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Acceptance and perception of digital health for managing nutrition in people with Parkinson's disease and their caregivers and their digital competence in the United States: A mixed-methods study

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Abstract

Background and aims: This mixed-methods study examined participants' acceptance and perception of using digital health for managing nutrition and participants' digital competence. The results will be formative for making digital nutrition education more effective and acceptable for people with Parkinson's disease (PwPD) and their informal caregivers.

Methods: Qualitative data were collected through in-person semi-structured, dyadic interviews, and questionnaires from 20 dyads (20 PwPD and their caregivers) in the Northeastern United States and analyzed throughout the 2018 to 2019 academic year. Interview transcripts were deductively coded using the framework analysis method. Phrases related to acceptance of digital health were sub-coded into accept, neutral, or reject and those related to perceptions of digital health were sub-coded into perceived usefulness, perceived ease of use, and awareness of digital health. Quantitative data were analyzed using independent samples t tests and Fisher's exact tests. Qualitative codes were transformed into variables and compared to digital competence scores to integrate the data. An average acceptance rate for digital health was calculated through examining the mean percent of phrases coded as accept from interview transcripts.

Results: Twenty-five of 40 (62.5%) participants used the internet for at least 5 health-related purposes and the average acceptance rate was 54.4%. Dyads rejected digital health devices if they did not see the added benefit. The majority of participants reported digital health to be useful, but hard to use, and about half felt they needed education about existing digital health platforms. There was no difference in digital competence scores between PwPD and their caregivers (28.6 ± 12.6).

Conclusion: Findings suggest that dyads accept and use technology but not to its full potential as technology can be perceived as hard to use. This finding, combined with

digital competence scores, revealed that education is warranted prior to providing a digital nutrition intervention.

KEYWORDS

caregivers, digital health, mixed methods, nutrition education, Parkinson's disease

1 | INTRODUCTION

Parkinson's disease (PD) is an incurable, progressive, neurodegenerative movement disorder that traditionally occurs in the second half of life.[1] Over 900 000 Americans are diagnosed with PD,[2] and it costs the United States over $14 billion annually.[3] Sequelae, or conditions that result from PD, such as postural instability, muscle rigidity, resting tremors, cognitive decline, changes in taste and smell, and constipation,[1] can compromise dietary intake and nutritional status.[4] In spite of these changes highlighting the critical nature of a nutrition professional, it is uncommon to integrate nutrition professionals into the healthcare team for PD.[5] People with Parkinson's disease (PwPD) can have limited access to healthcare providers due to sequelae, age, and location, even with the presence of a caregiver.[6,7] The majority of informal PD caregivers spend up to 40 hours per week providing care.[8] An improved healthcare model that addresses nutrition and includes the caregiver in an accessible format is needed to better facilitate PD management. Digital health broadly describes technologies that better manage and track health status[9] and include videoconferencing, smart phones, internet applications, wearable devices, and online social networks.[10] PwPD could benefit from digital health technologies to increase access and enhance quality of care due to their limited mobility,[11,12] and the need for regular visual assessment.[6]

Two digital health mediums extensively used for managing PD include telehealth (ie, interactive videoconferencing)[13,14] and wearable devices, (ie, technology that collects continuous data overtime).[15] For PD management, telehealth offers healthcare providers with a way to get visual cues of patients that make the visit more objective,[16,17] and provide social support for PwPD and caregivers.[18,19] Economic benefits and high patient satisfaction have been reported by both PwPD and caregivers.[14,20] Speech therapy via telehealth saved each caregiver 48 hours of time, 92 hours of work time, and over $1000.[21] Wearable devices collect continuous data to provide a more realistic portrayal of PwPD's daily behaviors and clinical outcomes overtime compared to subjective data or cross-sectional assessments.[15]

Organizations, including the Movement Disorder Society, promote using clinically relevant and patient-centered digital health to complement in-person health services and provide reliable health interventions.[22,23] Therefore, the development of digital nutrition services must include the needs and preferences of informal caregivers and PwPD as both are confronted with changes in roles and responsibilities, and planning for the trajectory of PD.[22,24] Research indicates that caregivers and PwPD are receptive to technology, especially if there is added value, such as improving disease management.[25,26] However, research has not directly examined the use of digital health

for managing nutrition-related PD concerns. The purpose of this mixed-methods study was to examine PwPD's and their caregivers' acceptance and perception of digital health for managing nutrition and health. This study also aimed to describe participants' digital competence in order to help inform digital nutrition education for PwPD and their caregivers.

2 | METHODS

2.1 | Study design

The current study was part of a larger, cross-sectional study, which examined technology preferences and completed comprehensive nutrition assessments of PwPD and their informal caregivers through a home visit and series of phone interviews. A mixed-methods, convergent, parallel[27] research design was used to collect, compare, and synthesize qualitative and quantitative data from the same sample of PwPD and their informal caregivers to inform the developmental stages for a digital health service by obtaining a better understanding of participants' experiences with digital health, as well as their needs and preferences toward using technology for health- and nutrition-related purposes.[22,28] Ethical approval was provided by the university's Institutional Review Board (HU1819-001).

