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Intervention Research

Usability Testing of the PACE-App to Support Family Caregivers in Managing Pain for People With Dementia

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Abstract

Background and Objectives: Pain management is often suboptimal in individuals with dementia, and their family caregivers are tasked with supporting pain management despite limited preparation. The web-based PACE-app (PAin Control Enhancement) was designed to assist caregivers in managing pain for individuals with dementia. This study aimed to evaluate the usability of the PACE-app.

Research Design and Methods: A convergent parallel mixed-methods design was used to evaluate the PACE-app's usability with 16 family caregivers and 6 healthcare professionals. Quantitative data were collected using the Post-Study System Usability Questionnaire (PSSUQ), and qualitative data were gathered through guided-app reviews and semistructured interviews. Quantitative data were analyzed descriptively, and qualitative data were thematically coded.

Results: The PSSUQ results indicated that both family caregivers and healthcare professionals had a highly positive experience with the PACE-app: overall scores (2.01 vs 1.68), system usefulness (1.76 vs 1.68), information quality (1.98 vs 1.80), interface quality (2.30 vs 1.60), and satisfaction (2.00 vs 1.60) were rated on a 1–7 scale (with lower scores indicating better usability). Qualitative findings supported these results, with participants endorsing the PACE-app's usefulness, ease of use, learnability, effective information presentation, aesthetics, clear layout, and overall satisfaction. Participants also provided valuable feedback for improving information quality (enhancing clarity) and interface quality (real-time coaching on pain management).

Discussion and Implications: The study demonstrated favorable usability and strong satisfaction among family caregivers and healthcare professionals using the PACE-app. Incorporating participants' suggestions will guide enhancements to the app's information and interface, ensuring it better meets users' needs.

Keywords: Dementia, Family caregiver, Pain, Pain management, Web-based application

Background and Objectives

Alzheimer's disease and related dementias (ADRD) affect about 6.5 million people in the United States, a number projected to reach 13 million by 2050 (Alzheimer's Association, 2022; Hebert et al., 2013). As ADRD progresses, cognitive decline impairs individuals' ability to perform daily activities independently, necessitating support from family caregivers, or long-term care facilities. The economic and emotional toll of ADRD on family caregivers is substantial (Alzheimer's Association, 2022; Chiao et al., 2015).

Two-thirds of people living with ADRD experience chronic, bothersome pain, often stemming from other comorbidities such as arthritis and diabetes. Neuropathological changes associated with ADRD can also distort pain perception (Van Kooten et al., 2016). For people with ADRD, pain often wears a hidden mask. In the early stages (mild to moderate), it can manifest atypically as behavioral changes such as agitation, aggression, or disrupted sleep and eating patterns (Shega et al., 2007). Notably, those with the condition are less likely to be prescribed pain medication even with similar pain scores (Monroe et al., 2014). As the disease progresses (moderate to severe), communication difficulties and cognitive decline make it even harder for people with ADRD to express their pain and respond to treatment, leading to inadequate pain management (Achterberg et al., 2020; Herr et al., 2019). This poses a significant challenge for caregivers who must rely

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heavily on nonverbal cues to assess pain and make informed care decisions (Tarter et al., 2016).

Inadequate pain management in dementia has far-reaching consequences for both patients and family caregivers. For patients, untreated pain exacerbates cognitive decline, disrupts sleep, hinders daily activities, and diminishes overall quality of life. It can also intensify neuropsychiatric symptoms (e.g., agitation, aggression), leading to inappropriate antipsychotic use, unnecessary emergency room visits, and hospitalizations (Achterberg et al., 2020; Atee et al., 2021; Benner et al., 2018; Flo et al., 2014; Hunt et al., 2018). Caregivers face significant challenges due to a lack of training and difficulty assessing pain. This leads to frustration, hesitancy in treatment, and deviations from pain management plans. Consequently, caregivers experience increased burden, stress, and risk of depression. Moreover, managing complex pain situations and witnessing unrelieved suffering can expose caregivers to health risks (Chiao et al., 2015; Huang et al., 2012; Nah et al., 2020; Regier et al., 2021; Tarter et al., 2016; Zwerling et al., 2016).

Existing interventions are often lengthy, require in-person training, or lack comprehensiveness (Chi et al., 2020a). However, the high technology adoption rate among family caregivers suggests that web-based solutions may hold promise. In the United States, 87% of family caregivers have a cell phone and access to the Internet, 84% search for health information online, and 40% use assistive technology for caregiving (Family Caregiver Alliance, 2022). App-based interventions that increase family caregiver knowledge for general caregiving tasks have demonstrated reductions in caregiver burden and stress (Lucero et al., 2022). To address the current gap between traditional training and on-demand support, there is a critical need for accessible and user-centered interventions.

Healthcare apps may not be adopted if they fail to meet end-users' needs. This is evident in low adoption rates of current smartphone pain apps due to a lack of user and healthcare professional involvement, poor quality content, and inadequate testing (Lalloo et al., 2015, 2017; Zhao et al., 2019). To address this gap and create a user-centered, evidence-based, and accessible intervention, our research team has collaborated with experts, healthcare professionals, and family caregivers to iteratively develop essential and evidence-based content and features for the web-based PACE-app (PAin Control Enhancement application, PACE-app). A web-based format ensures broad accessibility across various devices (tablets, laptops, and computers). Usability testing is a critical step in the development of an app to solicit users' feedback to ensure that the content, functions, and system interface are useful, easy to use, easy to learn, efficient to complete, have no errors, and meet user satisfaction (Lewis, 2002; Nielsen, 1993). The purpose of this study was to evaluate the PACE-app's usability among family caregivers and healthcare professionals supporting individuals with ADRD in the community. The results from this study will inform the refinement of the PACE-app for becoming a user-centered app.

