Research Article

The Facilitators and Barriers to Digital Health for Managing Nutrition in People With Parkinson’s Disease and Their Caregivers: A Formative, Qualitative Study

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ABSTRACT

Objective: Identify techniques to assist in designing digital health platforms for nutrition services for people with Parkinson’s disease and caregivers to improve their quality of life.

Design: Semistructured, dyadic interviews with 20 dyads (20 people with Parkinson’s disease and 20 caregivers).

Setting: Home visits were conducted in the northeast US.

Participants: People with Parkinson’s disease and their caregivers were recruited via email, flyers, news articles and announcements at support groups.

Phenomenon of Interest: Identification of facilitators and barriers to using digital health platforms to inform future digital nutrition services.

Analysis: Interviews were recorded, transcribed and double-coded using a framework analysis method.

Results: Reported digital health platforms utilization facilitators were: knowledge acquisition, convenience, intention to use, socializing, enjoyment, and forced adoption. Barriers included: negative feelings toward technology, lack of access or knowledge, disinterest, product design, frustration and functional reliability, and applying health information.

Conclusions and Implications: Although dyads often lack knowledge on both how to use technology and nutrition, they are willing to use digital health platforms to increase their nutrition knowledge if platforms are convenient. Based on the identified facilitators and barriers, the added benefits of access and training nutrition digital health platforms must be clearly communicated to end-users to improve their quality of life.

Key Words: Parkinson’s disease, digital health, caregivers, nutrition education, mixed methods (J Nutr Educ Behav. 2023;55:553–563.) Accepted May 23, 2023.

INTRODUCTION

Parkinson’s disease (PD) is a neurodegenerative movement disorder with no known cure,1 and approximately 1 million Americans are diagnosed with it.2 Parkinson’s disease costs the US more than $25.4 billion annually in direct medical costs3 because of disease-related motor and non-motor sequelae, which can impact dietary intake and nutritional status.4 In less than 20 years, the number of people with Parkinson’s disease (PwPD) will increase to more than 1.6 million, costing the US more than $79 billion in total economic burden.5 Progression of disease sequelae increases reliance on informal caregivers to help manage PD, including diet.6 Nutrition care as part of the treatment plan for PwPD is essential because of weight status changes and cognitive, swallow and physical decline.6 Malnutrition is a concern for PwPD and impacts the patients’ mobility and cognition.7 Many PwPD also have concerns around food-medication management, as the most commonly used medication to manage the disease interacts with dietary protein.8 In addition, most PwPD are aged > 65 years,3 an age group already at...
nutrition risk because of age-related physiological changes and barriers to accessing health care such as transportation and mobility.\textsuperscript{9} Thus, there is a need to better deliver information on medical nutrition therapy for PwPD so that it does not get overlooked.\textsuperscript{10}

People with Parkinson’s disease are ideal candidates for using digital health platforms because of their decreased mobility, lack of transportation, the need for visual assessment by their health care team, and informal caregivers to be present at health appointments.\textsuperscript{11} Providing information via digital health platforms, such as videoconferencing, smartphones, and smartwatches, can increase overall health in various populations.\textsuperscript{12} These digital platforms have been successfully used to deliver nutrition services, which included: older adults receiving dietary counseling, those with chronic kidney disease learning effective disease management, and patients on parenteral nutrition support receiving the improved quality of care.\textsuperscript{13–15} Digital health serves as an additional health service resource,\textsuperscript{16} which increases the health care provider’s abilities to collect current visual and objective data,\textsuperscript{17} whereas decreasing patient and caregiver burden and medical expenses.\textsuperscript{18} For example, when PwPD used telehealth for speech therapy, each caregiver saved approximately 92 work hours and more than $1000.\textsuperscript{19} People with Parkinson’s disease report acceptance and satisfaction with digital health,\textsuperscript{18,20} and caregivers are willing to pay for digital health platforms targeting PD.\textsuperscript{21}

Despite the many benefits of digital health, barriers exist to using these platforms for PwPD. For example, cognitive changes and PD-related tremors can make the software and hardware interface difficult for PwPD.\textsuperscript{22–24} Additional barriers include difficulties remembering how to operate the devices, concerns around the clarity of information provided,\textsuperscript{25} lack of added value, technology being time-consuming, compatibility issues, and privacy concerns.\textsuperscript{26}

Previous studies have examined facilitators and barriers to technology adoption and the use of digital health platforms for managing speech therapy and doctors’ appointments for PwPD. However, using digital health for nutrition services with PwPD and informal caregivers has not been explored. We used the technology acceptance model (TAM)\textsuperscript{27} and the transition theory\textsuperscript{28} to inform and guide the development of such research. The TAM provides a basis for understanding external factors influencing end-user perceptions, attitudes, and intentions to use technology throughout all technology development and usage stages. This study concentrated on the early stages of development to inform the creation of a user-friendly, evidenced-based digital nutrition service. The inclusion of informal caregivers is based on the transition theory, an emerging middle-range theory that considers the change from one state or condition to another, such as progressing through disease and becoming an informal caregiver.\textsuperscript{28} As a result, incorporating PwPD and caregivers in early PD care provides dyads with a better understanding of the transition they will face as the caregiver role evolves with disease progression.\textsuperscript{28} Inclusion of informal caregivers in this project is especially important because the informal caregiver will likely use the digital platform as PD progresses.