2.2 | Theoretical framework

This study was based on two theories. The inclusion of informal caregivers is based on the emerging middle-range theory of transitions.[29] This theory elucidates the change from one state or condition to another, and it includes life development stages, like disease progression and becoming an informal caregiver. Collecting data from PwPD and caregivers fills a gap in the literature to provide a more complete perspective to understand the transition dyads specific to PD face.[29] The technology acceptance model (TAM) provides a basis for understanding external factors that influence end users' perceptions, attitudes, and intentions to use technology.[30] The model hypothesizes that perceived usefulness and perceived ease of use jointly determine acceptance, by influencing intention to use and actual technology use.[30]

2.3 | Sampling, recruitment, and eligibility

Study recruitment and data collection occurred between October 2018 and April 2019. Participants were recruited via emails, flyers,

and announcements at PD support groups. Prior to the first study visit, dyads were screened for eligibility; both PwPD and their caregiver had to be community-dwelling, 18+ years old, English-speaking, and both had to participate. All participants needed to score ≥18 on the Telephone Montreal Cognitive Assessment (T-MoCA), a cognitive screening tool.[31] At the beginning of the home visit, both PwPD and caregivers completed the informed consent process and signed consent forms.

Of the 25 dyads that expressed interest, 18 were eligible and 2 of these dyads included couples who were both living with PD and identified as each other's informal caregivers and were double counted as a PwPD and a caregiver. Five dyads did not continue due to scheduling conflicts or low T-MoCA scores. There were 20 dyads (20 PwPD and their 20 informal caregivers) from Rhode Island, Massachusetts, New York, and Connecticut in the final analyses. Ourstudy sample was powered to reach data saturation for the qualitative data; based on prior qualitative research among PwPD and caregiver dyads, the point of saturation was expected to be 20 interviews.[32-36]

2.4 | Qualitative data collection and analysis

The PwPD and their informal caregiver completed the semi-structured interviewers together. The 24-question moderator guide (Appendix I, Supporting information) informed by the previous literature and the research team, was organized to capture three main domains: PD and diet, accessibility of nutrition and health information, and digital health for PD.[25,37-43] From these domains, participants' acceptance and perception were assessed. Prior to starting the study, interviews were pilot tested with two dyads and questions were modified based on participant feedback. Interviews were conducted in the participants' homes by the lead researcher and audio-recorded using a digital recorder. The mean interview length was 39 minutes (range 21-64 minutes). Operational definitions of terms (technology, digital health, smart phones, smart watches, apps, videoconferencing) were provided during interviews. Photo prompts were used to help describe different technological devices and digital health tools.

Qualitative data were analyzed using deductive and inductive reasoning. Transcripts were deductively coded using the framework analysis method, which is a seven-stage, systematic procedure.[44] Transcripts were also inductively coded using Colaizzi's Strategy in Descriptive Phenomenology[45] to identify emerging themes; this interpretative approach draws an understanding of participants' "lived experiences."[46]

After recordings were transcribed verbatim, the lead researcher checked transcripts for accuracy and divided transcripts into three batches (stage 1). The lead researcher and a trained research assistant analyzed one batch at a time. Before coding individually, the researchers read through an entire batch of transcripts and developed a list of initial themes and then coded a priori (stage 2). Both researchers coded one transcript from each batch independently and in duplicate (stage 3). Coding was compared and reconciled for these three transcripts. There was strong agreement between the

researchers on the preliminary coding. During this discussion of preliminary coding, the two researchers developed a working analytical framework and agreed upon which codes to use on the remaining transcripts (stage 4). The transcripts were uploaded to NVivo12 (QSR International Pty Ltd, Australia) and coded separately by the lead researcher and research assistant. The inter-coder reliability was >80% (acceptable) for each overarching theme.[47,48] The two researchers met to discuss coding differences and came to consensus. The research committee and the lead researcher met to collapse and finalize themes (stage 5). Data were then charted into framework matrices using NVivo12 to display codes within each theme (stage 6). The number of phrases coded within themes was summed to calculate frequencies and percentages. Data were interpreted, and connections related to digital competence and technological preferences of PwPD and their caregivers were made (stage 7). By the 20th interview data saturation was obtained as there was a redundancy in the data collected in relation to the themes identified.