Research Design and Methods

The PACE-App

The University of Iowa Institutional Review Board (IRB) approved all study procedures under ID 202101517. The PACE-app was developed based on our prior research identifying common caregiver pain management challenges (Chi et al., 2022), and then incorporating evidence-based guidelines to address these challenges and equip caregivers with practical strategies (Centers for Disease Control and Prevention (CDC), 2022; Davis et al., 2019; Herr et al., 2019; International Association for the Study of Pain, 2021; Levenson et al., 2021; Schofield, 2018; The Oregon Pain Guidance Group, 2023). To ensure user-centeredness, our research team engaged experts, healthcare professionals, and family caregivers throughout the development process. Their feedback helped validate the app's content and features (Chi et al., 2020b).

The app includes a 13-question screening tool to assess caregiver challenges and needs in pain management. Based on the screening results, the app delivers targeted, evidence-based pain management strategies. These strategies encompass pain recognition, pharmacological and nonpharmacological interventions, and communication tools. Also, the app provides templates of discussion points to facilitate discussions between caregivers and healthcare providers. Moreover, caregivers can access an evidence-based pain library with essential information and resources, and a pain diary to record their care recipient's pain levels, impact on activities, administered treatments, and side effects.

Table 1 details the app's components, and Figure 1 provides visual examples.

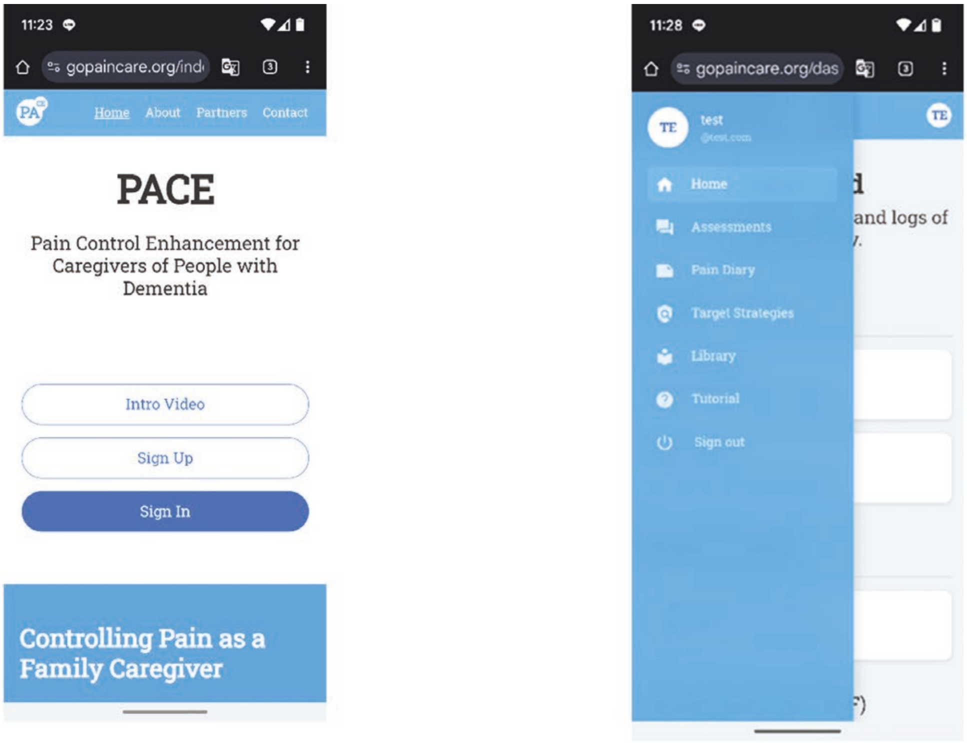
Table 1. Components of the PACE-App

Key components	Descriptions
1. Screening of family caregivers' challenges in pain management	A list of 13 assessment questions to screen and identify family caregivers' challenges in pain management. Examples of screening questions are: I would like to have more information about recognition and assessment of pain.
2. Targeted pain management strategies along with templates of discussion points	Based on the results of the screening, family caregivers can receive a list of targeted, evidence-based pain management strategies (e.g., verbal pain assessment, nonverbal pain assessment, pharmacological pain management strategies, nonpharmacological pain management strategies) to aid their pain management. Along with the pain management strategies, some discussion points are offered to family caregivers to discuss with their care partners' healthcare providers in pain management.
3. Pain management library	The library includes all essential information about pain management (medication, nonmedication, side effects) and pain assessment (verbal pain and nonverbal pain). A resource for family caregivers to review when they need more information on pain management.
4. Digital pain diary	A digital pain diary for caregivers to record pain management, including their care partner's levels of pain, the impact of pain on activities, treatments provided, and any side effects caused by pain treatments.

Note: PACE-App = PAin Control Enhancement application.

Participants, Sample Size, and Setting

To evaluate the PACE-app's usability, we recruited family caregivers and interdisciplinary healthcare professionals working with community-dwelling individuals with ADRD. A nationwide recruitment strategy was employed, utilizing channels such as the Alzheimer's Association Trial Match Listing, Gerontological Society of America forums, the University of Iowa listserv, and the Csomay Center for Gerontological Excellence website.



