and Results: In Study 1, interviews with prior EMMA app users informed recommendations for integrating new health-related features. Study 2 involved usability testing of the newly developed health features. Ten older adult participants generally rated the features as straightforward to use and reported high satisfaction with their design. Study 3 examined qualitative feedback and three-month usage data from 39 participants enrolled in a pilot clinical trial. Initial engagement with most health features was moderate but declined over time.

Conclusion: Findings highlight both the promise and challenges of integrating health tracking tools into digital cognitive aids for older adults. Themes of user engagement and reflections on the health features are discussed, along with opportunities to promote sustained use of health features among older adults with cognitive challenges.

Keywords: digital health, cognitive aging, cognitive support tools, technology adoption, user-centered design

INTRODUCTION

Accurate and timely monitoring of medical and health data is becoming increasingly important for older adults experiencing cognitive decline. Evidence suggests that encouraging healthy lifestyle behavior, such as regular physical activity, could prevent or delay up to half of dementia cases (Livingston et al., 2024). Similarly, the use of compensatory devices has been associated with slower rates of cognitive and functional decline by older adults, helping them to maintain greater independence over time (Farias et al., 2020). Digital technologies can play a key role in this process by reducing memory burden and consolidating information. Popular commercial applications like Cozi (n.d.), Touch Calendar (Touchable Apps, n.d.), Medisafe (n.d.), and Calendar Clock (n.d.) offer support for managing memory tasks, goal setting, and everyday activities. However, these tools typically lack integrated health tracking capabilities. Incorporating

health features into memory support apps may empower users to take a more active role in their health, improve communication with health-care providers, enable early detection of health concerns, support more consistent app use, and potentially delay further cognitive decline. This paper describes the user-centered design of the health features added to a digital memory aid and analyzes how older adults self-reporting cognitive difficulties used them during a three-month pilot intervention.

Technological innovations continue to transform healthcare in a multitude of ways. Tools such as wearable devices, mobile applications, patient portals, and telehealth services make health management simpler. While these technologies can improve health outcomes, independence, and quality of life, older adults often face barriers to adopting and integrating them into daily routines (Smrke et al., 2025). Common challeng-

Evaluating the use of integrated health features in a mobile app

es include lack of familiarity or confidence, perceived complexity of the technology, and concerns about costs (Vaportzis et al., 2017). Mobile health applications, in particular, have the potential to offer a flexible and individualized approach to health management through portable devices like smartphones and tablets. These apps can support users in tracking daily activities, maintaining healthy lifestyle habits, making behavioral changes, and improving overall well-being (e.g., Rowland et al., 2020; Joe & Demiris, 2013). However, research on their effectiveness in older adults remains limited. A 2021 review by Portenhauser and colleagues found that only 5% of health-related mobile apps showed evidence of efficacy in older adults (Portenhauser et al., 2021). Furthermore, a 2018 review on functional and physical age-related barriers to mobile health apps found that diminished perception, physical abilities, motivation, and cognition contribute to usability difficulties in older adults (Wildenbos et al., 2018).

To better understand and address these challenges, several technology adoption models offer valuable frameworks. The Technology Acceptance Model (TAM) identified perceived usefulness and ease of use as key determinants of technology adoption (Davis, 1989). Building on this, the Senior Technology Acceptance and Adoption Model (STAM) incorporates age-related factors such as sensory/motor abilities, technology self-efficacy, and environmental support (Renaud & Biljon, 2008). These models underscore the importance of designing health technologies that are accessible, relevant, and supportive of older adults' needs, an increasingly important goal given the growing aging population (U.S. Census Bureau, 2023).

The Electronic Memory and Management Aid (EMMA) is an iOS tablet application (app) grounded in evidence-based memory notebook training rehabilitation practices (Sohlberg & Mateer, 1989; Schmitter-Edgecombe et al., 1995) and developed iteratively with input from older adults experiencing cognitive decline and their caregivers (Dahmen et al., 2018; Raghunath et al., 2020). Originally designed to help reduce memory burden and support daily task organization, this paper details how EMMA evolved to include health tracking and medical information features in its latest iteration. Core features of the original EMMA app included a to-do list, calendar, and notes page (see Raghunath et al., 2020 for images). Through the initial stages of iterative development with older adult users, Schmitter-Edgecombe and colleagues found that simplified interfaces, readable text, clear language, and visual contrast improved usability for the target

population (Dahmen et al., 2018). Case studies using the original EMMA app demonstrated improvements in memory difficulties, coping self-efficacy, and satisfaction with life by individuals with cognitive impairment (Chudoba et al., 2019). In a pilot clinical trial, pairing the original EMMA app with smart home-based activity-aware prompting increased app use, broadened feature engagement and reduced functional difficulties compared to EMMA alone, while all participants reported improved coping and life satisfaction (Schmitter-Edgecombe et al., 2022). These findings highlight EMMA's potential to support psychological well-being for older individuals with cognitive concerns, with added functional benefits when paired with smart-home technology.

In addition to supporting daily memory, the EMMA app enables real-time tracking of adherence and usage patterns, enhancing its potential for detecting health changes and informing timely interventions. Luna and colleagues (2023) found that early engagement, specifically frequency and amount of using the original EMMA app during the second week of training, predicted sustained use of the EMMA app at three months post-training. Higher scores on language and delayed memory subtests also predicted long-term use, highlighting the importance of early training before significant cognitive decline.

Together, these findings underscore EMMA's value and potential as a proactive tool for supporting independence in older adults experiencing cognitive decline. The EMMA app original design focused primarily on compensatory support for memory and task management, without dedicated features for health monitoring or management. To expand EMMA's utility beyond compensatory functions, we integrated new health-related features aimed at mitigating the effects of cognitive decline by promoting healthy brain aging behaviors and enabling real-time tracking of health-related activities. We also introduced web-based access, allowing users to engage with the app not only on iOS tablets but also through smartphones and other internet-enabled devices. These additions not only support users in managing their health more proactively but also broaden the app's accessibility and increase its potential to detect early changes in health status and facilitate timely intervention by health-care providers.

Research objectives

This paper details a three-part, user-informed development and evaluation of new health-tracking features integrated into the EMMA app. The objectives were to (1) identify health features most relevant to older adults experiencing cognitive

Evaluating the use of integrated health features in a mobile app

challenges (Study 1); (2) assess usability and user satisfaction with the added health features (Study 2); and (3) examine engagement with the health features and user feedback during a three-month pilot trial (Study 3). This research was conducted in the United States and focused on older adults experiencing cognitive challenges, a group for whom digital health technologies remain underused. The unit of analysis across studies was the individual older adult participant. The overarching goal of the new health features was to create an inclusive, user-friendly space within the EMMA app that would allow older adults to monitor their health and engage in behaviors that support healthy brain aging.