2.5 | Quantitative data collection and analysis

To describe participants, PwPD and caregivers individually completed demographics and medical history surveys, along with the Dietary Screening Tool (DST, Appendix II, Supporting information).[49] The DST is a semi-quantitative questionnaire with 25 multiple choice questions.[49] It is validated and used to identify dietary patterns and nutrition risk in older adults, scores were categorized as: at risk (<60), possible risk (60-75), and not at nutrition risk (<75).[49]

Participants individually completed questionnaires around digital competence, technology use, and frequency. To assess digital competence among individual participants, questions were adopted from "Measuring Digital Health Skills across the European Union (EU): EU Wide Indicators of Digital Competence" (Appendix III, Supporting information).[50] This 15-item questionnaire assessed use and level of comfort using technology. For each statement participants responded on a Likert scale ranging from strongly disagree (0 points) to strongly agree (3 points), with possible scores ranging from 0 to 45. Responses for each question were totaled, divided by 45, and multiplied by 100 to get a total percentage score.

Acceptance of digital health was assessed through questionnaires examining technology and digital health use, combined with qualitative data. Technology use and frequency were assessed through questions adopted from previous literature (Appendices III and IV, Supporting information) surveys during the home visit (Appendix III, Supporting information).[51-55] Questions included the forms of technology participants used, how frequently, and 11 yes/no questions regarding if they used the internet for health-related reasons in the past 12 months. Quantitative data were analyzed using SPSSv26 (IBM Corp., Chicago, IL) and descriptive statistics were reported. Caregiver and PwPD group variables were analyzed using independent sample t tests and Fisher's exact tests to ensure the groups were comparable.

2.6 | Data integration

Acceptance of digital health was analyzed by assessing current technology and digital health usage from questionnaires and through themes coded from qualitative interviews. The theme acceptance contained three sub-themes: accept, neutral, and reject, and phrases coded within each sub-theme were counted and totaled. The total number of phrases coded as accept was transformed into a continuous variable, "percent acceptance rate per dyad" by dividing by the total number of phrases coded across the three acceptance sub-themes to calculate acceptance rates among each dyad. A mean of the percentages was calculated to derive the mean dyadic acceptance rate among each dyad. The total number of phrases coded as hard to use were transformed into a continuous variable, "percent of phrases coded as hard to use per dyad," by dividing the total number of phrases coded across the three ease of use sub-themes to calculate the percentage of phrases coded as hard to use in each dyadic interview. Codes from the qualitative interviews were tabulated and then reported as percent and frequencies. A contingency table of frequencies derived from perceptions and acceptance (qualitative data) and digital competence scores (quantitative data) were created and interpreted to describe the population and preferences for a digital health intervention (Table 4). The acceptance rate and the percent of phrases coded as hard to use for each dyad were analyzed as continuous variable. A Pearson correlation was used to explore if there

was an association between the variables: "percent of phrases coded as hard to use per dyad" and "percent acceptance rate per dyad."

3 | RESULTS

Almost all participants identified as Caucasian with the exception of one PwPD identified as Latinx (Table 1). The majority of caregivers were spouses/partners (85%), while two caregivers were children and one was a friend; 80% of dyads lived together.

3.1 | Technology access, usage and acceptance of digital health

All dyads had access to a computer and internet connection at home. The majority of participants (n = 17 PD and 19 caregivers [CG]) owned a smart phone and 60% (n = 11 PD and 13 CG) owned a tablet. Five dyads reported owning an Alexa. One home owned an Amazon Firestick, another had a smart TV, and another reported using a DVR. Most participants (65%) did not own a smart watch (a wearable technology device that measures personal health data, such as Apple Watch or FitBit), while 17.5% reported using a smart watch and 17.5% reported owning but not using one. The reasons dyads used technology and the internet are provided in Figures 1 and 2. Over

TABLE 1 Participant demographics of people with Parkinson's disease and their informal caregivers

Descriptive variables	PwPD (n = 20)	Caregivers (n = 20)	Range
Age (y)	69.7 ± 9.2	66.4 ± 13.0	39-89
Gender, n (%)[†]			
Male	13 (65)	4 (20)	NA
Female	7 (35)	16 (80)	
Education, n (%)			
HS diploma/some college	6 (30)	1 (5)	
Technical training/trade school/associates	3 (15)	5 (25)	NA
≥College degree or greater	11 (55)	14 (70)	
Employment status, n (%)			
Retired	15 (75)	10 (50)	
Part time	3 (15)	2 (10)	NA
Full time	2 (10)	8 (40)	
T-MoCA	19.8 ± 1.5	20.4 ± 1.1	18-22
Years since diagnosis	7.6 ± 5.4	NA	0.33-18.0
DST scores	56.95 ± 9.3	59.5 ± 10.7	37-81
Nutrition risk, n (%)			
At risk	10 (50)	11 (55)	
Possible risk	10 (50)	8 (40)	NA
Not at risk	0 (0)	1 (5)	
Digital competence	27.5 ± 12.8	29.7 ± 12.6	0–45

Note: Data reported as n (%) for categorical variables and mean ± SD for continuous variables.
Abbreviations: DST, dietary screening tool; HS, high school; PwPD, people with Parkinson's disease; T-MoCA, Telephone Montreal Cognitive Assessment.
[†]*P* = .01.