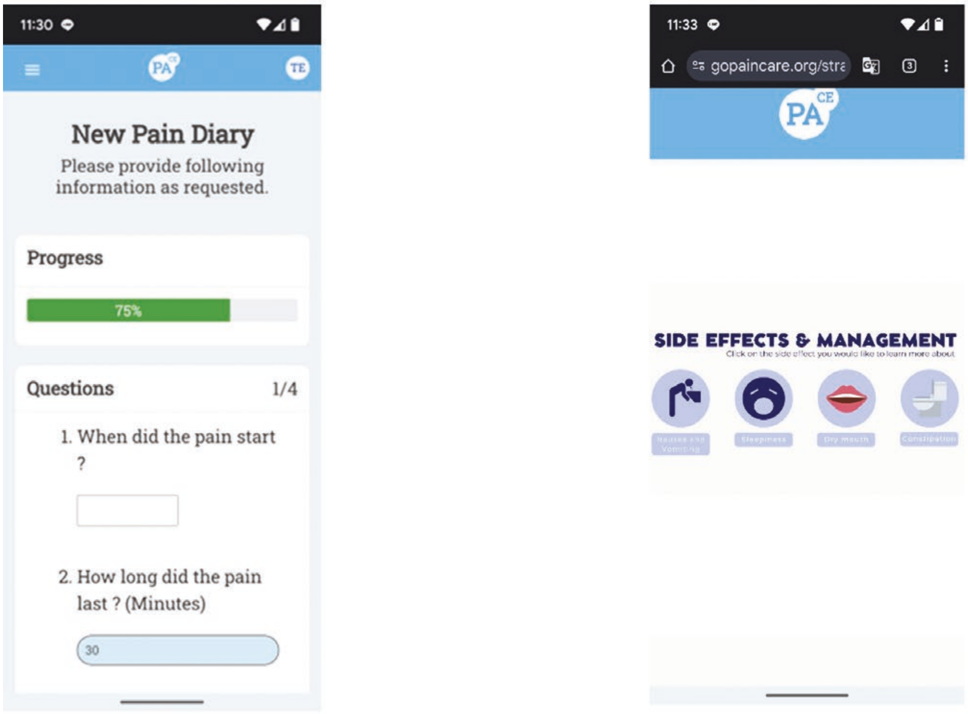
PACE

Pain Control Enhancement for Caregivers of People with Dementia

Controlling Pain as a Family Caregiver

Log-in Page

Menu Board



New Pain Diary

Please provide following information as requested.

Questions 1/4

1. When did the pain start ?

2. How long did the pain last ? (Minutes)

30

Pain Diary

Management Strategies for Side Effects

Figure 1. PACE-app's screenshots: log-in page, menu board, pain diary, and management strategies for side effects. PACE-App = PAin Control Enhancement application.

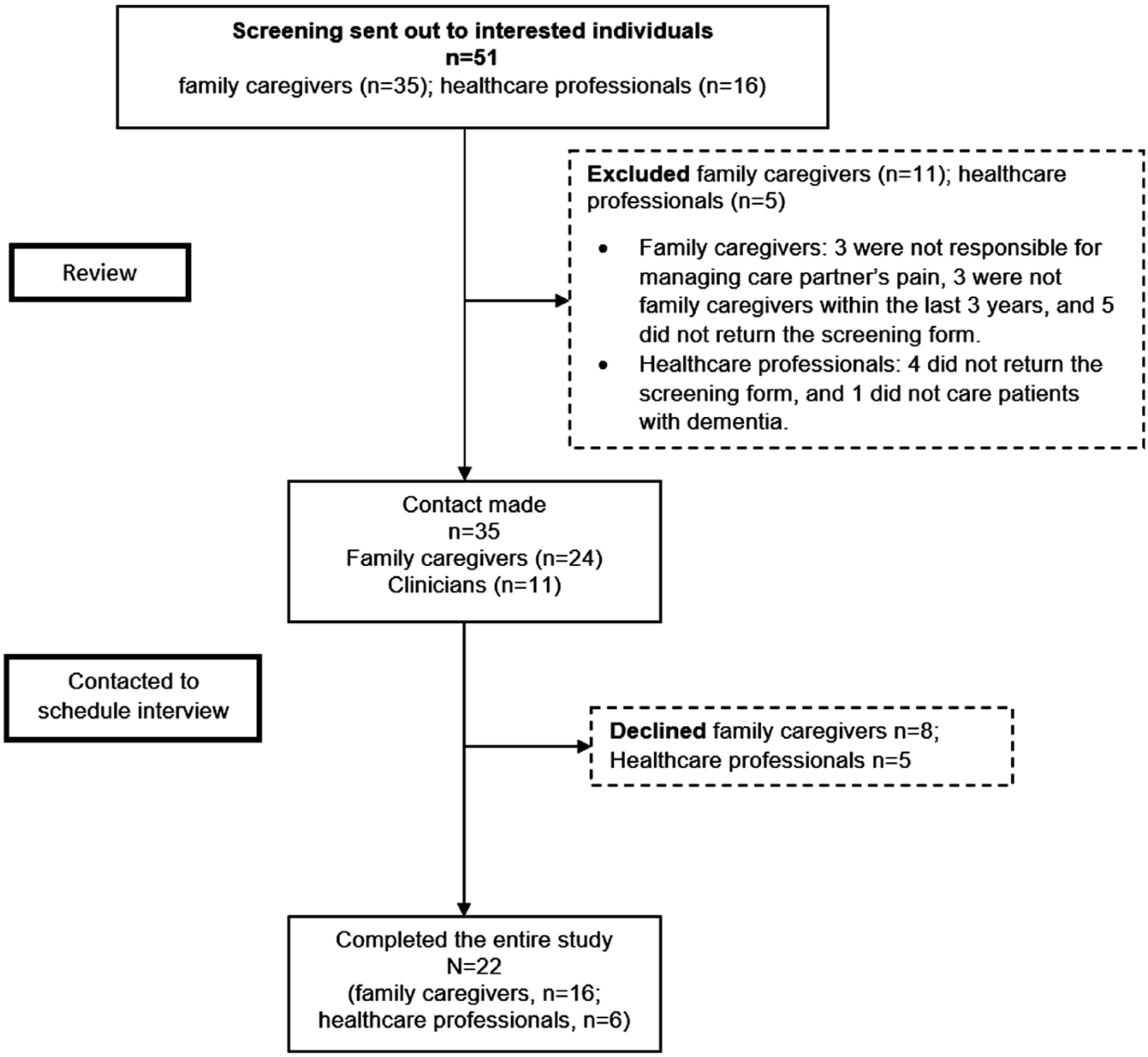


Figure 2. Enrollment flow chart. ADRD = Alzheimer's disease and related dementias.

