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ORIGINAL RESEARCH ARTICLE

Attitudes Toward the Adoption of Remote Patient Monitoring and Artificial Intelligence in Parkinson's Disease Management: Perspectives of Patients and Neurologists

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Abstract

Objective Early detection of Parkinson's Disease (PD) progression remains a challenge. As remote patient monitoring solutions (RMS) and artificial intelligence (AI) technologies emerge as potential aids for PD management, there's a gap in understanding how end users view these technologies. This research explores patient and neurologist perspectives on AI-assisted RMS.

Methods Qualitative interviews and focus-groups were conducted with 27 persons with PD (PwPD) and six neurologists from Finland and Italy. The discussions covered traditional disease progression detection and the prospects of integrating AI and RMS. Sessions were recorded, transcribed, and underwent thematic analysis.

Results The study involved five individual interviews (four Italian participants and one Finnish) and six focus-groups (four Finnish and two Italian) with PwPD. Additionally, six neurologists (three from each country) were interviewed. Both cohorts voiced frustration with current monitoring methods due to their limited real-time detection capabilities. However, there was enthusiasm for AI-assisted RMS, contingent upon its value addition, user-friendliness, and preservation of the doctor-patient bond. While some PwPD had privacy and trust concerns, the anticipated advantages in symptom regulation seemed to outweigh these apprehensions.

Discussion The study reveals a willingness among PwPD and neurologists to integrate RMS and AI into PD management. Widespread adoption requires these technologies to provide tangible clinical benefits, remain user-friendly, and uphold trust within the physician-patient relationship.

Conclusion This study offers insights into the potential drivers and barriers for adopting AI-assisted RMS in PD care. Recognizing these factors is pivotal for the successful integration of these digital health tools in PD management.

Key Points

Individuals with Parkinson's disease and neurologists expressed interest in AI-assisted remote patient monitoring.

The successful uptake hinges on clear clinical advantages, user-friendliness, and maintaining trust between doctors and patients.

Acknowledging these motivators is vital for effectively embedding AI and remote monitoring tools in PD care.

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1 Introduction

Parkinson's disease (PD) is a chronic degenerative disorder of the central nervous system [1], affecting approximately 8.5 million people in 2019 [2], with projections to affect more than 12 million by 2040 [3]. People with PD (PwPD) exhibit motor disturbances such as tremors and stiffness, alongside non-motor challenges such as anxiety and cognitive issues [1]. As PD progresses, complications amplify, heightening the dependency on caregivers [4–6]. This progression affects not only the well-being of patients, but may also place strain on the financial stability of both patients and their families [7, 8].

Early and accurate diagnosis of advanced PD remains elusive due to varied progression rates across individuals and the absence of a definitive biomarker [9]. Studies indicate that many individuals with advanced PD often go unrecognized [10, 11]. To monitor PD progression and enhance diagnostic precision, the adoption of remote monitoring solutions (RMS) using wearable (smartwatches or body-attached sensors) and non-wearable (smart medication dispensers or in-home video cameras) devices has been recommended [12–14]. These devices offer objective, continuous tracking of PD symptoms within the patient's natural living environment, capturing a range of data from motor symptoms (such as tremors, rigidity, and gait issues) to non-motor symptoms (such as sleep disturbances and cognitive changes), along with medication adherence and activity levels (steps taken, overall mobility) [15]. When these extensive data are combined with electronic medical records and patient-reported outcomes, it becomes a rich source for analysis. Leveraging artificial intelligence (AI), and particularly machine learning techniques, enhances our ability to extract significant insights from these data. AI can identify patterns in the patient's symptoms, enhancing the capacity for the early detection of advanced stages of the disease [16–18].

Though current treatments do not halt the progression of PD, invasive symptom-management therapies that are particularly effective in managing symptoms in advanced stages of the disease have become available in recent years. Among these, deep brain stimulation (DBS), L-dopa-carbidopa intestinal gel (LCIG) and apomorphine infusion have proven to offer superior symptom control beyond what conventional pharmacotherapy can achieve [19]. These therapies not only provide a more stable and consistent management of symptoms but also offer the possibility of reducing the dosage of oral PD medications, thereby minimizing their side effects [19]. Consequently, early detection of advanced PD is crucial. It opens the door to offering these invasive treatments to selected patients, marking a significant step in enhancing the quality of life for those with advanced PD [20–22].