FIGURE 1 Acceptance as measured by general technology use among people with Parkinson's disease (PwPD) and caregivers reported in frequencies. Self-reported technology use among PwPD and caregivers are reported as frequencies and served as a proxy of acceptance. There was no difference in technology between groups
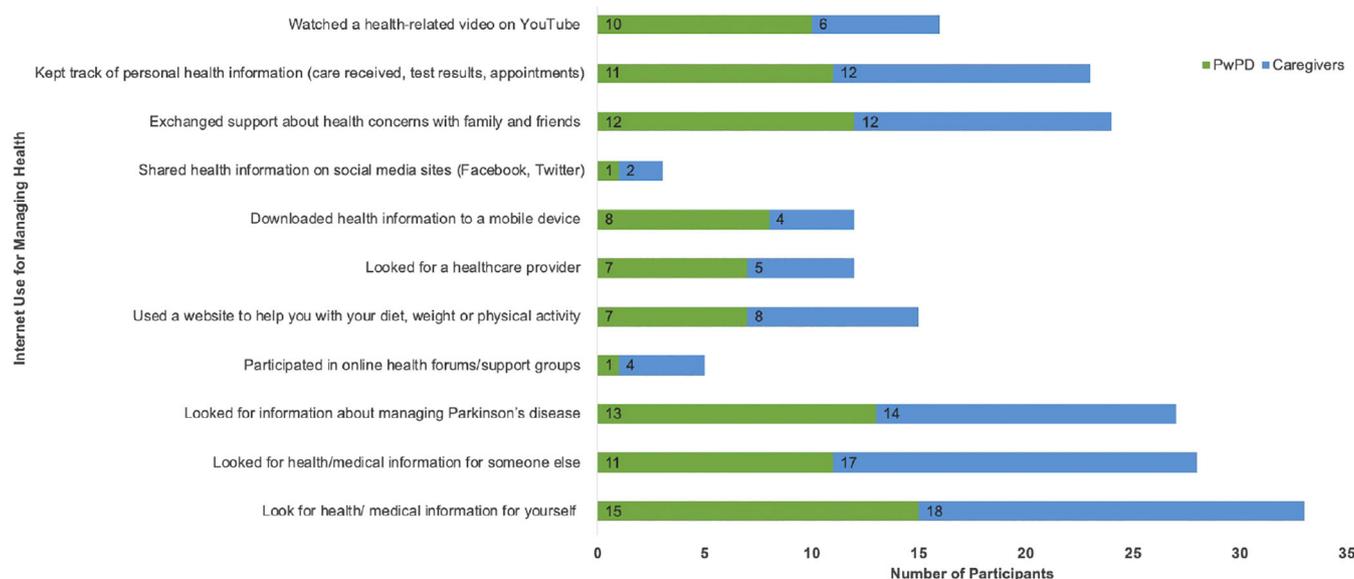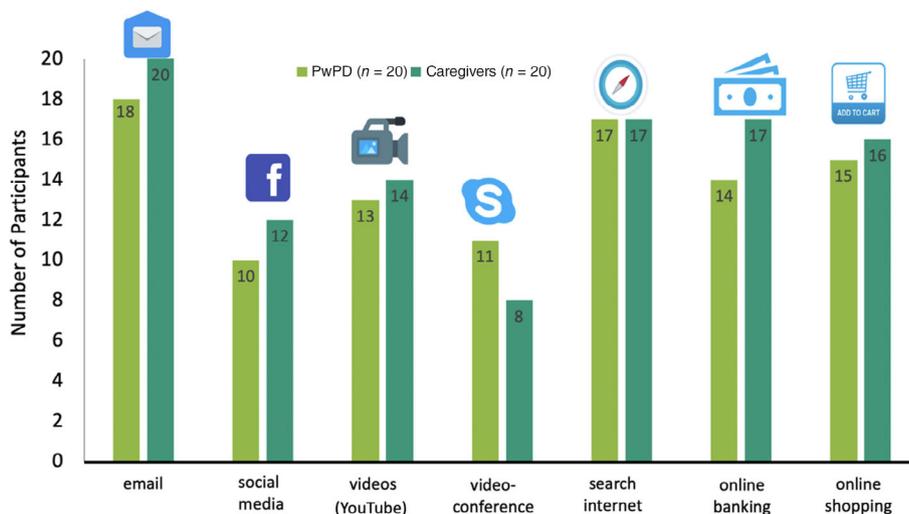
FIGURE 2 Description of internet use for managing health among people with Parkinson's disease (PwPD) and caregivers reported in frequencies. Reasons for internet use self-reported among PwPD and caregivers are reported as frequencies and served as a proxy of acceptance. There is no significant difference in internet use between groups

55% of dyads used social media, watched videos online, and participated in videoconferences, indicating these tools are viable platforms to bring nutrition into the home. Twenty-five out of 40 (62.5%) participants used the internet for at least 5 or more health-related purposes such as looking for health information, looking for information to manage PD, and discussing health concerns with friends/family. One participant reported not using any technology and two participants often participated with the assistance of their informal caregiver.