Potential participants underwent an eligibility screening. Family caregivers were included if they were English-speaking adults aged 18 or older, had cared for a person with ADRD experiencing moderate to severe pain for at least 3 months within the past 3 years, and were responsible for managing pain, pain medication, or nonmedication therapies. Healthcare professionals were eligible if they were English-speaking adults over 18 with experience caring for individuals with ADRD in the past 5 years and working with their family caregivers (Figure 2).

Our targeted enrollment aimed at 15 family caregivers and 5 healthcare professionals. This sample size was chosen considering that data samples as small as 5–7 participants per usability cycle typically reach saturation points (Nielsen, 1993). The study involved four usability testing cycles conducted over 4 months, from July 2022 to November 2022. Ultimately, the final sample included 16 family caregivers and 6 healthcare professionals (Figure 2).

Design

A convergent parallel, mixed-methods design was used for the PACE-app usability testing, integrating quantitative and qualitative data to enhance the validity and reliability of the findings (Creswell & Creswell, 2017; Schoonenboom & Johnson, 2017). Quantitative data collection involved the completion of the 16-item Post-Study System Usability Questionnaire (PSSUQ), a standard tool for software usability testing (Lewis, 2002). Qualitative data were collected during a one-time, individual, audio-recorded Zoom meeting that included a guided-app evaluation and a semistructured interview.

Procedure

The University of Iowa's IRB determined this project posed minimal risk, waiving written informed consent. Family caregivers and healthcare professionals participated in individual, audio-recorded Zoom meetings guided by trained research nurses (K. Nguyen and A. Shanahan). Participants received an app tour. They first completed 13 questions to identify their pain management challenges. The PACE-app then provided tailored pain management information based on these responses (e.g., pain recognition, pharmacological and nonpharmacological strategies) for participants to review. Participants were introduced to the app's pain diary through a practice scenario and explored the pain library (Table 1). Subsequently, they completed the Post-Study System Usability Questionnaire (PSSUQ; Lewis, 2002) via Qualtrics (2022). Additionally, participants engaged in interviews (nine questions for caregivers and eight for healthcare professionals) to provide feedback on the PACE-app (Table 2). Participants received $30 compensation.

Data Analysis

Demographic data and quantitative data from the PSSUQ usability questionnaires were analyzed and summarized descriptively. Demographic data were summarized using mean, standard deviation, and range for age, and frequencies and percentages were calculated using Microsoft Excel software. The PSSUQ is a 16-question tool that measures users' perceived usability and satisfaction with an app or software, with Likert scale ratings ranging from 1 (strongly agree) to 7 (strongly disagree). Lower scores indicate better user experience and usability. The overall score is calculated by averaging ratings for all 16 questions (Lewis, 2002). System usefulness is measured by averaging ratings for questions 1–6; information quality is measured by averaging ratings for questions 7–12; interface quality is measured by averaging ratings for questions 13–15. Overall satisfaction with the app is measured by question 16 (Lewis, 2002; Table 5 lists all 16 questions in the PSSUQ.

Qualitative data included recordings of each participant's guided-app review and semistructured interview. They were transcribed verbatim by a professional transcription company and verified by the research team members (N. Chi and K. Nguyen). The app usability was evaluated qualitatively by its usefulness, ease of use, learnability, few errors/error messages, information quality, interface quality, and subjective satisfaction (Nielsen, 1993). Hence, a qualitative thematic analysis approach was used to code the transcribed interviews within a framework of app usability (Hsieh & Shannon, 2005).

To ensure consistency and accuracy in coding (Kirk & Miller, 1986), all transcripts were uploaded into MAXQDA software (version 2022). Two coders (N. Chi and K. Nguyen) independently coded a 30% sample of the transcripts line-by-line using codes related to app usability. Based on this initial coding, a codebook was developed (Nielsen, 1993). The codebook was further refined throughout the coding process. At least two coders (N. Chi, K. Nguyen, A. Shanahan) independently coded each transcript. Codes were entered into the codebook and were then grouped into meaningful themes based on the relationships between the codes. The overall agreement rate of coding among the three coders was 84% (N. Chi, K. Nguyen, and A. Shanahan). Any coding disagreements were resolved through discussion among the coders to ensure a shared understanding of the themes related to PACE-app usability. After coding was completed, themes and codes were defined and described. The percentages of participants who commented on each theme and code were calculated. Two coders (N. Chi and K. Nguyen) then reviewed all themes, codes, and coded excerpts to select representative quotations for presentation in the manuscript. Trustworthiness in the analysis was assured through a mixed-methods design and the verification of data and transcripts before coding. Additionally, at least two coders coded each transcript independently, using qualitative software to standardize the coding process, and an audit trail (Kirk & Miller, 1986).