It was hypothesized that the newly developed health features could be feasibly integrated into the EMMA app, with high user satisfaction. Additionally, it was expected that the health features most frequently suggested by older adults during the design phase would be the ones most commonly used during the implementation trial. Based on the objectives, the study was guided by the following research questions (RQ):

RQ1 (Design Phase): Which health features do older adults with cognitive challenges perceive as most useful for supporting healthy aging behaviors?

RQ2 (Usability Phase): To what extent are the newly developed health features usable, and how satisfied are users with their functionality?

RQ3 (Implementation Phase): How do older adults engage with the health features over time, and how do they describe their experiences using them in daily life?

Overview of the three studies

The research followed a systematic, mixed-methods, user-centered design framework grounded in an exploratory process. Methods were selected to best address each research objective through an iterative process involving inquiry, testing, and refinement of the app. Across all three studies, qualitative and quantitative methods were integrated to iteratively inform development, testing, and evaluation of the EMMA health features. Findings from each phase directly guided decisions in the subsequent phase to ensure continuity in methodology and coherence across stages of the research process.

Study 1 used qualitative content analysis to identify user needs and guide health feature design; interview responses were then quantified to determine the percentage of participants endorsing interest in each feature. Insights from

this analysis guided the development of specific health features, which were integrated into the app and evaluated in Study 2. Study 2 usability testing combined qualitative user experience feedback and quantitative data assessing usability and satisfaction with the developed health features. Outcomes from Study 2 informed further refinement of health features, adjustments to training procedures, and feature implementation for Study 3. Study 3 used qualitative interviews and quantitative usage metrics to examine engagement patterns with the health features during a three-month pilot trial. Altogether, these methods formed a coherent analytic framework aligned with the overall research aim (Saunders et al., 2023).

The research protocol for all three studies was reviewed and approved by the Institutional Review Board at (Washington State University) and by the US Army Medical and Development Command Human Research Protection Office. Informed consent was obtained from all participants prior to their involvement in the study. Given that participants experienced varying levels of cognitive difficulty, decision-making capacity was informally assessed by trained researchers during the consent process. All participants demonstrated adequate understanding of study procedures, risks, and voluntary participation requirements prior to enrollment. Throughout the study procedures, participants were reminded that they could voluntarily remove themselves from the research at any time without penalty. Exclusion criteria across all studies included being under the age of 50, not residing in the community, inability to provide informed consent, lack of English fluency, and visual or motor impairments that would interfere with interaction with the EMMA app.

Study 1: Co-designing the health features

In Study 1, participants with prior experience using EMMA provided qualitative feedback on which health-related features would be most beneficial in supporting their daily routines and well-being. Insights gained from these individuals directly informed the design of the new health features.

Methods

Nine older adults with amnesic mild cognitive impairment (age: $M = 73.22$, $SD = 6.87$; education: $M = 16.11$, $SD = 2.57$; 66.67% female) who participated in a prior pilot clinical trial (Schmitter-Edgecombe et al., 2022) and had used the original version of the EMMA app (i.e., Digital Memory Notebook or DMN) completed an open-ended interview. The interview was designed to elicit their ideas about helpful

Evaluating the use of integrated health features in a mobile app

health-related features to include in the app (e.g., “What type of health tracking features would you like to see added to the EMMA?”). Participants were also introduced to a range of potential health features and asked to indicate their interest in seeing each of these integrated into the EMMA app. These included cognitive testing, physical activity, weight, blood pressure, medications, and health and emotion ratings.

Participant responses to the open-ended questions were transcribed verbatim and independently reviewed by two research assistants and a qualitative researcher using content analysis, ensuring rigor and credibility (Kumar et al., 2025). Statements were organized and preferred health features were ranked according to participant interest levels, as reflected by the percentage endorsing each feature. This feedback guided the design of the health interface, informing a team of clinicians on health features aligned with users’ preferences.

Results

When asked about general preferences for setting health goals and visualization of health data, participants expressed an interest in several key elements, including the ability to set customizable health goals, track and view progress through graphs (bar & line), and track doctor’s appointments. In addition, a few participants indicated an interest in a feature to manage medical information/records within a centralized location. When asked about specific health tracking features, 100% wanted a cognitive testing feature, 67% were interested in tracking weight, physical activity, and emotions, and 56% in tracking blood pressure and daily medications.

Outcome

Based on this feedback, the development team created a dedicated health page within the EMMA app consisting of two main components: (1) a medical information journal and (2) a health tracking system. The health application was designed for easy access by older adults experiencing cognitive difficulties, with a central, user-friendly graphical interface to help users navigate to each component of the health program. The medical journal allows users to organize and store information about doctor appointments, vaccinations, and other medical records in categorized folders. The health tracking system is integrated with the EMMA app’s event scheduling feature. When users add an event (e.g., “walk with a friend”) to their to-do list or calendar, they can designate it as a health-related activity. These events are visually marked with a heart icon on the scheduler (see *Figure 1*). Once the scheduled event is marked as completed, users are prompted to enter additional details, such as

exercise duration or current blood pressure, and can view their progress through graphical displays (see *Figure 1*). Users can track and view their progress on a variety of health-related factors, including medication adherence, weight, blood pressure, health and emotion ratings, well-being and cognitively stimulating activities, and physical exercises. Additionally, users can complete and monitor their performance on an n-back test, a cognitive task designed to assess executive attention abilities (c.f. Schmitter-Edgecombe et al., 2025). See *Figure 2* for a description of the health features. Access to these features is provided through a large grid enabling clear descriptions of the information available. The app also supports health-related goal setting and provides feedback on progress, to encourage sustained user engagement in healthy brain aging behaviors.

Study 2: Usability of the health features

Following the integration of the new health features into the EMMA app, a second study was conducted to evaluate their usability and ensure they could be effectively used by older adults. Guided by the TAM (Davis, 1989), this phase aimed to assess whether the features were intuitive, accessible, and aligned with user expectations, which are key indicators of perceived ease of use and usefulness and central to technology adoption. These insights were used to prepare the app for broader implementation in a clinical trial.