Although the integration of AI and RMS into PD management holds significant promise, their clinical adoption has been hindered by various complex challenges including concerns about confidentiality, data security, and privacy [23]. Additionally, post-data collection, adoption is hindered by other hurdles, including a certain degree of skepticism among medical professionals and patient reluctance to engage with and adhere to remote monitoring [24, 25]. To maximize the potential of these technologies, it is essential that they are tailored to meet the needs of PwPD and neurologists. The success and effectiveness of these tools are fundamentally dependent on their actual adoption in clinical practice; without it, their intended benefits remain unrealized. Hence, our study seeks to address this gap by exploring the viewpoints of PwPD and neurologists regarding the utilization of AI-enhanced RMS.

2 Methods

To meet the objective of this study, a qualitative approach was used that was composed of semi-structured interviews and focus groups with PwPD as well as semi-structured interviews with neurologists. We chose this approach for its strengths in yielding a deeper and more nuanced understanding of the subjects. Qualitative research is particularly effective in capturing the complexities of human experiences, perceptions, and behaviors, which are essential to the core of our study [26]. Both the methods and reporting followed the Standards for Reporting Qualitative Research guidelines [27].

2.1 Context and Ethics

The study sites were chosen for their role in the AICCELERATE project [28], a large European Union (EU)-funded collaboration aimed at advancing AI healthcare solutions. One of the use cases within this consortium is an AI-assisted remote monitoring system to track and predict the progression of PD. This system is currently under development and testing at Helsinki University Hospital (HUS) in Finland, and at the University of Padua (UNIPD) in Italy, the two sites included in the current study.

The study was conducted according to the principles of the Declaration of Helsinki and in accordance with the Medical Research Involving Human Subjects Act (WMO) and was approved by the local ethics committees at HUS, UNIPD, and Erasmus University Rotterdam. An informed consent was obtained from all interviewees before participation. Participation was voluntary and no material incentive was given.

2.2 Recruitment

We sought to carry out four focus groups (two in Finland and two in Italy) with six to eight PwPD per group, as well as six individual PwPD interviews (three in Finland and three in Italy). Participant recruitment for our study was conducted through purposeful sampling at the outpatient clinics of HUS and UNIPD [29]. Given the specific nature of our research, alongside insights from prior studies in this field and the experience of our research team, we anticipated achieving saturation with 30 patients [30–32]. Interested individuals were screened over the phone by a research assistant. During the screening call, the interview procedure and study objectives were described, and any questions about the study were addressed. Participant eligibility was confirmed at this stage. An informed consent document was sent via email for interested and eligible individuals to review. The intended end-users of the technology were patients at risk of developing advanced PD. Therefore, adult PwPD with a minimum of 2 years with PD diagnosis using levodopa at least three times per day were included. PwPD without good proficiency of the national language where the focus group or interview was being held, as well as PwPD who received, or were receiving, treatment with DBS or LCIG were excluded, as these PwPD already have advanced PD [33].

Prior experiences with wearable and non-wearable devices were considered an important starting point of the focus group discussions. Consequently, we decided to organize homogeneous focus groups from this point of view (i.e., a focus-group of PwPD with past experiences with remote monitoring solutions, and a focus group of PwPD with no experience with these technologies within each country). In each focus group we aimed for heterogeneity in terms of age, gender, education, and privacy concerns. This latter dimension has been considered as particularly important given its potential influence on the user's willingness to use devices for RMS. To gauge this dimension accurately, we incorporated a specific query about privacy concerns related to sharing personal data online during the initial screening calls with potential participants [39].

Neurologists were recruited informally through a comprehensive regional network known to the research team from HUS and UNIPD. Interested individuals received a participation information sheet via email and were invited to contact the research team if they wished to participate. Purposeful sampling was used to capture a broad range of perspectives within potential end-users of the AI-assisted RMS [29]. We sought to recruit a group of six general neurologists (three in Finland and three in Italy). The selection of these clinicians was based on the understanding that, as non-specialists in PD, they are prime candidates to benefit from the insights provided by AI-assisted RMS. General neurologists were considered neurologists not specialized in movement disorders who see a wide range of neurologic conditions, including on average between one and five PwPD per week. To collect heterogeneous experiences and opinions, we selected neurologists with different ages, genders, and years of professional experience.