The theme acceptance of digital health (n = 466 phrases, Table 2), included the sub-theme accept, where dyads described ways in which they used technology in their everyday lives, to manage PD, and/ or their interest in trying new forms of technology to manage health. The majority of participants reported going to the internet first to look up health-related questions, especially for PD issues. Participants reported using

digital health technologies, including: patient portals, automated blood pressure cuffs, glucose meters, webinars, and apps to manage diet (eg, Lose It and the Weight Watchers App) and track steps. Several participants reported setting alarms on their phone as medication reminders

> PD02: We've done the Weight Watchers app, which is very helpful … you can scan a product's label and it tells you how many points per serving.

The neutral sub-theme captured participants' moderate interest in using technology in general and specific digital health services. For instance, when asked if they would like to try a certain digital health medium and why, some participants were only interested in trying the product if it would benefit their provider. When a dyad was asked if

TABLE 2 Themes for acceptance and perception of digital health summarized by number of phrases coded, percent of comments, and number of dyads mentioning acceptance or perception within each category

	Number of phrases coded	Percent of comments	Number of dyads mentioning code/theme within each category
Acceptance	466	—	20
Accept	243	54.4	20
Neutral	109	23.4	20
Reject	114	24.5	19
Perceived usefulness	29	—	11
Useful	22	75.9	10
Neutral	4	13.8	4
Useless	3	10.3	3
Perceived ease of use	104	—	20
Easy to use	22	21.2	14
Neutral ease of use	12	11.5	10
Hard to use	70	67.3	19

they would be interested in taking pictures of meals and snacks for a nutrition professional to review, a caregiver responded:

> CG17: If nutrition was an issue there might be a reason to do it… if the doctor recommended it.

Other participants were interested in trying some products, such as dietary applications and wearable devices, but predicted they would likely lose interest in these platforms over time. For example, when asked if interested in using a Bite Counter, a watch that tracks motion to count bites and estimate calories consumed, PD05 stated:

> If you could tell me that the results would be useful to you, then I would do it as a personal favor.

Other participants said they felt they did not currently need certain digital health platforms but may want to take advantage of them as PD progressed. For example, when asked if interested in using a wearable device to monitor gait changes, PD08 stated:

> I'm not at the place where I need that yet, I'd imagine down the road, maybe.

Finally, some participants discontinued their use of digital health platforms, such as wearable devices and dietary tracking apps. One participant stopped using FitBit due to physical limitations unrelated to PD, which decreased their ability to walk and no longer had many steps to track. This participant reflected,

> PD14: Well when I first got my FitBit and I was kicking out 10,000 a day, and I kept getting all these messages about how good [I'm] doing …

Another participant stopped using his FitBit because it did not have enough technological features.

> PD12: I just stopped using [FitBit] after a while … it didn't have enough features, I did like that it kept track of how often I went up and down the stairs …

The sub-theme reject captured dyads' disinterest in using a form of technology or digital health platforms/services. Some dyads' rejection was related to skepticism of technology in general. For example, when asked if they were interested in using MyFitnessPal, an app to track dietary intake, one dyad stated:

> PD09: I don't think I'm at the risk of eating too much or eating the wrong things.

> CG09: I'm just not interested in knowing that much detail.

When asked how they would like to receive health information, several participants reported preferring hardcopies of literature rather than information provided digitally.

> PD07: I like reading the information, so rather than email or electronic form, I like to see a paper with the information on it. That way I can reference it any time I want.

3.2 | Perceptions of digital health

The perception of digital health category (n = 133 phrases) contained two themes: perceived usefulness and perceived ease of use (Table 2).

Perceived usefulness. Half of the dyads reported digital health or technology to be useful. Many of these participants noted that technological advancement could help them not only manage PD but maintain their independence.

PD06: I think I will be able to stay driving until the day I die because of autonomous cars. I have no problem with it. I think we are very lucky for the age we are— that it is happening now.

Other participants reported finding certain digital health technologies useful specifically for managing diet. When debating the usefulness of MyFitnessPal with her spouse, a caregiver stated:

CG04: We need to be more cognizant of the caloric intake because it affects how much you weigh, and if you lost 15 pounds, your core would be much more manageable.

Half of the participants felt that it would be helpful to work with a nutrition professional to manage eating for PD.

The sub-theme neutral perceived usefulness captured participants' mixed feelings about the benefits of technology or if they were unsure if nutrition services could benefit PD.

CG17: To me a computer is a tool … and I'm not going to sit in front of a screen, when I have other things to do.

PD10: I just type it in and whatever comes up I skim through, and some of it seems valuable and reliable, and some of it seems like a marketing scheme.