Methods

Preliminary usability testing of the new health features was conducted with 10 older adult participants (age: $M = 75.75$, $SD = 2.60$; see *Table 1* for sample characteristics). A brief tutorial was provided in which participants were shown the main navigation buttons at the top of the EMMA app screen, which included Today, Calendar, Health, and Notes. Participants were first guided to the Health page, where they were introduced to the two main options: Tracked Health Activities, which allows users to monitor health details like weight and physical activity, and Medical Information, which stores medical details like medical conditions and history in one place. Next, participants returned to the Today page to learn how to add a new event. They were shown the “Add Entry/Event” button, which brings up a simplified screen for entering information. At the bottom of this screen, participants saw the option to mark whether the entry is for health tracking. Selecting “Yes” brought up additional prompts to choose the type of health event. For returning users (i.e., participants who previously participated in a prior pilot study with the app), we pointed out a few small changes made to make navigation quicker and easier. Following the tutorial, participants were asked to complete sever-

Evaluating the use of integrated health features in a mobile app

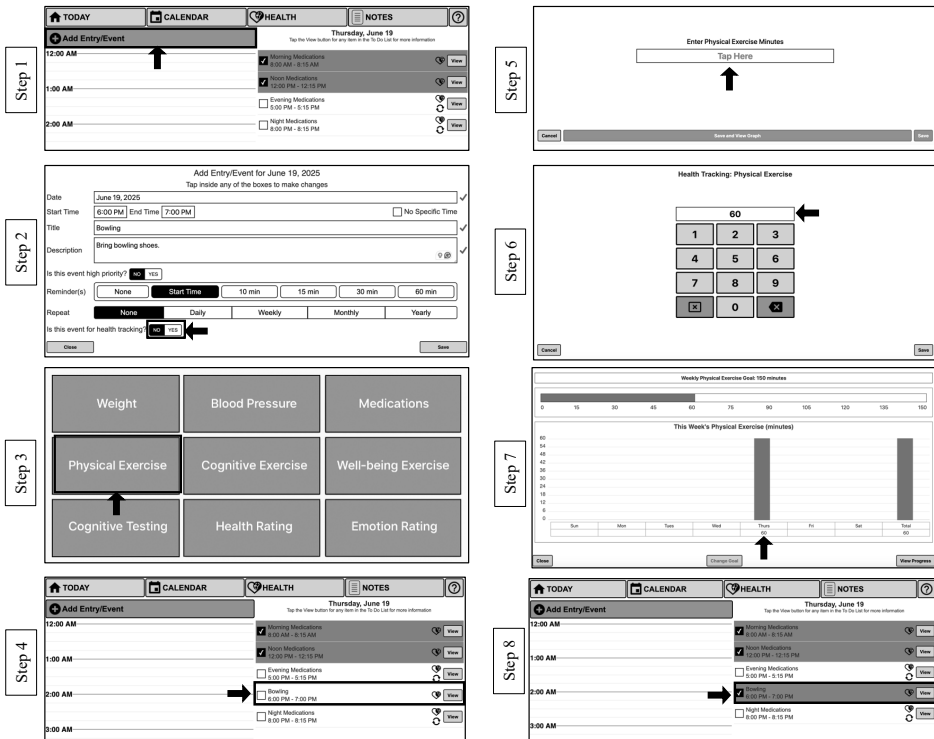


Figure 1. User flow for adding and tracking a health-related activity on the EMMA application

al task scenarios within the EMMA app designed to simulate real-world use of the new health features. For example, one scenario required participants to simulate adding and tracking three daily medications. This involved navigating to the 'Medications' section under Tracked Health Activities, entering the prescribed medications (time, title, description), marking them as taken on the Today page, and reviewing their weekly medication adherence graph.

After completing each task, participants provided feedback on their experience, including general comments, difficulty or ease of task completion, clarity of the health app information presented, and specific recommendations for improvement. Eight participants also completed the 19-item Post-Study System Usability Questionnaire (PSSUQ; Lewis, 1995), which asked them to rate their agreement with usability-related statements (e.g., "overall, I am satisfied with how easy it is to use this system) on a scale of 1 (strongly agree) to 7 (strongly disagree). They also completed the 27-item Questionnaire for User Interface Satisfaction (QUIS; Chin et al., 1988), which evaluated satisfaction with the web-based interface on a 0-9 Likert scale, with higher scores reflecting greater satisfaction. Both questionnaires have been found to be both reliable and valid (Chin et

al., 1988; Lewis, 1995).

Results

Overall, participants' feedback suggested that they found the health features easy and straightforward to use. Several noted that their ability to navigate the health features increased as their familiarity with the app functions improved. Suggestions for improvements included alternative labels for medication tracking and adding additional fields to the medical information section. The PSSUQ scores fell at the most favorable end of the scale ($M = 2.47$; $SD = 1.43$; lower 1-7 score better) as did the QUIS ($M = 7.31$, $SD = 1.22$; higher 1-9 score better), indicating high overall satisfaction with the usability of the new features.

Outcome

Participant feedback from Study 2 was used to further refine the health features of EMMA. Notable updates included the addition of new folders and fields in the medical information section and improvements to the medication entry process. These refinements were incorporated into the final version of the app used in Study 3, in which older adults with cognitive concerns completed an adaptive, web-based training intervention and used the EMMA app over a three-month period.

Evaluating the use of integrated health features in a mobile app

Table 1. Demographic information and survey data for Study 2 and Study 3

	Study 2 (n = 10) mean (SD) or %	Study 3 (n = 39) mean (SD) or %
Age	75.75 (2.60) ^a	71.44 (9.45)
Education	16.86 years (1.95) ^b	15.26 years (2.52)
Gender	62.50% female ^c	64.10% female
Race	87.50% White ^d	94.90% White
*PSSUQ total	2.47 (1.43) ^e	-
**QUIS total	7.31 (1.22) ^f	-
[†] I am confident in my ability to use the EMMA app's health tracking features in my daily life.	-	2.84 (1.89)
[‡] I have been using the EMMA app's health tracking features in my daily life.	-	4.30 (2.18)
[†] The EMMA app is helping me to better manage my health.	-	3.32 (2.04)
[†] The EMMA app is helping me to improve my wellbeing.	-	2.89 (1.73)

Note. PSSUQ = Post Study System Usability Questionnaire; QUIS = Questionnaire for User Interface Satisfaction; ^aN = 8; ^bN = 7; ^cN = 8; ^dN = 8; ^eN = 8; ^fN = 7; *scale of 1 (strongly agree) to 7 (strongly disagree); **scores range from 0 to 9, with higher scores representing higher satisfaction; [†]question from an EMMA experience survey (N = 37) with a scale of 1 (strongly agree) to 7 (strongly disagree).