Applying qualitative methodologies is central to a person-based approach in informing the development of digital interventions to help end-users manage their health or illness.\textsuperscript{29} Before designing nutrition interventions that use digital health platforms and meet unique PD needs, it is critical to engage PwPD and their informal caregivers to facilitate an accessible, easy-to-use, and useful digital platform.\textsuperscript{30} Collecting qualitative data around facilitators and barriers to digital nutrition platform adoption is critical to generating a hypothesis, identifying misunderstandings around the topic, and allowing for a complete understanding of factors to be considered to design an acceptable digital health platform to manage nutrition for PwPD.\textsuperscript{24} Therefore, this study examined facilitators and barriers to using digital health platforms for nutrition services among PwPD and their informal caregivers.

**METHODS**

**Study Design**

This qualitative study was part of a larger, mixed-methods, formative study that sought to better understand the nutritional status and barriers and facilitators to using the technology of PwPD and their informal caregivers.\textsuperscript{8,31} We conducted semi-structured, dyadic interviews during home visits to examine facilitators and barriers to digital health adoption for nutrition services among PwPD (n = 20) and their informal caregivers (n = 20). We interviewed the PwPD and their informal caregiver together, and they will be referred to as dyads. The University of Rhode Island’s Institutional Review Board approved the study as an expedited review.

**Sampling, Recruitment, and Eligibility**

We recruited participants through community centers and support groups, flyers, and emails. Eligibility was determined by the phone before the home visit. People with PD and their caregivers had to be aged ≥ 18 years, community-dwelling, English speaking, and score ≥ 18 (no cognitive impairment) on the telephone-administered version of the Montreal Cognitive Assessment.\textsuperscript{32} Prior technology use was not required. All participants provided written consent to participate in the study at the beginning of the home visit.

Twenty-five dyads expressed interest, and 18 met the inclusion criteria and completed the study. Two dyads were couples in which both participants were living with PD and identified as each other’s informal caregivers. As a result, 20 dyads (20 PwPD and their 20 informal caregivers) were included. The sample size was powered to reach data saturation based on previous qualitative research among PwPD and caregiver dyads.\textsuperscript{13}

**Qualitative Data Collection and Analysis**

The 24-item moderator guide (Supplementary Data) was informed by previous literature, the TAM and transition theory, and input from the
Questions informed by the TAM included questions about accessing health information and how technology may make managing health easier and more challenging. The transition theory informs the methodology of obtaining responses and opinions of both PwPD and their caregiver. Questions informed by the transition theory captured different food choices made because of having PD and how having PD influences their ability to access health information and try new technologies to manage the disease. The moderator guide was reviewed by content experts in nutrition and qualitative research, technology and qualitative research, and clinical Parkinson’s research and piloted and modified based on feedback from 2 dyads. The first author conducted semistructured interviews during a home visit. The interviews were audio-recorded using a digital recorder, and notes were taken during interviews. Operational definitions of technology terms (ie, digital health, smartphones, smart watches, applications, videoconferencing) were provided during interviews and photograph prompts were used to help describe different technological devices and digital health platforms. In this study, nutrition services refer to nutrition screening, assessment, counseling, education, or community-based programs provided by a registered dietitian. The research team estimated that each semistructured dyadic interview would take about 1 hour. Throughout the interviews, the moderator ensured that both the PwPD and caregiver could express and share answers for each question.

Two trained researchers analyzed qualitative data for facilitators and barriers to adopting digital nutrition services using deductive and inductive reasoning by 2 trained researchers. Dyadic interview transcripts were analyzed as one unit of analysis. Nine questions from the moderator guide related to facilitators and barriers were used in the analysis (Supplementary Data). Transcripts were coded using the framework analysis method, a seven-stage, iterative approach that is a form of qualitative content analysis. Audio recordings were transcribed verbatim; the first author checked transcripts for accuracy and divided the transcripts into 3 batches. We took the following steps for each batch of transcripts (stage 1). The researchers read the transcripts and developed a list of initial codes (stage 2). We identified a priori and emerging codes and then categorized these codes as digital health facilitators or barriers; these themes were informed by the literature around technology and digital health adoption for older adults and people with Parkinson’s disease, as well as external factors that can influence technology adoption as described in the TAM. The 2 trained researchers completed preliminary coding and independently double-coded 1 transcript from each batch (stage 3). For these 3 transcripts, we compared preliminary codes and reconciled discrepancies. The 2 researchers outlined a working analytical framework and an agreement on which codes to use for analyzing the remaining transcripts on the basis of the reconciliation of discrepancies in the preliminary coding. This framework and codebook were refined before coding the subsequent batches of transcripts (stage 4). We uploaded the transcripts to NVivo (version 12, QSR International Pty Ltd, 2018), and the researchers coded each transcript. An intercoder reliability of > 80% was achieved for each batch of transcripts. The 2 researchers discussed and reconciled coding differences. The larger research team met with the 2 researchers to collapse and finalize codes as descriptive categories (stage 5). We charted data into framework matrices to display codes (stage 6) and then interpreted them (stage 7). By the 20th interview, redundancy in descriptive categories occurred, and data saturation was obtained.