The sub-theme useless captured when participants saw little value or benefit from using technology. These participants may have also found nutrition interventions to be useless. For example:

PD04: Some of [technology] is very useful but the majority of it is junk.

Dyads were asked to rate how important they felt it was to follow an eating plan for PD; 45% of dyads agreed that it was important (n = 10 PwPD, n = 8 CG), while 35% (n = 6 PwPD, n = 8 CG) reported they were unsure, were neutral, or felt the question was not-applicable because they had not thought about the importance of healthy eating for PD.

Perceived ease of use. The theme perceived ease of use contained three sub-themes: easy to use, neutral, and hard to use. Almost three quarters of the interviews reported aspects of digital health and technology were easy to use, while 95% mentioned digital health and technology were hard to use. Within the sub-theme, easy to use, participants described that technology helps them access nutrition and health information; several felt that taking pictures of their meals to be reviewed by a dietitian, videoconferencing or receiving health information via email would take little effort and be helpful.

CG13: I can certainly check an email easily. That's probably the simplest, easiest way to get information.

PD11: I think it's easier to make an appointment, you have more flexibility through a skype session.

Some participants perceived digital health and technologies as neither easy or hard to use (neutral ease of use). Participants were actively using technological devices. Reported some annoyances or inconvenience but continued to use technology. One participant summarized her experience with ordering her meal-delivery subscription online:

PD19: [Sun Basket's] a little bit time consuming, when [on the website], I feel I need time to go through it all, but I do it and it's fine.

Within the sub-theme, neutral ease of use, participants also described how they either had not thought to look for nutrition information for PD or felt that finding nutrition information was easy, but interpreting this information was a challenge. For instance, when asked how easy or difficult is it to find information related to healthy eating, 55% (n = 11 PwPD, 11 CG), said it was difficult or somewhat difficult. While 17.5%

TABLE 3 Those participants who responded slightly or strongly agree to individual digital competence questions among people with Parkinson's disease and caregivers

Digital competence question, n (%)	PwPD (n = 20)	Caregivers (n = 20)
Searching and finding information about goods and services	18 (90)	18 (90)
Reading or downloading news/newspapers/news magazines	16 (80)	17 (85)
Using copy/paste tools	13 (65)	13 (65)
Seeking health information	17 (85)	17 (85)
Sending/receiving emails	18 (90)	20 (100)
Using videocalls, such as skype	11 (55)	10 (50)
Participating in social networks	11 (55)	12 (60)
Posting messages on social networks	9 (45)	12 (60)
Uploading self-created content to any website to be shared	7 (35)	7 (35)
Sharing talents and ideas with on social networks	6 (30)	9 (45)
Sharing interests and ideas with those you know	13 (65)	16 (80)
Connecting and installing new devices	12 (60)	12 (60)
Internet banking	13 (65)	14 (70)
Buying or ordering goods or services for private use (last 12 months) over the internet	16 (80)	15 (75)
Making an appointment with a practitioner via a website	12 (60)	14 (70)

Note: Fisher's exact test completed to compare between group differences.
Abbreviation: PwPD, people with Parkinson's disease.

of participants responded neutral or felt the question was not applicable, with the rationale that they did not know nutrition was important or had not been looking for nutrition information prior to this study.

> CG01: [It's] easy to find, difficult to follow.

> CG13: I would say we haven't really looked for it yet.

The sub-theme hard to use captured participants' difficulty with using technology. Most of these difficulties around technology were reported by the PwPD.

> PD09: It's [technology] become more complex I think, that bothers me too. I want it to be simpler like it used to be. It's just become more complex and I just don't know how to do things now.

> PD11: … the cognitive limitations and challenges that come with Parkinson's, you know you can't always read something and immediately translate it into what it is you're supposed to be doing … so sometimes that's

frustrating because if you don't understand it you aren't going to use it.

Some participants stated understanding nutrition information could be a challenge and may impact their experience utilizing digital health to manage nutrition,

> CG12: … I feel that nutrition is a particularly difficult topic because [there's] so much conflicting information out there.

3.3 | Digital competence

There was no difference in total digital competence scores between PwPD and caregivers (27.5 ± 12.8 vs 29.7 ± 12.6). The mean score translated to a 63.6% competence level (Table 1). Responses to individual questions from the digital competence questionnaire are summarized in Table 3. There was no difference in scores between PwPD and caregivers and over 80% of participants felt comfortable finding information, reading or downloading news, seeking health information, and sending emails.