Study 3: Older adults' use of EMMA's health features after a training intervention

After the health features were integrated into the EMMA app and the adaptive, web-based training program created (Li et al., 2026), a pilot randomized controlled trial (RCT; ClinicalTrials.gov #NCT05696756) was conducted. The trial included community-dwelling older adults aged 50 and above who reported experiencing cognitive decline over the past 1-3 years and expressed concerns about these changes. While the primary outcomes of the RCT will be reported in a separate manuscript, the current work focuses on participants' engagement with EMMA's health features in the three months following the training intervention. To explore this engagement, both qualitative (i.e., participant feedback) and quantitative (i.e., EMMA app health data metrics, Likert question responses) data were analyzed. We were particularly interested in identifying common themes and usage patterns pertaining to participants' adoption of the added health features.

Methods

Of the 62 older adults with cognitive concerns enrolled in the study, 49 completed the web-based training, which introduced the health features of the EMMA app in the final training lessons, that is, Lessons 5 and 6. As the EMMA app continuously collects real-time usage data, participants' app usage was then monitored for the three-months after they completed training. Notably, participants were not instructed to use any specific features of the app, allowing their engagement to reflect natural interest and self-motivation. At the end of the monitoring period, 39 participants (age: $M = 71.44$, $SD = 9.45$) participated in follow-up interviews (see Table 1 for sample characteristics). These interviews explored their experiences us-

ing the EMMA app, with a particular focus on the newly added health-related features. Interview questions included:


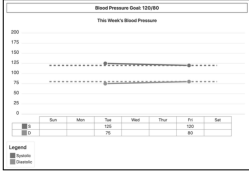
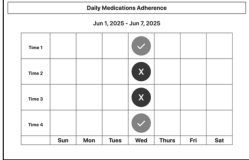
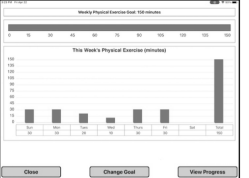
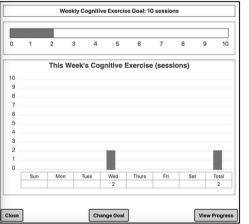

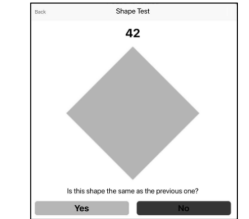
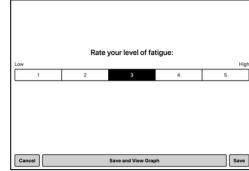
"What health tracking feature or features are you using in your daily life?"

"Is there anything that you find unappealing about the health tracking features? How would you improve it?"

"Is there any additional feedback that you would like to provide us about your experience using the EMMA health tracking features?"

The responses were transcribed verbatim, followed by a review of the interviews by two research assistants and a qualitative researcher to identify and confirm meaningful patterns in participants' responses. Specifically, saturation was assessed retrospectively by examining whether new or distinct themes continued to emerge during iterative coding (Grodal et al., 2021; Kumar et al., 2025). After iterative coding by multiple researchers, no additional themes emerged in the final rounds of analysis, and additional interviews became repetitive rather than yielding new insights. The research team agreed that the data were sufficient to fully address the study aim. A final review of the complete dataset confirmed that no additional themes were present, confirming thematic saturation. Given the modest sample size, coding was conducted manually through collaborative review and consensus rather than qualitative software, which was deemed sufficient for rigorous thematic analysis. In addition, participants responded on a Likert scale, from 1 (strongly agree) to 7 (strongly disagree), to four questions related to their use of the EMMA app (see Table 1). This quantitative data

Evaluating the use of integrated health features in a mobile app

Feature	Function	Image
Weight	The weight feature allows users to track their weight on a daily basis and monitor their weekly average weight across time.	
Blood Pressure	The blood pressure feature allows users to track their systolic and diastolic blood pressure on a daily basis and monitor their daily blood pressure across time.	
Daily Medications	The daily medications feature allows users to track whether they took their daily medications and monitor the days that they missed taking all medications.	
Physical Exercise	The physical exercise feature allows participants to track their daily minutes of physical exercise and monitor their total weekly physical exercise across time.	
Cognitive Exercise	The cognitive exercise feature allows participants to track their number of cognitive exercise and monitor their total weekly cognitive exercise across time.	
Well-Being Exercise	The well-being exercise feature allows participants to track their number of well-being exercise and monitor their total weekly wellbeing exercise across time.	
Cognitive Testing	The cognitive testing feature allows users to complete a cognitive test and track the results across time.	
Health and Emotion Rating	The health and emotion ratings feature allows users to rate specific aspects of their health and emotion and monitor the ratings across time.	

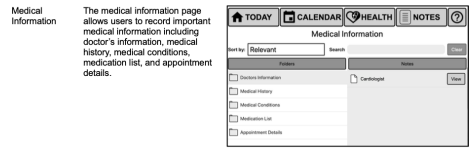


Figure 2. EMMA application's health features

was compared with the qualitative statements for congruency, thus enhancing credibility and rigor (Hendren et al., 2023).

Results

Thematic analysis of participants' qualitative feedback ($N = 39$) revealed several key themes related to how older adults used and perceived the health tools within the app (e.g., simplification of health routines, engagement in health-promoting activities, supplementing the app with other health tools).

Health feature use

When asked about which EMMA health features were used (e.g., "What health tracking feature or features are you using in your daily life?"), 12 participants reported using specific health features within the app. These included medication tracking, storing medical information (e.g., allergies, vaccines), tracking health activities, and scheduling medical appointments. Participants described using the EMMA app to log medications, track physical exercises and weight, record blood pressure, and document medical histories and appointments. For instance, one participant used the medication list feature and tracked volunteer work through the cognitive exercise feature, while another participant recorded doctors' names in the medical information section. Additionally, one participant stated the following regarding the progress graphs: "I like the feature that you have, which is setting the goal and then being able to check the progress. I'm a visual learner, so seeing the charts is good [024]." In general, users reported a variety of approaches to integrating the EMMA app into their personal health management routines.