2.3 Data Collection

Between November 2021 and August 2022, interviews with PwPD and neurologists were conducted by a four-person research team (C.G., F.M., L.M., W.D.). Of the team, F.M., L.M., and W.D. (one male, two female) collectively boast more than two decades of postdoctoral experience in qualitative health services research. They, being unfamiliar to the participants, along with C.G. (male, Ph.D. candidate), carried out all the interviews. Both English and local languages (i.e., Finnish or Italian) were used depending on the participants' proficiency level. For each session, in addition to the lead interviewer, a secondary researcher was present to record notes (C.G., P.O). Patients interviews and focus group sessions in Finland occurred through videoconference. In contrast, while individual patient interviews in Italy utilized Microsoft Teams, focus groups were held in person at the UNIPD outpatient clinic. Neurologist interviews were hosted individually via Microsoft Teams. A semi-structured interview guide (Supplementary Exhibits 1–5) shaped by literature review and expert insights steered discussions on disease progression detection, current monitoring methods, and perspectives on AI-assisted RMS. PwPD were offered illustrative materials about the project during these sessions, such as images of RMS (wearable and non-wearable devices, Supplementary Exhibit 6). All interactions were audio-recorded, transcribed verbatim, and translated into English as needed.

2.4 Data Analysis

A qualitative thematic analysis with an abductive approach (i.e., the use of interactive cycles of deductive and inductive reasonings) was employed by two researchers (C.G. and F.M.) [34]. Initially, this process involved the identification of a preliminary set of categories, including themes and subthemes related to AI and remote monitoring methods in PD, drawing from existing literature and defined research objectives. During the coding process, text fragments relevant to these initial themes were identified, while simultaneously allowing for the emergence and definition of new themes to categorize data not aligning with the preestablished categories.

The two researchers reviewed the transcripts independently, which were translated into English.

Subsequently, a coding frame was developed, modified, and refined as new themes and subthemes emerged throughout the analysis (Supplementary Exhibit 7). To maintain the trustworthiness of the analysis, the resulting themes and subthemes were discussed among coders until a final consensus was reached [29].

3 Results

We conducted five individual interviews with PwPD (four with Italian participants and one with a Finnish participant) and six focus groups (two with Italian participants and four with Finnish participants), engaging a total of 27 PwPD. In Finland, three PwPD who were initially chosen for individual interviews opted out and were subsequently included in the focus groups. Focus groups averaged 67.5 (range 54–92) min, while individual interviews averaged 54 (range 44–77) min in duration. Of the 27 participants, 16 (62%) were male and 11 (54%) had used wearable devices before, and 3 (12%) voiced major privacy concerns. The average participant age was 68 years (range 53–81 years; Table 1). Having conducted interviews and focus groups with 27 participants, we arrived at a stage of data saturation, evidenced by the lack of new insights in the interviews with the last two patients. Consequently, we made the decision to conclude the data collection process at this stage.

We carried out six interviews with neurologists, three from Finland and three from Italy. Each session averaged 58 (range 47–68) min. The median age of the neurologists was 50 (range 38–71) years, with a median of 10 years of practice in neurology (range 7–39 years). Two of the neurologists were men and four were women. Finnish neurologists reported a higher median number of weekly consultations with PwPD (median 6, range 5–7) than their Italian counterparts (median 2, range 1–10). A summary of the characteristics of interviewed neurologists is given in Table 2.

Table 2 Characteristics of neurologists participating in the interviews.

	Neurologists' interviews, Finland	Neurologists' interviews, Italy
Number of interviews	3	3
Participants' gender, M/F	1/2	1/2
Duration in min, average (range)	53 (47–58)	59 (58–68)
Age, average (range)	42 (40–61)	59 (38–71)
Years of professional experience, median (range)	9 (9–39)	11 (7–35)
Number of weekly PD[a] patient consultations, median (range)	6 (5–7)	2 (1–10)

[a]Parkinson's disease (PD)

From the analysis, four major themes emerged: PwPD's and neurologists' experiences and frustrations with current PD management; expectations of RMS in PD; AI, PD, and the decision-making process; and barriers to and facilitators of the use of RMS and AI (Table 3).