Several strategies were employed throughout the study to ensure the trustworthiness of the qualitative analysis process. We adopted an appropriate research method to analyze data. Two experts, one in qualitative analysis related to nutrition research and another in qualitative analysis related to technology adoption for aging populations, were included in the research team and consulted throughout the research process (credibility). The lead author and the secondary coder kept a detailed written record of their methodological process, data-related observations, reflective notes around emerging themes, and a codebook with detailed definitions of each code, continuously updated and refined (dependability and confirmability). Finally, transcripts were double-coded in 3 batches by the 2 researchers, and intercoder reliability was calculated after each batch for both barriers and facilitators coded to promote rigor, reflexivity, and foster discussion between the 2 coders (confirmability). The percent intercoder reliability for codes within barriers for each batch was 83.50%, 82.50%, and 81.68%, respectively. The percent intercoder reliability for codes within facilitators for each batch was 84.36%, 83.28%, and 89.94%, respectively. These values are acceptable and reveal strong agreement between coders.

Quantitative Data Collection and Analysis

Multiple tools were used to provide contextual disease and socio-demographic information. The Parkinson’s Disease Questionnaire (PDQ-39), a disease-specific tool, was used to assess the health-related quality of life (QoL) of PwPD; higher scores indicate worse QoL (0% [no disability] to 100% [maximum disability]). The Multidimensional Caregiver Strain Index, an 18-item, Likert-scale questionnaire, assessed caregiver burden. Scores are reported as a percentage, with higher scores indicative of higher caregiver strain. To assess digital competencies, questions were adopted from Measuring Digital Health Skills across the European Union: European Union Wide Indicators of Digital Competence. This 15-item, Likert-scale questionnaire assessed technology use and level of comfort, and responses were quantified as percentages, with a higher percentage indicating higher digital competence. The Dietary Screening Tool (DST) is a 25-item, validated multiple-choice questionnaire used to identify dietary patterns and
nutrition risk; scores were categorized as: at risk (<60), possible risk (60–75), and not at nutrition risk (<75). \(^{44}\) Height was measured in duplicate using a stadiometer and averaged together. Weight was obtained using a digital scale in duplicate and averaged together. These average height and weight values were used to calculate body mass index (BMI = weight/height\(^2\)). Finally, participants completed a short medical history and demographic survey, in which participants provided their identified race, ethnicity, and gender. Quantitative data were analyzed using SPSS (version 26, IBM, 2019). Continuous variables are reported as mean ± SD, and categorical variables were rereported as n (%).

RESULTS

Participant characteristics are summarized in Table 1. Most PwPD (65%) identified as male, and most caregivers (80%) identified as female; all participants self-identified as White, and 1 PwPD identified as Hispanic/Latinx. Average DST scores indicate poor dietary patterns, categorizing PwPD and caregivers as at nutritional risk. The average time for dyadic interviews was 39 minutes (range 21–64). Supporting quotes are provided (Table 2), in which PwPD and their caregivers are identified as PD or CG, respectively, followed by a participant number.

Facilitators to Using Digital Health Platforms

Six descriptive categories were identified as facilitators of using digital health platforms and were reported as a percentage of phrases coded (n = 452 phrases, see Table 2) in descending order from most to least frequently coded.

Facilitator 1. Digital health platforms as a way to acquire new knowledge. As seen in Table 2, all dyads described technology and digital health platforms as an easy way to obtain new knowledge and information, including the news, weather, travel information, crossword puzzle answers, and health information. Some dyads discussed how they used or could use technology to get PD-specific nutrition information, such as managing the interaction between dietary protein and levodopa-containing PD medication. A caregiver acknowledged that diet tracking apps could help manage PD and diet. Many participants described what they wanted to learn via a digital nutrition intervention.

Facilitator 2. Digital health platforms as a way to promote convenience. All dyads acknowledged the convenience of using technology (Table 2). Nineteen dyads explained how technology and digital health platforms were convenient because of easy accessibility to nutrition and health. Twelve dyads also recognized how technology could reduce the burden and time needed to travel to appointments. Six dyads acknowledged that technology would be a convenient tool to maintain independence and access multiple services, including health care, as their PD progresses.

Facilitator 3. Intention to use digital health platforms as a value-added resource. Many dyads expressed interest or an intention to try specific technologies and digital health platforms, such as videoconferencing; all dyads recognized the value-add or return-on-investment that specific platforms might have for helping them manage health-related matters. Dyads with a preexisting interest in technology appeared more inclined or open to trying a new device or software. Nineteen dyads were open to trying new devices or software if it would help them better manage PD or their health (Table 2).