Health feature non-use

Despite these aforementioned benefits, feature non-use was also a common response, with 11 participants indicating they did not use certain health features of the EMMA app (e.g., emotion rating, cognitive testing). Reasons for non-use varied from not needing certain functions in their daily routines to preferring other tools. For example, one participant did not use the health features at all, and another participant did not engage with the cognitive exercise component of the app. Furthermore, one participant stated

Evaluating the use of integrated health features in a mobile app

Table 2. Percentage of Study 3 participants (n = 39) using the EMMA health features weekly

Feature	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Weight	20.5	23.1	17.9	23.1	17.9	23.1	20.5	15.4	15.4	20.5	10.3	15.4
Blood pressure	15.4	15.4	10.3	15.4	15.4	12.8	15.4	12.8	12.8	15.4	12.8	12.8
Medication	28.2	30.8	33.3	30.8	35.9	33.3	30.8	33.3	30.8	30.8	30.8	33.3
Physical exercise	25.6	20.5	17.9	23.1	20.5	20.5	20.5	23.1	17.9	15.4	17.9	17.9
Cognitive activity	23.1	12.8	17.9	15.4	23.1	17.9	30.8	15.4	10.3	15.4	12.8	12.8
Well-being Activity	28.2	15.4	17.9	15.4	17.9	12.8	17.9	12.8	7.7	10.3	10.3	12.8
Cognitive test	25.6	12.8	10.3	10.3	15.4	10.3	20.5	7.7	15.4	7.7	7.7	7.7
Health & emotion	28.2	10.3	15.4	7.7	10.3	7.7	12.8	12.8	12.8	10.3	5.1	7.7
Medical information	28.2	23.1	15.4	25.6	12.8	7.7	23.1	10.3	12.8	15.4	12.8	7.7

Note. The values represent the percentage of interviewees from Study 3 who used the features weekly.

the following regarding the emotion rating feature: "The emotional rating- I really haven't used that one much at all. I don't know why. I think I'm intimidated by it, cause that's kind of a personal thing [13]." These responses underscore the importance of flexibility and personalization in digital health tools.

Health activity engagement

Greater engagement in health activities was self-reported by 11 participants as a result of EMMA app use. Users described positive changes in their health behaviors, including more consistent physical exercise and increased participation in cognitively stimulating and well-being activities. For example, one participant reported using the health tracking feature to monitor daily exercises such as yoga and walking, while another reported engaging in daily cognitive exercises. Additionally, one participant stated the following about tracking exercises: "I make sure that all my tracked health activities- that I have it in there- that I'm doing those exercises and reporting how long I'm getting physical exercise. I'm clicking off a cognitive exercise every day [034]." In general, participants described using the app to support healthier lifestyle habits.

Alternative systems or devices

Several participants (n = 11) reported using alternative systems or devices alongside the EMMA app, including supplementing the app with tools such as smartwatches (e.g., Fitbits for tracking physical activity and physiological data), other mobile health apps (e.g., MyChart for accessing personal health records), or paper logs. For instance, one participant used a smartwatch to track exercise and sleep, along with an electronic pill dispenser, while another participant relied on a paper log to monitor blood pressure and glucose levels. Furthermore, one participant noted the following: "I have a Fitbit, and so I use

a Fitbit app to keep track of things, you know, health-related things and exercise [011]." In general, users reported combining traditional and digital methods, or using alternative methods, to meet their health tracking needs.

Suggestions for additional features and functional changes

Several participants (n = 8) suggested additional features or enhancements to the app for greater customizability and personalization in health tracking. Their recommendations included expanding functionality to track sleep, pulse, glucose levels, and steps walked (e.g., "for physical exercise, it's fine, but you really need a step count in there too [14]"). One participant suggested the following: "Tracking a diet... things like that that would be good- especially your water intake. You know, because I drink water, but I could drink more [028]." Additionally, a participant proposed personalizing the health information based on individual fitness levels, while another suggested incorporating effectiveness ratings for well-being activities. A smaller number of participants (n = 4) suggested functional improvements, such as adjusting graph scales or clarifying the language used in the cognitive testing feature. One participant also noted difficulty navigating the health graphs. Together, these insights emphasize the importance of user-centered design and the need for adaptable features that align with diverse health management preferences.

Support and simplification

Participants (n = 5) generally found the EMMA app helpful for supporting and simplifying their daily routines, particularly in managing and remembering medical appointments. The calendar feature was mentioned as a valuable tool for organizing schedules and keeping track of their doctors' visits. Two participants reported bring-

Evaluating the use of integrated health features in a mobile app

ing the app to doctor's appointments to share health information (e.g., "I can show my doctors what I've been doing. You know, for example, with my cardiologist [028]"), highlighting its potential use as an assistive communication tool. These experiences highlight the potential utility of the app in enhancing day-to-day health management and facilitating more informed interactions with healthcare providers.

Reported outcomes from use

In terms of impact, five participants reported positive life changes attributed to the EMMA app. These included better medication adherence, increased exercise, being more intentional about engaging in healthy activities, and reduced stress. For instance, one participant noted improved memory for medication and exercise routines, while another participant became more mindful of their overall health (e.g., "[EMMA] made me more mindful of what is going on, you know, mentally and physically and emotionally and spiritually, and with my interaction with other people [038]"). Another participant [027] stated being more "purposeful" from using the EMMA app. These examples highlight the potential for the EMMA app to support meaningful, health-related behavior change.

Overall, the qualitative feedback highlights both the app's strengths in promoting health behavior change and self-awareness, while also pointing to opportunities for further improvements to enhance users' experiences.

Monitored use of the health features

Analyses were conducted using IBM SPSS Statistics. Using the continuous data collected from the EMMA app, participants' weekly use of the health features was examined for the 12-week period (i.e., for 3 months post-training). To measure engagement with each of the health features, usage was defined as any participant having a mean feature usage greater than zero for a given week. The percentage of the 39 participants who interacted with each health feature at least once during a given week is presented in *Table 2*. Overall, the monitored use data revealed distinct engagement trends over time, with certain features (e.g., medication tracking) showing sustained or increasing use, while others (e.g., cognitive testing, emotion rating) declined following initial adoption.

As shown in *Table 2*, analysis of EMMA app usage over the 12 weeks following training revealed a pattern of moderate initial engagement (20% - 30%) across most health features. The medication tracking feature stood out as the one feature that was consistently used by approximately one-

third of participants (28.5% - 33.3%) throughout the monitoring period. The medication tracking feature was also the only feature that saw increased usage over time, suggesting that earlier adopters maintained their engagement and other participants spontaneously added use in later weeks. In contrast, usage of all other health features declined over the 12-weeks. Use of the weight, blood pressure, and physical exercise tracking features showed relatively minor declines (2.6% to 7.7%), indicating that most people who began using these features continued to use them. However, features like cognitive activity, well-being activity, cognitive test, health and emotion ratings, and medical information page showed more substantial decreases (10.3% to 20.5%), suggesting that initial users were more likely to discontinue use. While moderate early use indicated initial interest, long-term engagement with the app's health features remained low, underscoring the need for strategies to support sustained engagement. These engagement trends highlight the importance of aligning digital health features with users' perceived needs and daily routines to support sustained use. Features that are seen as less relevant or perceived to be of low usefulness may result in minimal use.