3.1 PwPD's and Neurologists' Experiences and Frustrations with Current PD Management

In the current follow-up process, neurologists described that they primarily rely on the narratives from PwPD and informal caregivers as to symptoms and daily functioning to recognize disease progression. However, despite the best efforts of PwPD and caregivers, the information they receive during the appointments could be incomplete or imprecise. PwPD may have difficulty accurately summarizing their response to medication, and it is complex for them to recall past events, especially for those with some degree of cognitive impairment. In addition, neurologists pointed out that some PwPD may not tell the truth, perhaps out of shame for not following treatment recommendations or fears associated with the social acceptability of certain symptoms (*Q#1*).

Table 1 Characteristics of patients participating in the interviews and focus groups.

	PwPD interviews		PwPD focus groups	
	Finland	Italy	Finland	Italy
Number of PwPD[a] in interviews/focus groups	1	4	13	9
Participants' gender, men/women	0/1	3/1	8/5	5/4
Duration in min, average (range)	44	60 (44–77)	62 (54–78)	80 (69–92)
Age, average (range)	63	74 (65-81)	63 (55–80)	65 (53–75)
Years with PD, median (range)	2	13 (6–18)	6 (2–33)	7 (4–14)
Experience with wearables or non-wearable devices, yes/no	0/1	4/0	6/6	4/5
Privacy concerns, yes/no	1/0	0/4	0/13	2/7

[a]People with Parkinson's disease (PwPD)

Table 3 Overview of themes and subthemes that emerged from the analysis.

Themes	Subthemes
PwPD's and neurologists' experiences and frustrations with current PD management	
Expectations of RMS[a] in PD	Increasing symptoms' awareness
	Supporting treatment adherence, safety, and independent living
AI, PD, and the decision-making process	
Barriers and facilitators to the use of RMS and AI	Perceived benefits
	Integration into daily routine
	Privacy
	Accuracy
	Maintenance of the human factor in care

[a]*RMS, remote monitoring solution*

Q#1—"Well, sometimes the patients don't tell us the things we want to know. During the medical appointment, you can get a wrong picture of the situation. There are different reasons for that. Sometimes they [patients] are not following the treatment recommendations and sometimes they [patients] are not completely open about their symptoms. Or it's just too hard for them to bring up all the things." ***Neurologist 4***

The duration of the medical appointment was mentioned as a barrier by both PwPD and neurologists. Both agreed on the fact that the consultation time is too short to do a complete assessment (Q#2). Moreover, neurologists pointed out that because of PD's characteristics, some signs of disease progression may remain unnoticed during the physical examination, and current instruments to classify and stage PD are time consuming and do not fit in the clinical routine (Q#3, Q#4).

Q#2—"I experience side effects with the medications. This is something that unfortunately I can't get [address] in the appointments with the doctor, given that [the consultation time] everything comes down to a lapse of time of 30 minutes." ***Patient 1***
Q#3—"The moment you are with the patient in the clinic really doesn't tell you much about how he/she manages at home or the daily life. The patient might be doing very well in the clinic and doing extremely poorly at home." ***Neurologist 6***
Q#4—"I have 20 minutes per patient, it is unthinkable to apply certain scales." ***Neurologist 2***

3.2 Expectations of RMS in PD

Expectations of RMS in PD included two subthemes. The first subtheme revolved around increasing awareness of symptom among PwPD and neurologists. PwPD anticipated that RMS would allow them to track the progress of symptoms, identify patterns, and effectively communicate their experiences with their healthcare provider, thereby facilitating the challenging task of describing their daily functioning and medication response in detail during medical appointments (Q#5, Q#6). In parallel, by remotely monitoring symptoms, medication responses, and disease progression, doctors anticipated gaining more objective insights into the patient's individual disease trajectory, surpassing the limitations of PwPD's self reporting narratives and physical examination alone. This increased awareness might enable doctors to make more informed clinical decisions, tailor treatment plans, and provide personalized care (Q#7).

