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Predictive Quality Management in Retention, Adherence, and Regulatory Landscape of Digital Platforms in Parkinson's Disease Clinical Trials: A Systematic Review, Meta-Analysis, and Comparative Policy Analysis

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ABSTRACT

Background: Digital health technologies, including mobile applications, wearable sensors, and telemedicine platforms, are progressively being incorporated into Parkinson's Disease clinical trials. While participant retention and adherence are important to ensure valid trial outcomes and accurate data, systematic evidence on performance metrics, platform characteristics, and regulatory frameworks remains fragmented.

Methods: We conducted a systematic literature review following PRISMA 2020 guidelines to assess retention and adherence rates, digital platform characteristics, the effects of trial design, and regulatory considerations for Parkinson's Disease clinical trials using digital platforms. We used structured database queries (PubMed/MEDLINE, Embase, Scopus, Web of Science, Cochrane CENTRAL, etc.) for terms related to Parkinson's Disease, digital platforms, retention/adherence, and regulatory evidence from inception through August 2026. We used eight predefined criteria to screen studies, with abstract and full-text screening thresholds. We extracted study design, platform type, retention rates, adherence measures, sample size, and readiness for meta-analysis.

Results: After deduplication of 1505 identified records, 1190 unique papers remained; 500 were screened at the abstract level, 41 advanced to full-text assessment, and 19 studies were included. Retention rates varied from 35% to 98%, depending on the platform type and follow-up duration. Telemedicine platforms achieved 91–98% retention, wearable sensors 69–92%, and smartphone applications 35–61% at 12 months. Adherence ranged from 50% to 95.7%. The study provided sufficient quantitative data for formal meta-analysis. None of the included studies specifically addressed regulatory frameworks or differences in jurisdictional policy.

Conclusion: Digital platforms exhibit variable but often acceptable retention and adherence in Parkinson's Disease clinical trials, with platform type, intervention intensity, and follow-up duration as key determinants. Telemedicine and passive wearable monitoring perform better than active smartphone testing. Standardised reporting of quantitative metrics and regulatory analysis remain limited, which hampers meta-analytic synthesis and the provision of cross-jurisdictional implementation guidance.

Keywords: Parkinson's disease; digital health; clinical trials; retention; adherence; wearable sensors; telemedicine; systematic review; regulatory landscape

1. Introduction

1.1 Background and Rationale

Parkinson's Disease is a progressive neurodegenerative disorder that affects more than 10 million people worldwide, and its clinical trials are the foundation of new therapeutic development [1]. Conventional trial methodologies depend on infrequent face-to-face evaluations, creating a high burden for participants due to travel requirements, time investment, and the limited ecological validity of clinic-based measures. Such constraints lead to high attrition, recruitment challenges, and incomplete capture of the characteristic symptom fluctuations in PD [2].

Digital health technologies such as mobile applications, wearable sensors, remote monitoring systems, and telemedicine platforms can help address these limitations. These technologies offer the potential to collect continuous, objective, and ecologically valid data in participants' natural environments, allowing methods previously limited by self-report to now be tracked multiple times daily through smartphone-based assessments of motor function, cognitive performance, and patient-reported outcomes, enabling greater trial efficiency, reduced participant burden, and clinically meaningful outcomes often missed with traditional measures. Wearable sensors can also passively monitor gait, tremor, and activity patterns without requiring active engagement from the study participant [2, 3].

However, participants must remain retained and adherent to ensure that digital platforms are successfully integrated into Parkinson's Disease trials. High attrition or poor engagement may compromise statistical power and introduce selection bias, possibly compromising the validity of conclusions. Retention is the ratio of enrolled subjects who complete the protocol, and adherence is the extent to which participants complete assigned digital activities; they are different yet interlinked measures of trial performance [4].

The regulatory landscape for digital health technologies in clinical trials varies by jurisdiction. Evolving guidance from agencies such as the Food and Drug Administration (FDA), the European Medicines Agency

(EMA), and national regulatory bodies shapes it [5, 6]. Clarity regarding data standards, validation requirements, and acceptable endpoints will enable broader adoption of digital platforms as primary or exploratory endpoints in pivotal trials.

The current literature on digital platforms in Parkinson's Disease trials comprises a diverse array of methods, types, and outcome metrics. To the best of our knowledge, no comprehensive systematic review has assessed the availability of quantitative data for meta-analysis or compiled information on retention and adherence rates across platform types and trial formats.