Likert ratings

As shown in *Table 1*, participants reported that they mostly agreed with being confident in their ability to use the EMMA app's health tracking features in their daily lives ($M = 2.84$, $SD = 1.89$). They also mostly agreed that the app is helping them improve their well-being ($M = 2.89$, $SD = 1.73$). Additionally, participants somewhat agreed that the EMMA app is helping them better manage their health ($M = 3.32$, $SD = 2.04$). However, they neither agreed nor disagreed that they have been regularly using the app's health tracking features in their daily lives ($M = 4.30$, $SD = 2.18$).

DISCUSSION

This paper presents a case study of the EMMA app, a prototype digital cognitive compensatory tool developed in collaboration with older adults experiencing cognitive challenges. Three exploratory studies detailed the integration of health features into the EMMA app. In Study 1, older adults contributed to the design of health features that reflected their expressed needs and preferences such as medication tracking, cognitive testing, and health progress graphs. Study 2 demonstrated the usability of the newly integrated health features, with participants reporting high usability satisfaction ratings. Study 3 showed initial use of several health features, suggesting the value of inclusive design (Czaja & Weingast, 2020), but engagement declined over

Evaluating the use of integrated health features in a mobile app

time, indicating a need for strategies to support sustained use.

In line with the principles of inclusive design and designing for aging populations, the app's intuitive design was likely a key factor in helping participants easily learn to use the health features. To reduce cognitive load, the EMMA app incorporated age-friendly design elements such as large fonts, simple icons, text support, clear color contrasts, and consistent navigation features. In Study 2, participants rated the app positively on usability metrics (e.g., ease of use), with scores indicating overall high user satisfaction with the health features. These findings align with core constructs from the TAM, which emphasizes perceived ease of use and usefulness as central to technology adoption (Davis, 1989). Additionally, participants also reported that repeated use and increased familiarity improved their comfort with the app. This pattern reflects the effort expectancy and performance expectancy constructs from the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). In Study 3, engagement with the health features was moderate directly following the training intervention but declined over time for all features except medication tracking. This pattern suggests that while initial training is important, continued support may also play a crucial role in the sustained adoption of digital health technologies in older adult populations (Czaja & Lee, 2007). Additionally, in the EMMA experience survey conducted during Study 3, participants reported confidence in using the EMMA app and perceived it as at least somewhat helpful for improving well-being and managing health. However, consistent with the health feature usage data, responses to the question about regular use of health features were generally neutral, indicating limited sustained engagement.

In addition to being seen as a promising means to support independent living within the context of aging in place (Wang et al., 2019), digital tools like the EMMA app show potential to support self-management and healthy aging among individuals with cognitive concerns (e.g., adults with SCD or MCI). The qualitative findings from Study 3 revealed that several participants voluntarily integrated the health-related features of the app into their health routines (e.g., logging medications, documenting medical information). Reported benefits included increased engagement in physical and cognitive activities, improved medication adherence, and greater mindfulness. These findings suggest that digital health tools not only support health tracking but may also have the potential to encourage

positive behavioral change through increased healthy activity engagement (e.g., Stockwell et al., 2019).

Comparing participants' requested health features in Study 1 with actual real-world usage in Study 3 revealed key insights. Medication tracking was a moderately requested feature and was the only feature that grew in the number of participants using it over the 12-week monitoring period. Of note, this growth included up to a third of participants (33.3%) using the medications tracking during any given week. Other more highly requested features, such as physical activity, weight tracking, and emotion ratings showed a range of initial engagement from 20.5% to 28.2% of participants. This highlights a discrepancy between the stated desire for a health tracking feature and engagement with the feature. Cognitive testing, despite being the most requested feature, showed only moderate initial engagement and was among the least used health features by the end of the monitoring period, suggesting a challenge with sustained engagement with the feature. Overall, usage of most health features markedly declined over time, indicating a gap between users' reported interests and their sustained engagement. This discrepancy suggests that initial enthusiasm does not always translate into sustained use. Technology adoption models note that perceived usefulness alone is insufficient without supporting factors such as facilitating conditions, effort expectancy, and habit formation (Renaud & Biljon, 2008; Venkatesh et al., 2003). It could be that the design of the health features, though easy to use and user-informed, did not adequately capture what users needed. Alternatively, even when individuals are initially interested in using digital health features and tools, continued use may be challenging. This may be due to factors like forming habits, staying motivated, managing multiple health devices, and varying levels of digital literacy and familiarity with using self-monitoring tools. Incorporating strategies like gamification, automated personalized reminders, an integrated health profile across digital platforms, or habit-building supports may help promote long-term adoption and more consistent use of health-related features.

Participants in Study 3 expressed interest in additional features such as diet and water intake tracking, step count, and sleep monitoring. These suggestions highlight a desire for more comprehensive, flexible, and personalized health tracking within the EMMA app. Furthermore, a notable theme in Study 3 was the multi-tool approach to health management. Many participants used the EMMA app alongside oth-

Evaluating the use of integrated health features in a mobile app

er tools, such as Fitbits, MyChart, or traditional paper logs. This concurrent use might partly explain the decline in engagement with the app's health features over time, as participants may have reverted to their previously established tracking systems. This underscores the need for interoperability (i.e., communication with users' existing health platforms) and data integration to reduce redundancy and enhance user experience by streamlining interactions across digital health tools (Alami et al., 2017).

Practical and theoretical implications

This study shows that while age-inclusive, user-friendly design supports initial adoption of digital health tools, sustained engagement needs added strategies like personalized reminders, habit-forming supports, or clinician check-ins. The gap between stated feature preferences and actual use underscores the need for adaptable and customizable design rather than relying solely on self-reported interest. The use of multiple health-tracking tools further emphasizes the need for interoperability to reduce redundancy and support real-world health management. These findings extend TAM and UTAUT, suggesting that perceived ease of use and usefulness appear important for early uptake, while long-term adoption may also be shaped by habit building and ongoing motivation, particularly among older adults with cognitive concerns.

Integrating health metrics in apps like EMMA also opens up promising opportunities for intelligent algorithms to analyze longitudinal health data and detect early health status changes. For example, detecting changes in blood pressure or activity could trigger automated alerts for timely clinical interventions. In addition, user ability to track and monitor their own health data and personalized features such as customizable health goals, offer opportunities to enhance user engagement and promote behavior change. While these findings are specific to the EMMA app, other implications extend more broadly to digital health tools for older adults, particularly the value of age-inclusive design, the role of perceived usefulness in adoption, the need for sustained engagement supports, and the importance of interoperability across health technologies. These tools can encourage individuals to take a more active role in their health by promoting engagement in healthy routines.