Q#5—"I think it [remote monitoring devices] can improve one's [a patient's] status awareness and knowledge." ***Patient 7***
Q#6—"[Remote monitoring devices would] help patients to be aware and help the physicians. Data collection is improved with this in my opinion, so the physician can also use it [the information] more effectively." ***Patient 8***
Q#7- "Maybe I see [using remote monitoring] that in the last 6 months he [the patient] has fallen much more than in the previous year, then it means that he is getting worse, he doesn't respond anymore to the drug." **Neurologist 2**

The second subtheme identified was "supporting treatment adherence, safety, and independent living," which was mentioned solely by PwPD. They expected that RMS could automatically detect falls and generate alerts to family or neighbors to ensure timely and safe care (Q#8). Additionally, these solutions were believed to have the capacity to provide reminders that support medication adherence. By incorporating these features, RMS possess the potential to empower PwPD, enabling them to maintain a higher level of independence in their daily activities, thereby enhancing their overall well-being and quality of life (Q#9).

Q#8—"There should be a fall warning function, so that if someone is stationary for too long and does not move at all, it would alert [a relative, a neighbor]. I would use something like that." ***Patient 18***
Q#9—"Have I remembered to take my medication? Something beeps. Sure, if my memory is failing…" ***Patient 14***

3.3 AI, PD, and the Decision-Making Process

Participants also described their expectations regarding the contribution of AI to the clinical decision-making process when used in combination with RMS in PD. PwPD and neurologists envisioned AI as a decision support tool. They shared the belief that AI may be a helpful instrument to support medical decisions by gathering and summarizing patients' clinical information, identifying patterns, and proposing best courses of action (Q#10, Q11). Participants imagined that this would eventually translate into better therapeutical choices, better therapeutic regimens, and improvements in symptom control. Importantly, neither PwPD nor doctors anticipated AI to make decisions autonomously, highlighting the importance of human judgment in the clinical context.

Q#10—"In my opinion what artificial intelligence should be doing is letting us know what the right medication might be and in what order to start it and what dose for that individual patient based on the clinical phenotype." **Neurologist 3**
Q#11—"It [AI] is trained and taught to generate the best suggestions, so AI would likely generate the suggestions that are most likely to be right, which could be used [by doctors]." **Patient 19**

3.4 Barriers and Facilitators

Interviewees described a variety of barriers and facilitators to the use of RMS and AI in PD management. Facilitators included the perceived benefits of the technology and seamless integration of the technology into daily life. Privacy concerns, confidence in the technology, and the fear of losing human touch emerged as primary reasons for reluctance towards embracing technology.

3.4.1 Perceived Benefits

For PwPD, benefits were described as a crucial element for the acceptance and adoption of RMS and AI in PD management (Q#12). PwPD described that they would overcome the inconveniences brought by the technology and would be willing to use monitoring devices on a daily basis for a prolonged period of time if there would be tangible benefits from using it (Q#13). Despite some broad and heterogeneous descriptions of the desired benefits, PwPD were almost unanimous in stating that access to objective data on the symptoms and information about disease progression are considered a worthwhile benefit (Q#14).

Q#12—"In order to remember to use the device every day, there must be some tangible benefit." ***Patient 17***
Q#13—"It's clear that if I'm reliably told that it [remote monitoring] is a method that could give excellent results in terms of knowledge for the treating doctor, and for ourselves, I would wear it on my ear as well, just to say." ***Patient 10***
Q#14—"I think that [it] is finally a tool that improves monitoring. Something that tells us how our situation is progressing is welcome. I think it can improve awareness and knowledge of one's health [status]." ***Patient 7***

Likewise, neurologists expressed the need for benefits in terms of more detailed, more objective, and more accurate information about the current status of patients for the adoption of remote monitoring in clinical practice (Q#15, Q#16).