Table 2. Interview Guide

Questions
Family caregivers
1.How does this app help you in managing pain for your care partner?
2.How can this app help you work with clinicians in managing patients' pain?
3.How often do you think family caregivers need to complete the pain management challenge assessment and pain diary?
4.When or how often should clinicians review the information from the pain diary or your pain management challenge assessment?
5.How is the overall design of the app? (e.g., information organization, layout, features)
6.What features do you find most helpful?
7.What are some missing features you hope to see in this app?
8.Did you experience any difficulty navigating or using any features in this app? If you did, what are the challenges?
9.Is there anything else that you'd like to tell me or any questions that you have?
Healthcare professionals
1.How can this app help you work with family caregivers in managing patients' pain?
2.How often do you think family caregivers need to complete the pain management challenge assessment and pain diary?
3.When or how often should healthcare providers review the information from the pain diary or pain management challenge assessment?
4.How is the overall design of the app? (e.g., information organization, layout, features)
5.What features do you find most helpful?
6.What are some missing features you hope to see in this app?
7.Did you experience any difficulty navigating or using any features in this app? If you did, what are the challenges?
8.Is there anything else that you'd like to tell me or any questions that you have?

Table 3. Demographic Characteristics of Family Caregivers (*N* = 16)

Characteristic	*n*	%
Gender		
Female	14	87.5
Male	2	12.5
Race		
White	13	81.3
Black or African American	2	12.5
American Indian/Alaska Native	1	6.3
Ethnicity		
Non-Hispanic or Latino	15	93.8
Prefer not to answer	1	6.3
Type of dementia (some care partners have more than 1 type of dementia)		
Alzheimer's disease	10	52.6
Vascular dementia	3	15.8
Lewy body dementia	1	5.3
Other	2	10.5
Do not know/not sure	3	15.8
Relationship		
Parent	7	43.8
Spouse	2	12.5
Adult child	1	6.3
Sibling	1	6.3
Other	5	31.2
Employment		
Full time	9	56.2
Part time	4	25.0
No	2	12.5
Other	1	6.3
Lived with care partner		
No	7	43.8
Yes	6	37.5
Other	3	18.8
Educational level		
High school	2	12.5
Associate degree	2	12.5
Bachelor's degree	5	31.3
Master's degree	4	25.0
Doctorate	3	18.8

Note: Percentages may not total to 100% due to rounding.

Results

Participant Characteristics

Demographic characteristics of family caregivers are described in Table 3. Healthcare professional demographics can be found in Table 4. Family caregivers were primarily female (87.5%) and White (81.3%), with ages ranging from 18 to 74 years (mean = 57.9, *SD* = 13.4). They had been managing pain for a person with ADRD for 3–120 months (mean = 32.3, *SD* = 29.9). Approximately half (43.7%) cared for a parent. The majority of participating healthcare professionals were male (66.7%). Four out of six were physicians (66.7%), one was a pharmacist and one was a social worker. Their experience working with family caregivers in managing pain ranged from 2 to 20 years (mean = 9.5, *SD* = 6.3).

Table 4. Demographic Characteristics of Clinicians (*N* = 6)

Characteristic	*n*	%
Gender		
Male	4	66.7
Female	1	16.7
Do not answer	1	16.7
Race		
White	5	83.3
Asian	1	16.7
Ethnicity		
Not-Hispanic or Latino	6	100.0
Employment		
Physician	4	66.7
Social worker	1	16.7
Pharmacist	1	16.7

Note: Percentages may not total 100% due to rounding.

Mixed-Methods Results From the Evaluation of the PACE-App's Usability

To comprehensively understand the PACE-app's usability, quantitative (PSSUQ scores) and qualitative data (major themes and codes from guided-app reviews and interviews) were integrated and presented jointly in Table 5. For in-depth qualitative analysis, Table 6 details themes, codes, numbers and percentages of participants, and illustrative quotes.

The PSSUQ usability questionnaire indicated favorable user experiences for both family caregivers and healthcare professionals (Table 5). For family caregivers, the mean overall PSSUQ score was 2.01, system usefulness score was 1.76, information quality score was 1.98, interface quality score was 2.30, and satisfaction score was 2.00 (on a scale of 1–7, lower scores indicate better user experience and usability). Family caregivers (93%) were satisfied with the app. For healthcare professionals, the mean overall score was 1.68, system usefulness score was 1.68, information quality score was 1.80, interface quality score was 1.60, and satisfaction score was 1.60. Satisfaction with the app was rated positively with 100% of healthcare professionals rating they were satisfied with the app. Compared with family caregivers, healthcare professionals consistently reported more favorable scores than family caregiver in all subscales: system usefulness, information quality, interface quality, and satisfaction.

Qualitative findings aligned with these positive quantitative results. Participants praised the PACE-app's usefulness, ease of use, learnability, informative content, appealing design, and clear layout. However, participants also offered valuable suggestions highlighting areas for improvement in information quality and interface quality.

System Usefulness

Quantitative results

Both family caregivers and healthcare professionals rated the PACE-app highly for system usefulness on the PSSUQ (mean scores 1.76 and 1.68, respectively, on a 1–7 scale). Participants agreed the app was easy to use and learn. However, they rated slightly lower on items related to productivity ("I could become productive quickly using this app") and task completion speed ("Complete the tasks quickly using this app"),

Table 5. A Joint Display Table to Compare Usability Results From Quantitative Data and Qualitative Data