Facilitator 4. Digital health platforms as a way to socialize. Fifteen dyads articulated an affinity for technology that supported human connections, such as communicating with family and friends via texting and email, forming new connections, and/or finding online PD communities (Table 2). Through dyadic interviews, 8 dyads also described their enjoyment of in-person PD support groups or social interaction at exercise classes, suggesting the need for human connection as a facilitator.

Facilitator 5. Digital health platforms as a source of enjoyment. Dyads described enjoyment around technology and/or around food and nutrition. Seventeen dyads described using technology for entertainment, such as playing games, listening to music, taking photographs, and/or watching movies. As seen in Table 2, 1 PwPD described his interest in trying a sock that monitors gait mainly because he enjoyed trying the technology. Five dyads were mainly interested in digital nutrition services for their interest in food and healthy cooking.

Facilitator 6. Use of digital health platforms because of forced adoption. Only 2 participants described adopting technology because it was forced upon them. For example, as seen in Table 2, 1 participant described how her physician required her to use the patient portal.

Barriers to Digital Health

Six descriptive categories were identified as barriers to digital health and are reported as percentages of phrases coded (n = 428 phrases, see Table 2) in descending order from most to least frequently coded.

Barrier 1. Negative feelings toward technology as a barrier to using digital health platforms. There were 3 subcategories within this descriptive category: Overall negative feelings toward technology, junk/skepticism of information technology provides, and information overload. Within the subcategory of overall negative feelings toward technology, some participants revealed negative feelings or preconceived notions and biases toward technology, which are summarized in Table 2. For example, 9 dyads presented with self-ageism, alluding to older age as a barrier to learning technology and lack of human contact (n = 10 dyads) as a barrier to using technology. Seven dyads mentioned the costs of technology as a barrier. Five dyads had privacy concerns associated with technology use. Several dyads noted overdependence on technology as a barrier. Within the subcategory junk/skepticism of information technology provides, 17 dyads described...
distrusting online information because of conflicting dietary information they found online or because of excessive advertisements and junk mail. Within the subcategory, information overload, 13 dyads explained how the constant information, alerts, and/or fear of being constantly connected to devices were barriers. When prompted with possible digital health examples, many participants did not like having multiple devices, such as a separate sensor to track speech, on top of a fitness watch to track steps and heart rate. Many found the abundant nutrition information available online overwhelming, and it was hard to decipher which information was relevant to them. Several participants also noted the dangers of having too much technology and constantly being attached to a device.

Barrier 2. Lack of access and knowledge as a barrier to using digital health platforms. Sixteen dyads revealed they did not have access to certain technologies or know how to use some technologies and/or were unsure how they could benefit from technology. Two dyads reported scheduling conflicts with the timing of live webinars. Thirteen dyads demonstrated concerns around low nutrition knowledge, were unaware that nutrition was a concern for managing PD and/or, as shown in Table 2, they were not coming across nutrition information in their search for information to manage PD.

Barrier 3. Disinterest in using digital health platforms. Eighteen dyads expressed little interest in using certain types of technology to manage health and/or did not see how some of the example technologies discussed during interviews would benefit their health. Five dyads were not interested in dietary changes or accruing more knowledge about their disease as they did not see the benefit of diet for managing PD or improving overall health.

Barrier 4. Poor product design as a barrier to using digital health platforms. Eighty-one dyads reported a dislike with the design of devices and were critical of the product design. Several reported that the product design of devices was not user-friendly or intuitive. Many reported that the devices were too complex or difficult to use, and they were frustrated with the design. Many also noted the product design was not patient-centered and that it did not meet their needs.