Q#15—"I think that would be very helpful if we had some devices that would give us actionable data." ***Neurologist 6***
Q#16—"So, if the bracelet records that for 5 days a week he [the patient] had blocking symptoms, or conversely severe dyskinesias causing falls, then yes, it would make sense [to adopt remote monitoring in clinical practice]." ***Neurologist 2***

3.4.2 Integration into Daily Routine

Convenience and ease of use were considered facilitators for remote monitoring adoption. PwPD preferred monitoring devices that resemble familiar devices and are easy to use. This is exemplified by the constant referral to bracelets, wristwatches, and smartwatches. Placement of the device in unusual locations such as the waist is perceived to be burdensome by them (Q#17). Some PwPD expressed concerns about the continuous use of devices and emphasized the desire to be able to remove the monitoring devices during leisure activities, shower, or sleep (Q#18).

Q#17—"I have no problem with it if I'm supposed to put it on my wrist. At the ankle it would probably go the same way, but I can't say about the waist, because it needs suspenders to keep it there." ***Patient 21***
Q#18—"During the day, while I'm working, it's okay. If I have to take a shower, no." ***Patient 8***

Neurologists described the need to integrate the new technology seamlessly into clinical routine. The need for a time-consuming interpretation of results during the clinical consultation was a concern for most of the health professionals interviewed (Q#19). They would like an AI tool that summarizes the large amounts of RMS data in a meaningful way to facilitate interpretation and analysis during the medical appointment (Q#20).

Q#19—"Data should also be simple, so it wouldn't take me a really long time to evaluate it." ***Neurologist 4***
Q#20—"I have 20 minutes per patient, it [interpretation of results] must be something a little intuitive and fast because if it begins to get too long, I find it difficult to apply." ***Neurologist 2***

3.4.3 Privacy

PwPD mentioned they feel comfortable in sharing information about their symptoms and daily functioning with healthcare providers through monitoring devices. They conveyed familiarity with sharing personal information on different digital platforms (e.g., social media), and the fact that they have been diagnosed with PD is not a secret (Q#21). In addition, they did not imagine that information about the condition could have any value outside the medical context (Q#22).

Q#21—"Sometimes when I hear people talking about privacy I have to laugh, because we disclose our data far and wide to all sorts of people." ***Patient 2***
Q#22—"No one is interested in my memory scores except me, and the doctor and the people close to me. There's nothing interesting or exciting about me." ***Patient 20***

However, many PwPD found continuous home-based video monitoring to be intrusive. They expressed concerns that such recordings could inadvertently capture intimate moments, potentially violating their privacy and that of family members, housemates, and friends (Q#23, Q#24). This feeling of being constantly observed led many to decline video recordings as part of remote monitoring. However, a subset of participants was amenable to this approach on the condition that they maintained control over the recording process. This could include conducting standardized video tasks at home or limiting recordings to a clinical environment (Q#25).

Q#23—"I don't want any CIA [Central Intelligence Agency] equipment in the corner of my home." ***Patient 17***
Q#24—"I probably wouldn't want a device like that in the bathroom." ***Patient 20***
Q#25—"If the camera is limited to you who can control it, yes." ***Patient 3***

3.4.4 Accuracy

Confidence emerged as a key factor influencing the willingness of PwPD and neurologists to adopt AI in PD treatment. A significant number of participants voiced uncertainties about the accuracy of health insights generated by AI, and a prevailing unfamiliarity with AI was observed among both PwPD and neurologists (Q#26, Q#27). Yet, the adoption of this emerging technology hinged on its ability to consistently produce trustworthy results.

Q#26—"Hopefully all the software is designed in such a way that no mistakes are made." **Patient 23**
Q#27—"At the beginning, if we had something like this [AI], it would be hard to trust. I would be suspicious. I would have to have some way to recheck that evaluation. I would have to see the patient myself as well." ***Neurologist 4***

3.4.5 Maintenance of the Human Factor

When it comes to incorporating AI into healthcare, the preservation of the human touch is paramount for both PwPD and neurologists (Q#28, Q#29). The notion that AI might overshadow human interactions presents a barrier to its widespread acceptance (Q#30). It is widely agreed that the onus of medical decisions and actions should squarely rest with humans, underscoring that AI cannot supplant the vital human elements intrinsic to medical practice.