Quantitative usability questionnaire (PSSUQ) subscales and items	PSSUQ: mean scores for family caregivers (*n* = 16) (1 = strongly agree to 7 = strongly disagree, lower scores indicate better usability)	PSSUQ: mean scores for healthcare professionals (*n* = 6) (1 = strongly agree to 7 = strongly disagree, lower scores indicate better usability)	Themes and codes from qualitative data (guided-app review and interview), percentage of participants
Subscale 1: system usefulness	1.76	1.68	Usefulness (100%)
Satisfaction with how easy to use	1.68 (100% agree)	1.80 (100% agree)	Ease to use (60%)
Simple to use	1.75 (100% agree)	1.60 (100% agree)	
Complete the tasks quickly using this app	1.75 (100% agree)	2.1 (83% agree)	
Comfortable to use	1.56 (100% agree)	1.50 (100% agree)	
Easy to learn	1.81 (100% agree)	1.50 (100% agree)	Ease of learning (17.3%)
Become productive quickly using this app	2.06 (93.75% agree)	1.60 (100% agree)	
Subscale 2: information quality	1.98	1.80	Information quality
Give error messages to fix problems	2.9 (37.5% agree; 37.5% nonapplicable)	2.6 (50% agree; 50% nonapplicable)	Information quality: Few error/errors preventions (8.6%)
Recover easily from errors	1.25 (100% agree)	1.60 (100% agree)	
Clear information	1.80 (93.75% agree)	1.60 (100% agree)	Information quality: Enhancing clarity (78.2%), adding more pain diary input options (47.8%), expanding pain management strategies (30%)
Easy to find information	1.90 (93.75% agree)	1.60 (100% agree)	
Information was effective in helping complete tasks	1.81 (93.75% agree)	1.60 (100% agree)	Information quality: effective information (100%)
Clear organization of information	2.25 (93.75% agree)	1.80 (100% agree)	
Subscale 3: interface quality	2.30	1.60	Interface quality
Pleasant interface	1.93 (93.75% agree)	1.60 (100% agree)	Interface quality: Aesthetics and clear layout (78%) Interface quality: adding more visuals (39.1%)
Like using the interface	2.187 (87.5% agree)	1.80 (100% agree)	Interface quality: adding more navigation and scrolling bars (26%)
Including all expected functions and capabilities	2.80 (93.75% agree)	1.50 (100% agree)	Interface quality: adding additional functions (73%)
Subscale 4: satisfaction with this app	2 (93% agree)	1.60 (100% agree)	Satisfaction (40%)
Overall PSSUQ score	2.01	1.68	

potentially due to the limited exposure to the app during this one-time usability testing session.

Qualitative results

Findings from qualitative data aligned with quantitative results, with three emerging themes: usefulness (100%), ease of use (60%), and ease of learning (17.3%). All participants considered the PACE-app a useful and valuable tool for caregiver support in pain management. The pain management strategies and pain diary were particularly appreciated. A healthcare professional (H1) shared, "I think it's all very good suggestions, communication techniques, and nonpharmacological treatment options that [family caregivers] can use. It's all put in a very succinct and meaningful way." Also, participants valued the pain diary for tracking pain management efforts and facilitating communication. One caregiver (F6) said, "Nobody has to decipher my handwriting. When another family member was going to take over, I would be confident that they could read what's there [in my pain diary] and follow the steps." About half of participants recognized the pain diary's potential to inform treatment decisions. One healthcare professional (H4) explained, "If patients having a lot of pain and caregivers are trying to figure out an effective solution for that pain. I think just having a record of what I did, treatments X, Y, and Z, this really seemed to help versus if I did treatments B and C, those really didn't seem to help. I think that could be useful." Moreover, participants reported the PACE-app was easy to use and learn, even for those less tech-savvy or older adults. One caregiver (F6) stated, "I wouldn't have a hard time explaining to my 84-year-old mother how to operate it."

Table 6. Qualitative Usability Results

Themes	Codes	Percentages of participants (number of caregivers and professionals; $N = 22$)	Examples
Usefulness		100% (17 FC; 6 H)	
	Pain Management Strategies	82.6% (14 FC; 5 H)	"There's information that somebody didn't know. You don't have to call a doctor's office to get that information." (F6)
	Pain diary helps family caregivers keep track of pain management	69.5% (11 FC; 5 H)	"If [family caregivers] use the diary, it would give an accurate record of how often and to what degree there's pain, and then what help[s] alleviate it." (F14)
	Pain diary helps providers adjust treatment regimens	52.1% (9 FC; 3 H)	"If [the care partner] comes for an outpatient appointment … [healthcare providers] can wait to stick with the plan or plan according to the pain diary." (H1) I think that's really helpful when you're talking to the doctor about needing a refill on something. If you have a record of every day this is what's going on. I know doctors are real nervous about ordering narcotics and refilling them and I understand why that is. I think any documentation that you have in front of you will help you communicate more clearly with the doctor." (F15)
Ease to use		60.8% (10 FC; 4 H)	"I feel like it's really easy and simple to use and navigate." (F8)
Ease of learning		17.3% (4 FC)	"Some of them are significantly less tech savvy. Like they write the steps on the TV kind of thing. I feel like any of them could use this app." (F11)
Information quality			
	Enhancing clarity	78.2% (13 FC; 5 H)	"To make that [the content] a little clearer." (F2)
	Adding more pain diary input options	47.8% (7 FC; 4 H)	"If [family caregivers are] able to add [their] own [inputs] because there are specific things that my grandma does …" (F11)
	Expanding pain management strategies	30.4% (6 FC; 1 H)	"I feel like maybe adding a more targeted, actionable information" (F1) "I would like to have more information about the importance of pain management." (F7) "Add more about the side effect" (F8)
	Considering comorbidity in pain management	21.7% (3 FC; 2 H)	"There's certainly some other types of, um, complications and comorbidity that people have by the time they reached their nineties, eighties that you gotta take into account." (F4)
	Few Errors/Error Messages	8.6% (2 FC)	"I thought it was pretty dummy proof, which is kind of what you want … if you entered something in error, you could go back and change it, which is great." (F6)
Interface quality		78% (10 FC; 4 H)	
	Aesthetics	43.5% (7 FC; 3 H)	"It was nice and clean, not confusing, not overwhelming. Short and sweet. Because when you're in the thick of it, you really don't wanna have to click around all this other stuff or look around and see the little pictures over here and little, because it's clutter." (F7)
	Clear layout	21.7% (3 FC; 2 H)	"I like it, it looks really simply. I think the colors are nice … it seems pretty straightforward." (H7) "It seemed well organized and obviously there's a great deal of thought that's gone into this." (F9)
	Adding more visuals	39.1% (6 FC; 3 H)	"It's not as easy to read as some of the other pages … [this page] needs a picture." (F2)
	Adding navigation tools	26.1% (3 FC; 3 H)	"There should be more navigation buttons." (H4)
	Adding scrolling bars	26.1% (3 FC; 3 H)	"A scroll bar would be really helpful because if you're trying to look and see what's going on, it's kind of hard [without one]." (F2)
	Consistent design	21.7% (5 FC)	"I think there should be consistency in the overall look [of the app]." (F1)
	Offering the PACE-app at a low cost	13% (2 FC; 1 H)	"Is it planning to be Medicare Medicaid approved and insurance approved? I hope it's low cost." (F7) "It's like offering caregivers a lot of resources, Hopefully the cost is low enough that people will still wanna use it." (H7)
	Add additional functions		
	➢*Direct coaching on the patient's pain condition*	36.7% (6 FC; 3 H)	"I wish it could coach me a little more … a little more live support, I think would be helpful" (F1)
	➢*Share pain diary with healthcare providers*	26.1% (2 FC; 4 H)	"Caregivers can have an option to send the pin diary to a provider if they notice something's different, something's off. And that could be a function of the web app too." (H1)