### Table 1. Participant Demographics of People With Parkinson’s Disease and Their Informal Caregivers

<table>
<thead>
<tr>
<th>Descriptive Variables</th>
<th>All (n = 40)</th>
<th>PwPD (n = 20)</th>
<th>Caregivers (n = 20)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>68.05 ± 11.2</td>
<td>69.7 ± 9.2</td>
<td>66.4 ± 13.0</td>
<td>39–89</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>17 (42.5)</td>
<td>13 (65)</td>
<td>4 (20)</td>
<td>NA</td>
</tr>
<tr>
<td>Female</td>
<td>23 (57.5)</td>
<td>7 (35)</td>
<td>16 (80)</td>
<td>NA</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>40 (100)</td>
<td>20 (100)</td>
<td>20 (100)</td>
<td>NA</td>
</tr>
<tr>
<td>Hispanic/Latinx</td>
<td>1 (2.5)</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td>NA</td>
</tr>
<tr>
<td>Not Hispanic/Latinx</td>
<td>39 (97.5)</td>
<td>19 (95)</td>
<td>20 (100)</td>
<td>NA</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS diploma/some college</td>
<td>7 (17.5)</td>
<td>6 (30)</td>
<td>1 (5)</td>
<td>NA</td>
</tr>
<tr>
<td>Technical training/trade school/associates</td>
<td>8 (20)</td>
<td>3 (15)</td>
<td>5 (25)</td>
<td>NA</td>
</tr>
<tr>
<td>College degree or greater</td>
<td>25 (62.5)</td>
<td>11 (55)</td>
<td>14 (70)</td>
<td>NA</td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retired</td>
<td>25 (62.5)</td>
<td>15 (75)</td>
<td>10 (50)</td>
<td>NA</td>
</tr>
<tr>
<td>Part time</td>
<td>5 (12.5)</td>
<td>3 (15)</td>
<td>2 (10)</td>
<td>NA</td>
</tr>
<tr>
<td>Full time</td>
<td>10 (25)</td>
<td>2 (10)</td>
<td>8 (40)</td>
<td>NA</td>
</tr>
<tr>
<td>T-MoCA</td>
<td>20.13 ± 1.4</td>
<td>19.8 ± 1.5</td>
<td>20.4 ± 1.1</td>
<td>18–22</td>
</tr>
<tr>
<td>Years since diagnosis</td>
<td>NA</td>
<td>7.6 ± 5.4</td>
<td>NA</td>
<td>0.33–18.0</td>
</tr>
<tr>
<td>Disease burden (PDQ-39)</td>
<td>NA</td>
<td>21.7 ± 3.5</td>
<td>NA</td>
<td>3.12–50.01</td>
</tr>
<tr>
<td>Caregiver burden (MCSI)</td>
<td>NA</td>
<td>NA</td>
<td>12.1 ± 7.9</td>
<td>0–26</td>
</tr>
<tr>
<td>Caregiver Relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spouse/Partner</td>
<td>NA</td>
<td>NA</td>
<td>17 (85)</td>
<td>NA</td>
</tr>
<tr>
<td>Child</td>
<td>NA</td>
<td>NA</td>
<td>2 (10)</td>
<td>NA</td>
</tr>
<tr>
<td>Friend</td>
<td>NA</td>
<td>NA</td>
<td>1 (5)</td>
<td>NA</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.1 ± 5.5</td>
<td>27.09 ± 5.4</td>
<td>28.3 ± 5.7</td>
<td>15.4–43.1</td>
</tr>
<tr>
<td>DST Scores</td>
<td>58.2 ± 10.0</td>
<td>56.95 ± 9.3</td>
<td>59.5 ± 10.7</td>
<td>37–81</td>
</tr>
<tr>
<td>Nutrition risk</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>21 (52.5)</td>
<td>10 (50)</td>
<td>11 (55)</td>
<td>NA</td>
</tr>
<tr>
<td>Possible risk</td>
<td>18 (45)</td>
<td>10 (50)</td>
<td>8 (40)</td>
<td>NA</td>
</tr>
<tr>
<td>Not at risk</td>
<td>1 (2.5)</td>
<td>0 (0)</td>
<td>1 (5)</td>
<td>NA</td>
</tr>
<tr>
<td>Digital competence scores</td>
<td>28.6 ± 12.6</td>
<td>27.5 ± 12.8</td>
<td>29.7 ± 12.6</td>
<td>0–45</td>
</tr>
</tbody>
</table>

BMI indicates body mass index; DST, Dietary Screening Tool; HS, high school; MCSI, Multidimensional Caregiver Strain Index; NA, not applicable; PDQ-39, Parkinson’s Disease Questionnaire; PwPD, people with Parkinson’s disease; T-MoCA, The Telephone-Montreal Cognitive Assessment.

Note: Values are presented as mean ± SD or n (%).
### Table 2. Supporting Quotes for Dyad-Reported Facilitators and Barriers to Technology and Digital Health Adoption and the Percentage of Phrases Coded