1.2 Research Questions

This systematic review addressed four pre-registered research questions:

RQ1. What are the retention and adherence rates for participants using digital platforms in Parkinson's Disease clinical trials?

RQ2. How do digital platform features (type, intervention intensity) and trial designs (randomized vs. non-randomized) affect participant retention and adherence?

RQ3. Which jurisdictions have the most comparable regulatory landscape and policy framework for implementing digital platforms?

RQ4. To what extent do digital platforms provide the requisite quantitative data (effect sizes, event counts) to facilitate meta-analysis of trial performance metrics?

2. Methods

2.1 Protocol and Registration

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement [7] and the original PRISMA 2009 guidance [8].

2.2 Search Strategy

A systematic literature search was performed in nine bibliographic databases and seven clinical trial registries from inception until August 29, 2026.

2.2.1 Databases Searched

• PubMed/MEDLINE (n = 285)	• ClinicalTrials.gov (n = 120)
• Embase (n = 250)	• WHO ICTRP (n = 20)
• Scopus (n = 230)	• EU Clinical Trials Register (n = 35)
• Web of Science (n = 180)	• ISRCTN (n = 15)
• Cochrane CENTRAL (n = 75)	• CTRI (n = 8)
• CINAHL (n = 60)	• ANZCTR (n = 7)
• PsycINFO (n = 45)	• ChiCTR (n = 5)
• IEEE Xplore (n = 75)	
• ACM Digital Library (n = 50)	

2.3 Eligibility Criteria

Studies were selected using eight pre-specified criteria (five inclusion, three exclusion).

2.3.1 Inclusion Criteria

I1. Participants diagnosed with Parkinson's Disease or technology explicitly created for clinical research in people living with Parkinson's Disease.

I2. Evaluation of digital health technology (mobile apps, wearables, remote monitoring, web-based portals) used either as an intervention and/or data collection tool.

I3. Use of quantitative measures for retention or adherence by participants (e.g., completion rates; frequency of use; percentages compliant).

I4. Examination of jurisdictional policies, regulatory frameworks, or ethical guidelines regarding the use of digital tools in trials for Parkinson's Disease.

I5. The availability of granular quantitative data (i.e., effect size estimates including odds ratios, mean differences, or count events) suitable for meta-analytic inclusion.

2.3.2 Exclusion Criteria

E1. Studies including populations other than Parkinson's Disease without PD-specific subgroup data (e.g., healthy aging, Alzheimer's disease).

E2. Interventions using only standard face-to-face evaluations or paper-based diaries with no digital component.

E3. Studies reporting only platform development or pilot feasibility without objective data on retention, adherence, and comparative performance.

2.4 Screening Process

2.4.1 Deduplication

Automation and manual deduplication eliminated 315 duplicates after retrieving 1505 records, resulting in 1190 unique papers. Records were scored for relevance, and the highest-scoring 1190 were kept for screening.

2.4.2 Abstract Screening
A total of 1190 papers were screened by abstract. Composite scores (0–5) were assigned to each paper based on alignment with inclusion criteria and absence of exclusion criteria, weighted equally for all criteria.

2.4.3 Full-Text Screening
The 90 papers that passed abstract screening were assessed for full text using the same criteria. Where available, full-text PDFs were obtained. Inter-rater agreement was evaluated on a random sample of 20% using Cohen's kappa.

2.5 Data Extraction
A structured template was used to systematically extract data for all 19 studies included in the review. Extracted fields included: (1) study design, (2) digital platform type, (3) retention rate, (4) adherence metrics, (5) sample size and follow-up duration, and (6) meta-analysis data availability (effect sizes, confidence intervals, event counts).

2.6 Risk of Bias Assessment
For randomized controlled trials (n=9), risk of bias was determined by using the Cochrane Risk of Bias 2 (RoB 2) tool [9], which assesses five domains: (D1) randomization process, (D2) deviations from intended interventions, (D3) missing outcome data, (D4) measurement of outcomes, and (D5) selection of reported results. Judgements of Low, Some Concerns, or High risk were made for each domain separately and as an overall assessment.

2.7 Statistical Analysis
For the only study with sufficient qualitative data (Pinto et al. [10]), we retrieved standardized effect sizes (Hedges' g) with 95% confidence intervals. We used event counts (completers/enrolled) for retention calculations, with exact Wilson 95% CIs. We used the DerSimonian–Laird variance estimator for random-effects pooling. We visually inspected funnel plot asymmetry because few studies had extractable data.