Table 6. Continued

Themes	Codes	Percentages of participants (number of caregivers and professionals; *N* = 22)	Examples
	➢*Security—privacy*	26.1% (5 FC; 1 H)	"[Including requirements for passwords] that aligned with best practices for data security." (F1)
	➢*Tutorial*	21.7% (3 FC; 2 H)	"I think a little more in the tutorial about how to use this app." (F1)
	➢*Download function*	17.3% (4 FC)	"It'd be really helpful if there [was] a way to download the strategies or diary either to a Word document or Excel document so that when [family caregivers] go to the doctors with [their] care partners … the doctor can see what [has] been [recorded]." (F2)
	➢*Centralized account for multiple family caregivers*	17.3% (4 FC)	"I would say that if you're caring for multiple patients, you may [want to] have the ability to select multiple … patients … for me, both of my parents have dementia." (F2)
	➢*Sending reminders to complete pain diary*	13% (2 FC; 1 H)	"I would do for the pain diary is a once-a-week kind of reminder." (F4)
Satisfaction		39.1% (6 FC; 3 H)	"I think overall I thought it looked really good." (F2)

Notes: FC = family caregivers; H = healthcare professionals.

Information Quality

Quantitative results

Both family caregivers and healthcare professionals rated the PACE-app highly for information quality on the PSSUQ (1.98 vs 1.80 on a 1–7 scale, respectively). Participants agreed that the information on the PACE-app is clear, easy to find, and effective in helping pain management, and they can recover from errors quickly. However, both groups rated the "error messages" item lower (2.9 vs 2.6, respectively), likely due to the limited error occurrences during the one-time usability testing session. Additionally, family caregivers rated "clear organization of information" slightly lower (2.25).

Qualitative results

Qualitative findings provided additional context for these ratings. Key themes included few errors, improving clarity, expanding pain diary options, and expanding pain management strategies. Few participants encountered errors, limiting feedback on error messages so only 8.6% of participants mentioned the error prevention feature. A caregiver (F1) who received error messages shared her experience, "[The app is] telling me exactly what's wrong. So that's a helpful thing." Many users (78.2%) suggested enhancing content clarity for better readability. One caregiver shared her thought, "I think just kind of cleaning up, you know, a syllable check. It's probably about an 11th grade now." Additionally, some experienced caregivers (30.4%) desired more in-depth, actionable pain management strategies and information on medication side effects. Moreover, some caregivers (21.7%) proposed addressing pain management complexities for people with multiple chronic conditions.

Interface Quality

Quantitative results

Both family caregivers and healthcare professionals reported positive overall experiences with the PACE-app's interface (PSSUQ scores: 2.3 and 1.6, respectively, on a 1–7 scale). However, caregivers consistently rated the interface lower across all dimensions: pleasantness, ease of use, and inclusion of expected features.

Qualitative results

Qualitative findings supported with these quantitative results. Although 78% of participants praised the app's aesthetics and clear layout, suggestions for improvement centered on visual enhancements (39.1%) and improved navigation (26%).

Participants overwhelmingly expressed a desire for additional features (73%). A significant proportion (40%) advocated for real-time coaching based on pain diary entries. One caregiver (F4) explained, "Maybe there could be a little bit of a trigger in the pain diary. If I recorded a seven (on the 1–10 pain scale), then I would get a pop-up message." Some caregivers (17.3%) wanted to download pain diary summaries for sharing with healthcare providers. Likewise, several healthcare professionals and caregivers (26.1%) addressed that they would like to be able to send/receive the pain diary or have caregivers contact their clinicians if caregivers notice a change in pain-related information. Moreover, some caregivers offered great suggestions to enhance the function and capability of the PACE-app: improving the app security (26.1%), adding tutorial (21.7%), allowing a centralized account for multiple family caregivers (17.3%), sending reminders to complete pain diary (13%), and offer the PACE-app at a low cost (13%).