Limitations

While the EMMA app shows promise for proactive health and clinician involvement, several limitations exist. Identifying these early challenges with the health-related features may help

to inform future improvements and guide the development of health apps for older adults experiencing cognitive difficulties. First, although initial user engagement was high, sustained usage across the health features was generally low. In the current study, participants were introduced to the health features during Lessons 5 and 6, which included discussions on brain health and a goal-setting exercise to help integrate a health feature into daily life. However, no additional guidance or follow-up was provided. This suggests that the app's health features may require stronger long-term strategies for retention. While we did not expect every participant to use all the health features, we anticipated more personalized and consistent use of some of the health features over time. Second, the way in which individuals variably used different features also suggests that it could be useful to offer more personalized experiences, such as offering automated boosters based on the specific features each person uses (e.g., "You previously tracked weight, ready to check it again?"). Lastly, the app's intuitive design and initial training period may have helped to encourage early engagement with the health features, but keeping users engaged might require continued support either externally (e.g., occasional check-ins by a clinician) or internally (e.g., app-based prompting, gamification, or technical support).

Additionally, there are limitations to consider with the study design more broadly. For one, this study focused specifically on the EMMA app and the health features developed within it. The findings are based on this particular app, so they may not directly apply to other digital health apps that function differently or are used by different populations. For example, the EMMA app had unique features not commonly seen in other digital health tools, such as cognitive testing, cognitive and well-being activity tracking, and health and emotion ratings. Thus, the generalizability of the findings to other digital health tools may be limited. However, certain design principles employed in EMMA, such as large fonts, simple icons, clear color contrasts, text support, a user-friendly graphical interface, self-monitoring opportunities, and consistent navigation, which made using the app's health features intuitive, are broadly applicable and may generalize more easily to other health apps designed for older adults. These features reflect best practices in age-inclusive design. Secondly, most participants in this study were White, highly educated, and female. While their feedback and usage provided helpful insights, they may not fully represent the experiences of older adults from different backgrounds.

CONCLUSION

This research contributes to the growing field of gerontechnology by demonstrating how user-centered digital health tools can inform technology adoption and sustained engagement among older adults. The findings highlight that while initial training promotes early engagement, ongoing support and reinforcement are essential for long-term use of digital health technologies. This underscores the importance for future research to design and evaluate adaptive, tailored interventions that align with older adults' evolving needs and cognitive capacities. The findings reveal opportunities to enhance interoperability and data synchronization across digital platforms to reduce redundancy and enhance users' experiences. However, the study revealed challenges with sustained engagement, particularly for features users initially suggested but rarely used. This suggests that initial interest may not always translate into long-term use, and that even well-designed, user-informed features may fall short if they do not fully align with users' daily routines,

motivations, or perceived value. By identifying factors that influence both adoption and decline in use, this study provides important insights for improving the design, implementation, and sustainability of digital health tools that support healthy aging.

Looking ahead, digital health tools are poised to play an increasingly meaningful role in care plans, particularly for mitigating or preventing cognitive decline. Beyond serving as a memory and task management aid, EMMA encourages healthy aging behaviors and enables clinicians to remotely monitor changes in these behaviors in a unified compensatory and health-tracking system, increasing its potential to be a valuable tool in supporting older adults and those with cognitive concerns. As digital health technologies continue to evolve, tools that are co-designed with users, adaptable to individual needs, and integrated into broader care systems will be essential for advancing proactive, person-centered care.

Acknowledgments

We thank Kim Johnson at Managed Health Connections and his team of software engineers for their work integrating the health features into the Electronic Memory and Management Aid (EMMA) application. We also thank members of the Neuropsychology and Aging Laboratory at Washington State University for their work assisting with these projects.

References

- Alami, H., Gagnon, M. P., & Fortin, J. P. (2017). Digital health and the challenge of health systems transformation. *mHealth*, 3, 31. <https://doi.org/10.21037/mhealth.2017.07.02>
- Calendar Clock. (n.d.). Calendar Clock – Dementia Day Clock. [Mobile app]. <https://calendarclock.app/>
- Chin, J. P., Diehl, V. A., & Norman, K. L. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 213-218).
- Chudoba, L. A., Church, A. S., Dahmen, J. B., Brown, K. D., & Schmitter-Edgecombe, M. (2019). The development of a manual-based digital memory notebook intervention with case study illustrations. *Neuropsychological Rehabilitation*, 30(9), 1829-1851. <https://doi.org/10.1080/09602011.2019.1611606>.
- Cozi. (n.d.). Cozi Family Organizer. [Mobile app]. <https://www.cozi.com/>
- Czaja, S. J., & Lee, C. C. (2007). The impact of aging on access to technology. *Universal Access in the Information Society*, 5(4), 341-349. <https://doi.org/10.1007/s10209-006-0060-x>
- Czaja, S. J., & Weingast, S. Z. (2020). The changing face of aging: Characteristics of older adult user groups. *Gerontechnology*, 19(2), 115-124. <https://doi.org/10.4017/gt.2020.19.2.004.00>
- Dahmen, J., Minor, B., Cook, D., Vo, T., & Schmitter-Edgecombe, M. (2018). Smart home-driven digital memory notebook support of activity self-management for older adults. *Gerontechnology*, 17(2), 113-125. <https://doi.org/10.4017/gt.2018.17.2.005.00>.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340. <https://doi.org/10.2307/249008>
- Farias, S., Gravano, J., Weakley, A., Schmitter-Edgecombe, M., Harvey, D., Mungas, D., ... Giovanetti, T. (2020). The Everyday Compensation (EComp) Questionnaire: Construct validity and associations with diagnosis and longitudinal change in cognition and everyday function in older adults. *Journal of the International Neuropsychological Society*, 26(3), 303-313. <http://doi.org/10.1017/S135561771900119X>
- Grodal, S., Anteby, M., & Holm, A. L. (2021). Achieving rigor in qualitative analysis: The role of active categorization in theory building. *Academy of Management Review*, 46(3), 591-612.
- Hendren, K., Newcomer, K., Pandey, S. K., Smith, M., & Sumner, N. (2023). How qualitative research methods can be leveraged to strengthen mixed methods research in public policy and public administration? *Public Administration Review*, 83(3), 468-485.
- Joe, J., & Demiris, G. (2013). Older adults and mobile phones for health: A review. *Journal of Biomedical Informatics*, 46(5), 947-954. <https://doi.org/10.1016/j.jbi.2013.06.008>
- Kumar, S., Barolia, R., Petrucka, P., & Ali, M. A. A. (2025). RIGOR: The assessment of trustworthiness. *Kashf Journal of Multidisciplinary Research*, 2(01), 10-19.
- Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, 7(1), 57-78. [https://doi.org/10.1016/1033-0425\(95\)90001-0](https://doi.org/10.1016/1033-0425(95)90001-0)