TABLE 4 Data integration: contingency table of digital competence scores (total scores (%)), acceptance rates calculated from semi-structured interviews

Dyads	Percent acceptance rate per dyad	Percent of phrases coded hard to use per dyad	PwPD Digital competence (score (%))	Caregiver digital competence (score (%))
Dyad 13	25.0	50.0	16 (35.6)	29 (64.4)
Dyad 4	31.6	60.0	18 (40)	31 (68.9)
Dyad 8	31.8	100	4 (8.9)	25 (55.6)
Dyad 9	31.8	100	25 (55.6)	4 (8.9)
Dyad 17	31.8	75.0	16 (35.6)	14 (31.1)
Dyad 15	39.3	80.0	21 (46.7)	31 (68.9)
Dyad 18	44.8	83.3	0 (0)	42 (93.3)
Dyad 14	48.1	75.0	32 (71.1)	7 (15.6)
Dyad 16	48.4	50.0	23 (51.1)	35 (77.8)
Dyad 7	50.0	50.0	31 (68.9)	45 (100)
Dyad 12	51.7	55.6	45 (100)	41(91.1)
Dyad 19	57.1	100	19 (42.2)	39 (86.7)
Dyad 1	58.3	50.0	28 (62.2)	8 (17.8)
Dyad 20	69.2	66.7	44 (97.8)	36 (80)
Dyad 10	69.4	87.5	39 (86.7)	40 (88.9)
Dyad 11	69.4	87.5	40 (88.9)	39 (86.7)
Dyad 6	78.9	25.0	41 (91.1)	33 (73.3)
Dyad 3	80.0	0.0	34 (75.6)	25 (55.6)
Dyad 5	80.0	50.0	41 (91.1)	44 (97.8)
Dyad 2	90.0	25.0	33 (73.3)	26 (57.8)

Note: Dyads are presented in order from lowest to highest "percent acceptance rate per dyad". "Percent acceptance rate per dyad" reported which was calculated by dividing phrases coded as accept by total number of phrases coded related to accept, neutral and reject for each interview. The "percent of phrases coded as hard to use per dyad" in each interview was calculated by dividing phrases coded as hard to use by total phrases coded related to ease of use. Digital Competence scores are reported for both PwPD and caregivers and are reported as total score (percentage).

3.4 | Data integration

Individual digital competence scores among PwPD and caregivers, the acceptance rate for each dyad, and percent of phrases coded as hard to use are displayed side-by-side (Table 4). Overall, it appears that dyads with higher digital competence scores had higher digital acceptance rates for technology. These acceptance rates could be influenced by the fact that within several dyads, one person was more comfortable using technology than the other. For instance, within Dyad 01, the PwPD had a much higher digital competence score compared to their caregiver (62.2% vs 17.8%), which may help explain an acceptance rate of 58% and 50% of phrases being coded as hard to use. There was a negative, significant association between the variables: "percent acceptance rate per dyad" and "percent of phrases coded as hard to use per dyad" ($r = -0.522$, $P = .018$). The mean dyadic acceptance rate calculated from dyadic interviews was 54.4%.

4 | DISCUSSION

This is the first study to analyze the acceptance and perceptions of digital health and digital competence among PwPD and their informal caregivers with the ultimate goal to design a digital nutrition service tailored to their needs. Findings from our study showed the majority of PwPD and their caregivers used technology and had access to technological devices that can incorporate digital health apps to facilitate delivery of nutrition services. Dyads reported technology and digital health platforms useful, but hard to use. Digital competence scores and interview responses provided insight to aspects of technology where PwPD and caregivers need education and support. Digital health may be a viable mechanism to increase access to nutrition information related to managing PD, but the added benefits of these services must be clearly communicated to participants. This study is timely given the increased adoption of digital health to deliver remote care for at risk populations in lieu of COVID-19.[56] As a result, healthcare delivery post-COVID-19 will likely incorporate more remote delivery.

This current study expands upon previous research by specifically examining the acceptance and perceptions of technological platforms to receive nutrition information, interact with nutrition experts, and include opinions of caregivers. Dyads were interested in specific aspects of technology for assisting with managing PD and nutrition. For instance, dyads expressed interest in videoconferencing with a dietitian, receiving nutrition email updates or taking photos of their food to be reviewed by a dietitian, but were not interested in tracking food or steps or using wearable devices unless requested by their healthcare provider. Findings from this study showed a convenient, user-friendly digital health intervention that provides tailored nutrition information could be an acceptable way to provide care for this population. These findings are in agreement with previous research that has found PwPD and their informal caregivers are interested in using digital health tools for managing PD[18,57] and is exemplified by over 11 000 views on a recruitment page for a study testing virtual house calls.[57]

Future research should explore if demographics, such as age, can influence PwPD's and their caregivers' acceptance of digital health tools to manage nutrition. In a study completed by Duroseau et al,[55] nearly 65% of PwPD reported they were willing to use electronic methods and 48% believed using technology to communicate with providers would help them to better understand their care.[55] However, those 65 and over were less likely to believe using technology to communicate with a healthcare provider would enhance their understanding of care.[55] Duroseau et al[55] attributed this to the thought that older patients may not be as comfortable with using technology. This research, along with the current study, indicates training older PwPD may be warranted.[58] Future research determining optimal communication platforms for digital nutrition services among PwPD and caregivers may need to investigate by demographics.