Q#28—"Sure, you can do the analysis, as long as the final decision is not left to the computer, the final decision should be made by the neurologist, based on the information that the computer said. The computer should not go in and decide." ***Patient 18***
Q#29—"This system [AI] cannot replace the doctor–patient meeting [relationship], it cannot replace that. It would be like an extra thing, some help for me [clinician]." ***Neurologist 4***
Q#30—"If I had a machine that gives me rules, undoubtedly for my mental health, I would run away from this address [place]." ***Patient 3***

4 Discussion

The primary aim of this study was to gauge the perspectives of PwPD and neurologists on the incorporation of RMS and AI in early detection of advanced PD. Our findings indicate a shared enthusiasm among both PwPD and neurologists for the utilization of these technology in the early identification

and proactive management of PD progression. Neurologists recognized the complexities involved in accurately tracking the progression of PD and exhibited interest in the potential advantages of RMS and AI in facilitating more precise clinical assessments and improving disease management strategies. Similarly, PwPD conveyed interest in this technology. They recognized its potential to offer a more precise understanding of their condition on a day-to-day basis, which is often difficult to fully capture during occasional clinic visits. Such enthusiasm is somewhat at odds with findings from other medical domains, where hesitancy or skepticism toward emerging AI technologies has been noted [24, 35]. Interestingly, despite the older age bracket of our participants, a significant number of PwPD showed readiness to digitally relay their personal health details to medical practitioners. This is in contrast with prior studies indicating an inverse relationship between age and propensity to divulge personal data [36, 37]. Such deviations may stem from the critical importance attributed to precise symptom tracking in PD management [31, 38]. The pressing need for objective and reliable monitoring methods might explain the favorable stance of both PwPD and neurologists toward RMS and AI.

Notwithstanding, this positive perspective toward RMS and AI was not unconditional. Both PwPD and neurologists emphasized the need for tangible and practical benefits to warrant the introduction of these technologies. Beyond perceived advantages, the easy integration of RMS and AI into their daily routines to ensure adherence and acceptance was underscored. To attain this, user-friendly technology with straightforward setup is required, which has the ability to generate data that can be seamlessly integrated into daily activities. This resonates with previous research underscoring patients' preference for wearable sensors that can be integrated into everyday items such as clothing, jewelry, or watches, which can collect and transmit daily symptom data automatically [39, 40]. The design of user-friendly technology might be particularly beneficial for chronic and elderly patients as it reduces the physical and mental burden, thereby fostering acceptance and engagement with the technology.

From the vantage point of neurologists, existing research underscores that while healthcare professionals appreciate the potential advantages of RMS and AI, they might express reservations about adopting such technology if perceived as a catalyst for more problems than solutions [41]. Anticipated additional workloads stemming from unexpected tasks linked to technology implementation, such as patient data analysis, could act as a deterrent to its acceptance [41]. This study echoes similar sentiments, with neurologists emphasizing the necessity of a seamless incorporation of this new technology into their clinical routines. The prospect of dedicating extensive time to interpreting results during clinical consultations was identified as a concern by most of the participating neurologists. Consequently, it is important to engineer technologies that not only blend smoothly into daily routines but also limit additional workloads for clinicians and patients alike. This would enhance the likelihood of their integration into standard healthcare practice.

Alongside these findings, two additional elements were identified as critical for RMS and AI acceptance: privacy considerations, particularly with home video recordings, and the maintenance of human involvement in the healthcare journey. These findings align with prior research indicating that video recording typically encounters resistance, yet can be deemed acceptable, provided specific conditions, such as replacing continuous video surveillance with patient-generated video clips, are met [42]. Moreover, our findings concur with previous studies that indicated a preference for human doctor guidance over AI recommendations [43]. While AI has the capacity to analyze extensive data and provide invaluable insights, it cannot replace the human touch, trust, and connection often required by patients during periods of illnesses [44–46].

An important consideration in our study was the scarce reference of stigma by patients with Parkinson's disease as a factor in their acceptance of RMS. This minimal mention contrasts to other research in which the visibility of devices is frequently cited as a barrier to remote monitoring due to stigma-related concerns [25, 47]. This inconsistency suggests that the influence of stigma on the use of remote monitoring in Parkinson's disease might differ across contexts. Potential reasons for these variations could include demographic variances among study participants, cultural perceptions of medical devices, or differences in the design and types of devices used in various studies [48, 49].