Satisfaction

Quantitative results

Quantitative data from the PSSUQ revealed high satisfaction with the PACE-app among both family caregivers (93%) and healthcare professionals (100%). Satisfaction scores on the PSSUQ subscale were 2 for caregivers and 1.60 for professionals (on a 1–7 scale).

Qualitative results

However, only 40% of participants reported satisfaction with the PACE-app.

This may be because the qualitative evaluation were semi-structured guided-app reviews and individual interviews and participants can provide any types of comments.

Discussion and Implications

Key Summary of Findings

This convergent parallel mixed-methods study evaluated the PACE-app's usability and potential improvements among 16 family caregivers and 6 healthcare professionals. Quantitative PSSUQ data indicated favorable user experiences and overall satisfaction for both family caregivers and healthcare professionals. Healthcare professionals reported a more favorable experience than family caregivers in all subscales: system usefulness, information quality, interface quality, and satisfaction. This may reflect caregivers' deeper engagement with the app in supporting daily pain management, leading to more specific feedback.

Qualitative findings complemented the quantitative data, supporting the app's overall usability while providing detailed feedback for enhancement. Participants praised the app's usefulness, ease to use, ease of learning, effective information, aesthetics, clear layout, and satisfaction. However, participants suggested improving content clarity, expanding pain management strategies, and enhancing visual appeal and navigation. Additionally, caregivers proposed real-time coaching based on pain diary entries and the ability to share pain diary data with healthcare providers.

Comparison With Other Studies and Smartphone Apps

Prior research highlighted challenges faced by family caregivers in managing pain for individuals with ADRD, including information gaps, difficulty assessing pain, and hindered caregiver–provider communication (Chi et al., 2022; Pu et al., 2023; Riffin et al., 2022; Tarter et al., 2016). Riffin's study (2022) emphasized the importance of standardized pain scales and written records for improved caregiver–provider communication.

The PACE-app addresses critical challenges faced by family caregivers of individuals with ADRD by providing a comprehensive platform for screening caregiver needs, delivering targeted pain management strategies, and facilitating communication with healthcare providers. Although not a substitute for caregiver–provider interaction, the app effectively complements caregiver–provider relationships. Our findings demonstrate that caregivers valued the app's pain management strategies and found the pain diary beneficial for tracking pain and enhancing communication.

In the current literature, there is a dearth of easily accessible pain management interventions to support family caregivers of people with ADRD (Chi et al., 2020a; Lucero et al., 2022; Shin et al., 2022). Unlike existing smartphone apps that often lack theoretical underpinnings, user involvement, and comprehensive functionality (Lalloo et al., 2015, 2017; Zhao et al., 2019), the PACE-app was co-developed with caregivers and healthcare professionals, guided by self-efficacy theory (Bandura, 1977). This rigorous, user-centered approach resulted in a tool that effectively addresses multiple needs in pain management. The app's positive usability and high user satisfaction highlight its potential as a model for future app development targeting family caregivers.

Implications and Future Direction

Although participants reported a positive user experience, feedback indicated opportunities to enhance information and interface quality. To improve the app before feasibility testing, we will implement suggested modifications, such as allowing caregivers to download and share pain diary summaries.

To further optimize the PACE-app, we envision integrating artificial intelligence (AI). AI-powered apps can leverage user progress, needs, and preferences to deliver personalized treatments and recommendations, improving outcomes for individuals with ADRD and their caregivers (Lo et al., 2018; Piette et al., 2022). By analyzing pain patterns and preferences, an AI-driven app can provide real-time, tailored pain management coaching. This feature will offer personalized strategies, facilitate early detection of potential urgent conditions, and guide caregivers in coordinating with healthcare providers as needed.

Connecting the PACE-app to electronic health records would further streamline communication and care coordination, improving adherence to pain management plans and enabling more responsive treatment adjustments. Future studies should focus on the app's integration with electronic health records, its usability in real-world settings, and its long-term effectiveness in managing pain for individuals with ADRD.

Strengths

The PACE-app represents a pioneering effort to address the complex challenges faced by family caregivers of individuals with ADRD in managing pain. By involving caregivers and healthcare professionals in the development process, the app effectively integrates multiple functions to support pain management, communication, and decision-making. The study's mixed-methods approach yielded valuable insights into user experiences, leading to a highly usable and satisfying app. This rigorous, user-centered development process serves as a model for future app development targeting family caregivers.

Limitations

The study's primary limitations include a small, relatively homogeneous sample, restricting the generalizability of findings. The cross-sectional design, involving only a guided-app tour, precluded assessment of the app's long-term impact and potential changes in caregiver outcomes. Some usability evaluation such as ease of use, learnability, error prevention, and satisfaction may have been underestimated by a lack of familiarity with the app that would develop with use. Additionally, social desirability bias and the controlled study environment may have influenced participant responses and limited our understanding of real-world app usage. The long-term sustainability of PACE-app usage by caregivers without ongoing support from the development team needs further investigation. Future research should address these limitations by expanding the participant pool, conducting longitudinal studies, and exploring the app's effectiveness in real-world caregiving contexts.

Conclusion

This study employed a convergent parallel mixed-methods design to evaluate the PACE-app's usability among family caregivers and healthcare professionals. Results indicated high levels of user satisfaction and favorable usability ratings.

Although participants expressed overall satisfaction, suggestions for enhancing information quality and interface design were provided. The integration of quantitative and qualitative data proved valuable in identifying areas for improvement and tailoring the app to meet user needs.

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Conflict of Interest

None.

Data Availability

Study data are accessible upon request from the corresponding author. The study was not preregistered.

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