Evaluating the use of integrated health features in a mobile app

- doi.org/10.1080/10447319509526110
- Li, X., Beech, B. F., Hales, T., Van Son, C., Chilton, R., Lujan, C., Duell, B., DeSmet, C., Cook, D., Johnson, R. K., & Schmitter-Edgecombe, M. (2026). Evaluating an adaptive, web-based training program for teaching older adults experiencing cognitive difficulties to use an electronic memory and management aid. *Archives of Clinical Neuropsychology*, 41(1), acaf102. <https://doi.org/10.1093/arclin/afaf102>.
- Livingston, G., Huntley, J., Liu, K. Y., Costafreda, S. G., Selbæk, G., Alladi, S., Ames, D., Banerjee, S., Burns, A., Brayne, C., Fox, N. C., Ferri, C. P., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Nakasujja, N., Rockwood, K., Samus, Q., ... Mukadam, N. (2024). Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *The Lancet*, 404(10452), 572–628. [https://doi.org/10.1016/S0140-6736\(24\)01296-0](https://doi.org/10.1016/S0140-6736(24)01296-0)
- Luna, C., Cook, D. J., & Schmitter-Edgecombe, M. (2023). But will they use it? Predictors of adoption of an electronic memory aid in individuals with amnesic mild cognitive impairment. *Neuropsychology*, 37(8), 955–965. <https://doi.org/10.1037/neu0000898>.
- Medisafe. (n.d.). Medisafe Medication Management. [Mobile app]. <https://www.medisafe.com/>
- Portenhaus, A. A., Terhorst, Y., Schultchen, D., Sander, L. B., Denking, M. D., Stach, M., Waldherr, N., Dallmeier, D., Baumeister, H., & Messner, E. M. (2021). Mobile apps for older adults: Systematic search and evaluation within online stores. *JMIR Aging*, 4(1), e23313. <https://doi.org/10.2196/23313>
- Raghunath, N., Dahmen, J., Brown, K., Cook, D., & Schmitter-Edgecombe, M. (2020). Creating a digital memory notebook application for individuals with mild cognitive impairment to support everyday functioning. *Disability and Rehabilitation: Assistive Technology*, 15(4), 421–431. <https://doi.org/10.1080/17483107.2019.1587017>.
- Renaud, K.V., & Biljon, J.A. (2008). Predicting technology acceptance and adoption by the elderly: A qualitative study. In: Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists, Wilderness, South Africa, 6-8 Oct 2008, pp. 210-219. <https://doi.org/10.1145/1456659.1456684>
- Rowland, S. P., Fitzgerald, J. E., Holme, T., Powell, J., & McGregor, A. (2020). What is the clinical value of mHealth for patients? *NPJ Digital Medicine*, 3, 4. <https://doi.org/10.1038/s41746-019-0206-x>
- Saunders, C. H., Sierpe, A., von Plessen, C., Kennedy, A. M., Leviton, L. C., Bernstein, S. L., Goldwag, J., King, J. R., Marx, C. M., Pogue, J. A., Saunders, R. K., Van Citters, A., Yen, R. W., Elwyn, G., Leyenaar, J. K., & Coproduction Laboratory (2023). Practical thematic analysis: A guide for multidisciplinary health services research teams engaging in qualitative analysis. *BMJ (Clinical Research Ed.)*, 381, e074256. <https://doi.org/10.1136/bmj-2022-074256>
- Schmitter-Edgecombe, M., Brown, K., Luna, C., Chilton, R., Sumida, C. A., Holder, L., & Cook, D. (2022). Partnering a compensatory application with activity-aware prompting to improve use in individuals with amnesic mild cognitive impairment: A randomized controlled pilot clinical trial. *Journal of Alzheimer's Disease*, 85(1), 73–90. <https://doi.org/10.3233/JAD-215022>.
- Schmitter-Edgecombe, M., Fahy, J. F., Whelan, J. P., & Long, C. J. (1995). Memory remediation after severe closed head injury: Notebook training versus supportive therapy. *Journal of Consulting and Clinical Psychology*, 63(3), 484–489. <https://doi.org/10.1037//0022-006x.63.3.484>
- Schmitter-Edgecombe, M., Luna, C., Beech, B., Dai, S., & Cook, D. J. (2025). Capturing cognitive capacity in the everyday environment across a continuum of cognitive decline using a smartwatch n-back task and ecological momentary assessment. *Neuropsychology*, 39(1), 28–43. <https://doi.org/10.1037/neu0000984>
- Smrke, U., Špes, T., Mlakar, I., Musil, B., & Plohl, N. (2025). Technophobia mediates the associations between age, education level, and readiness to adopt new (health) technology among aging adults. *Journal of Applied Gerontology*, 44(3), 497–507. <https://doi.org/10.1177/07334648241274260>
- Sohlberg, M. M., & Mateer, C. A. (1989). Training use of compensatory memory books: A three stage behavioral approach. *Journal of Clinical and Experimental Neuropsychology*, 11(6), 871–891. <https://doi.org/10.1080/01688638908400941>
- Stockwell, S., Schofield, P., Fisher, A., Firth, J., Jackson, S. E., Stubbs, B., & Smith, L. (2019). Digital behavior change interventions to promote physical activity and/or reduce sedentary behavior in older adults: A systematic review and meta-analysis. *Experimental Gerontology*, 120, 68–87. <https://doi.org/10.1016/j.exger.2019.02.020>
- Touchable Apps. (n.d.). Touch Calendar. [Mobile app]. <https://touchableapps.co.uk/>
- U.S. Census Bureau. (2023). 2020 Census: 1 in 6 people in the United States were 65 and over. <https://www.census.gov/library/stories/2023/05/2020-census-united-states-older-population-grew.html>
- Vaportzis, E., Clausen, M. G., & Gow, A. J. (2017). Older adults' perceptions of technology and barriers to interacting with tablet computers: A focus group study. *Frontiers in Psychology*, 8, 1687. <https://doi.org/10.3389/fpsyg.2017.01687>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478 <https://doi.org/10.2307/30036540>
- Wang, S., Bolling, K., Mao, W., Reichstadt, J., Jeste, D., Kim, H. C., & Nebeker, C. (2019). Technology to support aging in place: Older adults' perspectives. *Healthcare*, 7(2), 60. <https://doi.org/10.3390/healthcare7020060>
- Wildenbos, G. A., Peute, L. W., & Jaspers, M. W. (2018). Aging barriers influencing mobile health usability for older adults: A literature based framework (MOLD-US). *International Journal of Medical Informatics*, 114, 66–75. <https://doi.org/10.1016/j.ijmedinf.2018.01.01>