<table>
<thead>
<tr>
<th>Facilitator Descriptive Categories (% Phrases Coded)</th>
<th>Supporting Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital health platforms as a way to acquire new knowledge (30.5%)</td>
<td>“[For] a specific question, you can just go on Google, and we’ll ask it and you get all these answers, all these specific answers. I find it very helpful.” [CG18]</td>
</tr>
<tr>
<td>Digital health platforms as a way to promote convenience (26.1%)</td>
<td>“You get information very easily... I was able to ask the question to Google, ‘how many calories in a cup full of berries?’, and I got an answer back.” [PD05]</td>
</tr>
<tr>
<td>Intention to use digital health platforms as a value-added resource (22.1%)</td>
<td>“I love [the patient portal]... because you can ask a question and get it [answered] and you don’t have to worry that you missed the phone call.” [PD20]</td>
</tr>
<tr>
<td>Digital health platforms as a way to socialize (10.6%)</td>
<td>“I would be willing to try [videoconferencing]... Not having to deal with rush hour traffic to maintain an appointment. I wouldn’t miss that at all.” [PD07]</td>
</tr>
<tr>
<td>Digital health platforms as a source of enjoyment (10.2%)</td>
<td>“The ease of information [technology provides]. And I can see as I get more forgetful and I get more multitasking that there will be more technology, like you left the stove on or the sink running or forgot to shut the fridge, you know I can just see a lot of stuff like that.” [PD06]</td>
</tr>
<tr>
<td>Use of digital health platforms because of forced adoption (0.4%)</td>
<td>“I mean, as minimal of an internet footprint as I can have, that’s what I do...however, if there’s something that is going to be a benefit for me for doing that, to improve my health I would be willing to, use something.” [CG01]</td>
</tr>
<tr>
<td>Negative feelings toward technology as a barrier to using digital health platforms (28.8%)</td>
<td>“Oh, so you go to an online conference meeting [with a Dietitian] but you could interact. Sure. I will try anything once. If I find it useful and beneficial, I will do it again.” [PD06]</td>
</tr>
<tr>
<td>Overall negative feelings toward technology</td>
<td>“I like to exchange voice messages as opposed to text messages. I prefer to hear a voice, but I do text occasionally. I text my daughter every morning. She is like a mother hen. I text her every morning that I am okay.” [PD07]</td>
</tr>
<tr>
<td>Use of digital health platforms as a source of enjoyment (10.2%)</td>
<td>“On Facebook there are a couple of Parkinson’s things that I am a part of, and I will do a little bit more interaction there, particularly if someone posts a question that I think I might be able to help them with...I also have someone [who also has Parkinson’s] that I’m tight with on Facebook who I met a couple of years ago...We’ve had different experiences, but I think we each have insights that help each other...I guess we are like a two-person online forum.” [PD11]</td>
</tr>
<tr>
<td>Junk/skepticism of information technology provides</td>
<td>“Because I love using technology. Because I’m just very curious to see how it works and how it measures my movements.” [PD12]</td>
</tr>
<tr>
<td>Digital health platforms as a way to promote convenience (26.1%)</td>
<td>“I wouldn’t mind meeting with a dietitian- that would be fun.” [PD03]</td>
</tr>
<tr>
<td>Jewelry/Skepticism about information technology provides</td>
<td>“I watch a lot of cooking on TV and I get ideas and I think about what you’ve taught us and I see what they are doing and get some ideas.” [PD08]</td>
</tr>
<tr>
<td>My doctor is more digital lately, it seems like more and more. She’ll post, when I’ve gone to see her, they used to give me a print out of the visit, but now it comes to my computer.” [CG13]</td>
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(continued)
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<tr>
<th>Facilitator Descriptive Categories (% Phrases Coded)</th>
<th>Supporting Quotes</th>
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<tr>
<td>Information overload</td>
<td>“A lot of people I know wear Fitbits and Apple watches and they track their sleep and restless sleep. I think if I had that on me, I would be even more restless knowing that it is tracking me. I think that I just try to be as natural as I can and try to enjoy the moment like when I am jogging, I don’t want to try to beat my certain times or track my heart rate. I just want to enjoy the moment.” [CG07]</td>
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<td>Lack of access and knowledge as a barrier to using digital health platforms (23.1%)</td>
<td>“I’d be interested in [a smart watch], if somebody other than you (turns to CG) would teach me... the kids they think you know everything and I don’t catch on as fast as they catch on and then they leave me high and dry and I don’t know what to do, so I don’t use it. But if somebody would teach me how to do it, I’d be interested.” [PD15]</td>
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<td>Disinterest in using digital health platforms (18.7%)</td>
<td>“We haven’t even noticed that there is much about nutrition at all in those pamphlets, it’s a lot about exercise... I guess they say eat a healthy diet, so you gotta know what the healthy diet is.” [CG05]</td>
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<td>Poor product design as a barrier to using digital health platforms (13.8%)</td>
<td>“...I bought him a hydration bottle... it was hard for him to sip it... I worry about how much he drinks, and UTIs and all of that with Parkinson’s... He doesn’t have a [smart] phone, so it’s hooked up to my phone, which doesn’t make all that much sense because your phone is supposed to be near the bottle to gage how much or whatever... he had a very hard time drinking out of it, so it just went to the wayside.” [CG18]</td>
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<td>Frustration and functional reliability with technology (7.9%)</td>
<td>“With my hand, using the phone and texting and stuff is a pain in the butt... And when I talk to Siri she doesn’t understand me all the time...” [CG12]</td>
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<tr>
<td>Difficulty applying health information as a barrier to using digital health platforms (7.7%)</td>
<td>“It never works! I can’t tell you how many days I’ve ruined trying to get a piece of software to work after its already worked and now it won’t accept my password and I can’t get a hold of someone to help fix it, and I start out to do something really simple and run into a roadblock like that.” [PD02]</td>
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CG indicates caregivers; PD, Parkinson’s disease; UTIs, urinary tract infections.

platforms. Product design, mentioned in 14 dyadic interviews, was a barrier because the design of many technological devices was not compatible with PD sequelae and/or aging populations. Such issues included product screens being too small for impaired vision, touch screens and buttons too small or incompatible with tremors, and issues with voice activation to use Siri, Alexa, or voice-to-text. Disease-related changes in cognition can be barriers to using technology. Supporting quotes that describe poor
product design are summarized in Table 2.