Findings from qualitative analyses revealed that dyads perceived technology and digital health to be useful, but hard to use. Participants self-reported challenges using technology that indicate some training or support will be needed to effectively provide digital nutrition interventions for PwPD and caregivers. These perceptions expand upon previous research examining views of PwPD around digital health. Past research has focused on one specific form of technology, while our research has focused on how different forms of technology may be used specifically to manage nutrition. For example, participants who needed trained professionals present to assist with technology during a videoconference session were more likely to discontinue utilizing the service vs those who had not needed help with the technology.[59] Contrary to our findings regarding wearable devices, Ozanne et al[25] reported that PwPD in Sweden perceived wearable sensors to be cost-effective, improve treatment, facilitate diagnostics, and decrease number of hospital visits and subsequently participants felt these benefits outweighed the inconvenience of wearing a sensor. Similar to our findings, participants in this study perceived that interpreting digital nutrition and health information could be challenging.[25]

Findings of the current study support the need for training of digital health mediums among PwPD and their informal caregivers before implementing a digital health intervention. The quantitative and qualitative data aligned when exploring technology use and areas of digital competence. Most participants are comfortable with corresponding via email and searching for health information and services. However, installing new devices and using social networks may be problematic for some participants. Future research should look to models such as Cyber Seniors, an intergenerational program where college and high school students help older adults learn about technology and how to use it[51,60] to increase digital competence and perceived ease of use. Additionally, more information is needed about PwPD's and caregivers' knowledge of nutrition for managing PD and health literacy to ensure this population is accessing accurate and reliable nutrition information.

This is the first study to explore the association between technology perceptions and acceptance among PwPD and caregivers. There was a significant, negative association between "percent acceptance rate per dyad" and "percent of phrases coded hard to use per dyad." This relationship combined with the lack of awareness of digital health

among dyads and how nutrition can help manage PD, may help explain why dyads rejected certain digital health mediums. Finally, within dyads, digital competence scores varied, with one person within the patient-caregiver dyad having a higher digital competence score than the other. This may account for the acceptance rate falling just above 50%. Future research should explore ways to increase the acceptance rate among PwPD and caregivers, as well as educating dyads about how digital health can enhance disease management. Research should also explore the facilitators and barriers for digital health adoption.

Our study design was chosen to promote patient- and caregiver-centered care for managing PD symptoms and justifies nutrition professionals and caregivers as important members of the healthcare team. Additionally, the utilization of mixed-methods study design provided an in-depth understanding of dyads' perception, acceptance, and current level of digital competence. The use of semi-structured dyadic interviews is a strength, as dyadic interviews promote interaction between participants to help provide detailed information with regard to their experience on the topic of interest.[61] Findings from this study can be incorporated in the TAM and the emerging middle range theories of transition.

This study had several limitations. Our participants were educated, White, had access to technology, and were from the northeast region of the United States. As a result, findings may not be generalizable to PwPD in other regions of the country or from marginalized populations. Another limitation is that though items were adopted from the European Union Wide Indicators of Digital Competence, which has been used to create a digital competence framework,[62] it is not a validated instrument. Finally, requests for disease stage were sent to physician offices for personal health information, but this information for all PwPD was not obtained.

Results from this study can be used to help design and implement an effective digital nutrition service that is tailored to PwPD and caregivers to improve quality of life. The benefits of utilizing technology and healthy eating must be clearly communicated to PwPD, caregivers, as well as the medical community and health insurance companies for this service to be accepted. Our findings suggest that training of the service should be provided prior to implementing an intervention. Experts suggest when designing digital health interventions specifically for PwPD, developers should consider both PwPD and caregiver views, needs and preferences.[22,55] These remote services can help increase access to nutrition information among PwPD and caregivers and have the potential to improve health-related quality of life, disease and caregiver burden.

5 | CONCLUSION

This mixed-methods study focused on describing the acceptance and perceptions of digital health to manage nutrition for PwPD and their caregivers, and their level of digital competence. Results indicated mixed acceptance rates for technology and digital health platforms among dyads, possibly due to many participants perceiving digital

health as useful, but hard to use. Digital competence scores suggested dyads participating in a digital health nutrition intervention will need some training prior to study participation. Findings from this study complement existing literature regarding digital health for managing PD and help to better understand the opportunity to use digital health as an avenue to include nutrition and caregivers in the PD care plan. Future studies should explore digital health and technology as tools to provide evidenced-based nutrition and health knowledge to PwPD and caregivers. Prior to launching a digital health service to manage nutrition, dyads will need training and technical support.

CONFLICT OF INTEREST

The authors of this manuscript declared no conflict of interests with respect to research, authorship, and /or publication of this manuscript.

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All authors have read and approved the final version of the manuscript.

Dara LoBuono had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis."

TRANSPARENCY STATEMENT

Dara L. LoBuono, the lead author, affirms that this manuscript is an honest, accurate, and transparent account of the study being

reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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