Despite the valuable insights our research offers, it is important to recognize some limitations. First, the study did not provide participants with a tangible prototype of the monitoring solutions to be potentially used. This lack of direct interaction with the devices or simulated AI results might have limited participants' understanding of practical application. Actual implementation might therefore unearth unanticipated benefits or challenges that could alter their perspectives [50]. Additionally, it is important to note that the findings of this study are based on a sample of respondents drawn from Finland and Italy. It is acknowledged that healthcare work culture and technology use may vary across countries [51], and therefore the generalizability of the results may be limited. It is also noteworthy that, with the exception of the focus groups conducted in Italy, all interviews in our study were held online, reflecting either participant preferences or logistical constraints. Prior research indicates that, although in-person and video call interviews generally produce similar word

counts and cover comparable topic ranges, in-person interviews often have greater depth [52]. Despite this, qualitative interviews performed by video, telephone, and online are valid and trustworthy alternatives, and can offer practical solutions in situations where logistical or budgetary limitations are present [53]. Lastly, our recruitment method, which involved obtaining informed consent through email, and the predominant use of videoconferencing for interviews, might have inadvertently skewed participant selection toward individuals with greater technological proficiency.

5 Conclusion

Our research focused on understanding the attitudes of PwPD and neurologists toward the adoption of RMS and AI. The findings demonstrated a shared interest and acceptance of these technology in both groups. However, successful adoption necessitates the seamless integration of these digital tools into their routines. In addition, for effective deployment, it is crucial that these technologies provide demonstrable enhancements to the healthcare experiences of both practitioners and patients. Finally, and perhaps most importantly, our research underscores the necessity of preserving the physician–patient relationship, even as we embrace the benefits of digital health tools. The insights garnered from this study enrich our understanding of the factors that can impact the acceptance and utilization of AI-based RMS in PD care. This awareness is crucial to support effective integration of these digital health technologies into PD management, thereby maximizing their potential benefits.

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Author Contributions CG played a lead role in data curation and formal analysis and supported the investigation. He was the main contributor to the original draft and led the review and editing of the writing. FM led the project administration and was supportive in data curation. He equally contributed to formal analysis and methodology, and took a lead role in the investigation. He also played a key role in managing resources and was supportive in both the original draft and review and editing phases of writing. LM equally contributed to project administration, investigation, methodology, and resource management. She also supported the review and editing of the written content. MK offered equal contributions to project administration, investigation, and resource management and provided support in writing review and editing. EF shared equal responsibilities in project administration and resource management and was supportive in the writing review and editing process. LB had an equal stake in conceptualization, fund acquisition, and project administration. She also contributed to the writing, both in the original draft and its review and editing. CUG was the lead in conceptualization, fund acquisition, and project administration. She provided supportive roles in methodology, supervision, and writing—review and editing. WR equally contributed to conceptualization, fund acquisition, and project administration, while also offering support in methodology, supervision, and writing—review and editing. Lastly, WD equally contributed to conceptualization and project administration, led the methodology and supervision, and provided support in the original draft writing, formal analysis, and review and editing stages.

Declarations

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Competing Interests Carlos Antonio Godoy Junior—No conflicts of interests to disclose. Francesco Miele—No conflicts of interests to disclose. Laura Mäkitie—Received personal fees from Abbvie outside the submitted work. Maija Koivu—No conflicts of interest to disclose. Eleonora Fiorenzato—No conflicts of interests to disclose. Lytske Jantien Bakker—No conflicts of interests to disclose. Carin Uyl-de Groot—No conflicts of interests to disclose. William Ken Redekop—No conflicts of interests to disclose. Welmoed Kirsten van Deen—No conflicts of interests to disclose.

Data Availability The data underlying this article cannot be shared publicly to protect the privacy of individuals that participated in the study.

Ethics Approval and Informed Consent The study was conducted according to the principles of the Declaration of Helsinki and in accordance with the Medical Research Involving Human Subjects Act (WMO) and was approved by the local ethics committees at HUS (HUS/2349/2021), UNIPD (2020-III/13.41.7) and Erasmus University Rotterdam (ETH2122-0569). An informed consent was obtained from all interviewees before participation.

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