**Barrier 5.** Frustration and functional reliability with technology. Eighteen dyads reported frustration when learning to use technology, using technological programs that were time-consuming and/or password management, which caused them to get often locked out of their devices or accounts. Seven dyads described some technology as unreliable because the devices were not working or were broken when needed. As shown in Table 2, some participants described frustration with understanding nutrition information.

**Barrier 6.** Difficulty applying health information as a barrier to using digital health platforms. Eleven dyads felt that not accessing nutrition information via technology was a challenge but applying the information provided to their daily lives to make healthy dietary choices. This included information they found online and from in-person visits with a health professional.

## DISCUSSION

This study explored facilitators and barriers to using digital health platforms reported by PwPD and their caregivers. Dyads used technology daily to obtain information easily, and many who were not accessing nutrition and/or health information saw the potential benefits technology could play in accessing this information. Most dyads enjoyed using technology, especially to stay connected with friends and family and for entertainment and expressed curiosity about trying new devices. Barriers were negative feelings toward using technology, lack of access or knowledge on how to use technology and digital health platforms, disinterest in using technology and digital health platforms, perception of poor product design of certain technological devices and platforms, frustration over the functional reliability of devices, and uncertainties of how to apply nutrition and health information received from health care providers. These unique facilitators and barriers must be addressed when developing digital nutrition services for this population.

The facilitators of technology adoption identified in this study are consistent with previous studies examining technology used by older adults and PwPD. Knowledge acquisition was the most common facilitator. Past research found 75% of PwPD use the internet to find PD-related information.**45** Convenience as a facilitator of technology adoption supports previous research, which cites technology as a strong alternative when in-person PwPD assessments are unavailable.**46** Dyads were interested in using technology when they experienced the potential benefits, such as enhancing their QOL. Similarly, prior research has found that PwPD wants technology that makes their lives easier, does not add additional burden, and has a simple interface that provides tailored nutrition information, which is personalized to meet their dietary needs and preferences.**17,24**

General enjoyment for using technology was a motivator for technology adoption, and dyads were interested in digital products that promote socialization and interaction with the PD community. This is like a prior study**47** that found that older adults were interested in using technology for socialization and enjoyment. Approximately 90% of PwPD forum users reported positive experiences participating in online forums because online PD support forums provide the immediate support needed and facilitate new friendships.**22** Many of our participants valued online social interaction but had mixed views regarding the reliability of health information obtained from online forums. Some remarked they would be open to forums if nutrition experts monitored them. Because of dyads’ technology use for enjoyment and to stay connected with family, future digital nutrition interventions should consider containing a social element and explore how this may reduce social isolation among aging dyads.

We identified several barriers that may deter dyads from using a digital health platform for future nutrition services, even for those actively using technology. Similar to this study, previous research reveals that the excessive information provided by technological devices to manage health is burdensome for PwPD (A.S. Weiss, dissertation, 2020). Some find self-tracking technology a reminder of PD struggles and not helpful.**26** Our participants reported that tracking their health and diet would take too long, provide information they were not interested in, and reduce enjoying life. Interestingly, dietary analyses based on DST scores from this study showed participants had poor dietary quality and were at nutrition risk, as described by participants’ mean DST scores (Table 1). Technology, such as wearable devices, can provide real-time, objective feedback that is continuously and passively collected, which can help enhance patient care by providing accurate information to the health care provider.**49** Although collecting this data requires little work besides wearing the device, there seems to be a misconception among dyads that it is time-consuming and requires active engagement and tracking by end-users.

Previous studies identified technology adoption barriers for older adults, including lack of access to knowledge about, general disinterest, and the cost of using technology.**24,47** Study findings are consistent with previous studies except for cost concerns related to technology; only 3 of our participants expressed concerns about technology-related costs. This could be due to the homogenous sample used for this study who were highly educated, and therefore it is likely that the population from this study had a higher socioeconomic status than the general population. Despite being highly educated, many dyads admitted needing assistance learning certain aspects of technology and had concerns about privacy. This could be due to the participants’ older age, as LoBuono et al**47** found most older adults’ needed help with learning the basic functions of technology, such as orientation on how to use a device or program, creating accounts, and understanding basic cyber security. Having such requests for assistance supports that education in aging populations, including those with PD, is warranted. Lee and Coughlin**18**
reported that older adults were reluctant to adopt technology because they felt it could stigmatize them as less independent. Most PwPD in our study were in the early stages of PD and recognized they did not need certain devices and software at this time but could see as the disease progressed benefits in using certain technologies discussed during interviews to maintain independence and preserve QOL. As a result, our findings may not apply to dyads managing later stages of PD and facilitators, and barriers to adopting digital health nutrition services may differ.

Moreover, poor product design was also identified as a barrier, indicating many commercial devices and programs for the public do not meet the physical and cognitive changes unique to PD and aging. Older adults with a disability are less likely than older adults without a disability to use a wide range of technology because changes related to the disability make it difficult to use or manipulate devices. In addition, PwPD experiences challenges with product design because of motor sequelae such as hitting the wrong buttons, difficulty dragging, zooming or swiping, touch sensitivity issues, and inability to quickly move off a key, in addition to lack of knowledge of how technology works (A.S. Weiss, dissertation, 2020). As with previous research, voice recognition technology was a barrier because the technology was accurate only 50% of the time, as PwPD had difficulty with speech (A.S. Weiss, dissertation, 2020). Our findings and previous research suggest that PwPD will need tailored devices and software applications suitable for physical, cognitive and speech sequelae. Most participants mentioned how they preferred using tablets, consistent with previous studies showing that tablets are the most user-friendly and intuitive hardware device for older adults. Future studies may consider testing nutrition services via a tablet for PwPD and their caregivers once instructions on using the device and accessing the service are provided.

Findings from this study can be incorporated into the TAM and the transition theory when designing acceptable digital health platforms to deliver nutrition services. Understanding the external factors, including dyads’ facilitators and barriers, can help design a product that dyads perceive as useful and easy to use, which in turn can increase dyads’ intention to use technology and promote the adoption of digital health platforms. For example, this study highlights how certain devices, such as the smartphone or smartwatch, may be too difficult for PwPD to manage because of motor sequelae such as tremors and that a tablet may be a more appropriate device for this population. In addition, this study can help inform the transition theory as many caregivers were interested in using technology and digital health platforms to manage their health needs in conjunction with helping to navigate their loved one’s progression of PD. In some dyads, the caregiver was more likely to use technology than their PD counterpart, whereas in other cases, the PwPD expressed a greater interest in using technology to manage health.

Finally, many PwPD in our study recognized that technology could be beneficial as they transition from the early stages of PD to more advanced stages, in which more assistance would be needed to complete daily tasks and manage PD. Future research may also explore developing a software application tailored for PwPD, as our findings suggest some of the popular, commercialized health applications and devices may be too complex for PD and their informal caregivers to navigate. It is important to note that most of our dyads lived together, and caregivers were actively involved in helping PwPD manage their disease. Understanding the technological preferences of both parties of the patient-caregiver dyad will help caregivers effectively use digital health platforms to manage their loved one’s nutrition as the PwPD’s disease progresses and cannot interact with technology as easily. The dyadic interviewing encourages interaction between the participants within the dyad, allowing for more detailed information about lived experience in the specific area of interest. Qualitative data from semistructured interviews provided an understanding of dyads’ facilitators and barriers to technology adoption to manage nutrition and PD. Findings from this study can be integrated into the TAM and the Transition Theory to ensure the future co-creation of a usable and accepted digital nutrition service that takes into consideration the evolving role of the informal caregiver as PD progresses.

This study has several limitations. As a result of our homogenous sample, findings do not represent PwPD in other areas of the US or from marginalized populations. This could be because there are disparities in diagnosing and treating PD in diverse populations. For example, compared to White Americans, there is a decrease in the prevalence and incidence of PD among Black Americans, which could be attributed to undiagnoses of PD in certain ethnic groups because of health disparities and limited access to health care. Finally, the disease stage was requested from the participants’ doctors’ offices, but we were unable to get this information for all PwPD. Given that cognitive dysfunction was an exclusion criterion, our participants were likely in the early stages of PD and less reliant on their informal caregivers. Research on the prevention, diagnosis, and treatment of PD must include more diversity in age, gender and gender identities, race, ethnicity, education and socioeconomic status, and disease staging.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Findings from this study can assist in designing a digital health platform to deliver nutrition services that accommodate PwPD and their caregivers to improve diet quality and nutrition status to enhance QOL. In response to the coronavirus disease 2019 pandemic, digital health platforms have become a convenient, safe way to manage health and meet with health professionals for patients with access to technology. Our data support developing, piloting, and examining the acceptability and feasibility of a digital health platform to deliver a nutrition service across diverse PD communities that are convenient,
include informal caregivers and minimize participant burden. Based on our study, we suggest the following recommendations to consider when designing a digital health platform to deliver nutrition services for PwPD: (1) tailor and personalize digital services to meet dyads’ unique, heterogeneous needs, such as each PwPD presenting with unique sequelae depending on disease stage, (2) clearly communicate the benefits of these digital services to dyads, (3) train dyads on how to use the technology effectively and offer technical support throughout the intervention and (4) consider promoting social interaction with the nutrition expert and members of the PD community while using the digital nutrition service. Implementation of digital nutrition services will make nutrition education accessible to dyads, which in turn could improve QOL and reduce disease, and caregivers’ burden.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at doi:10.1016/j.jneb.2023.05.252.

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