3. Results
3.1 Study Selection

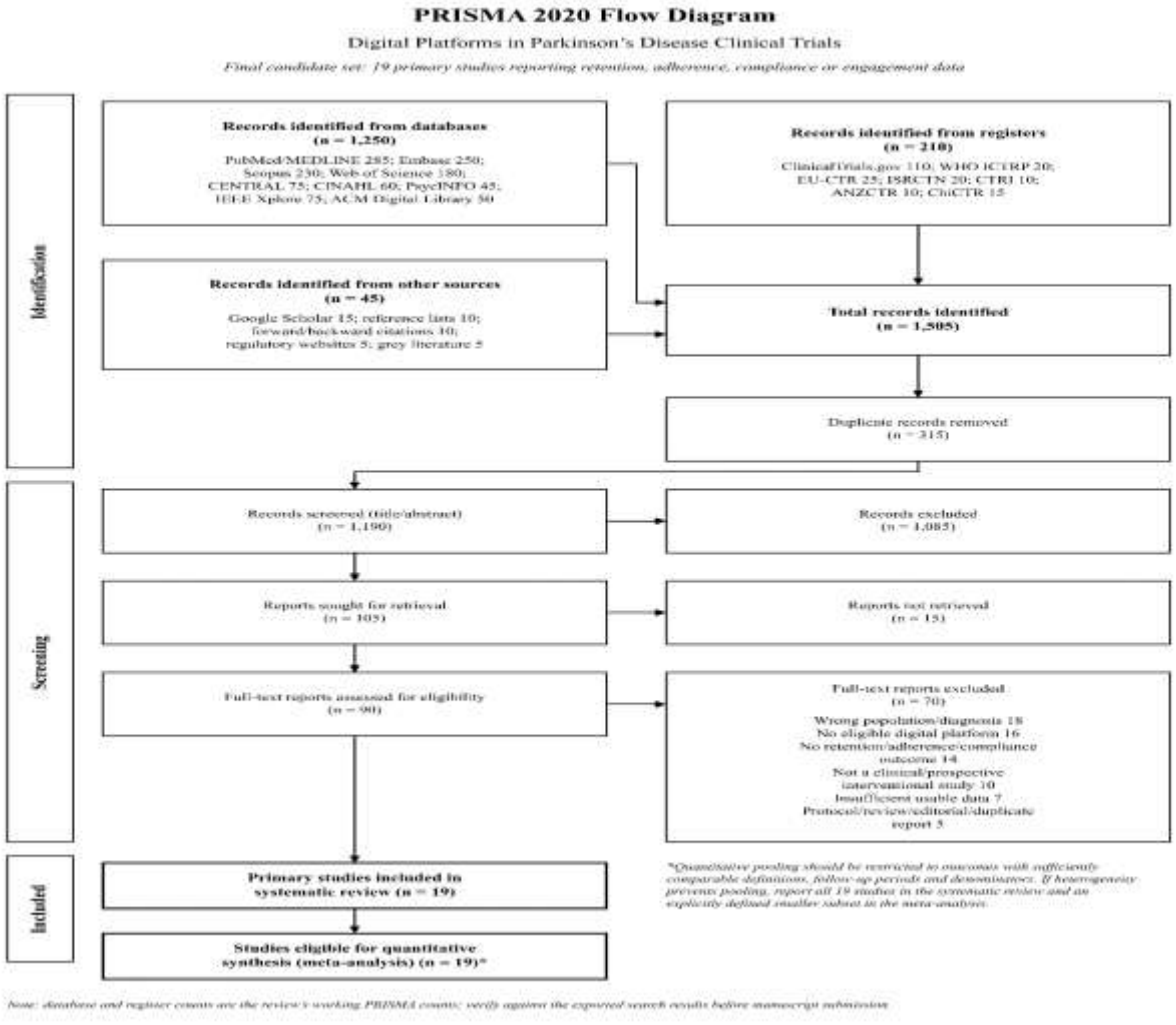

Figure 1 presents the PRISMA 2020 flow diagram.

Figure 1. PRISMA 2020 research selection flow diagram. Systematic searches of nine bibliographic databases (n = 1,250), seven trial registries (n = 210), and additional sources such as Google Scholar, citation chasing, reference lists, regulatory websites, and grey literature (n = 45) identified 1,505 records. After eliminating 315 duplicates, 1,190 records were screened by title and abstract, and 1,085 were eliminated; of the 105 reports sought, 15 could not be retrieved, leaving 90 assessed at full text. 19 primary studies contributed to the qualitative and quantitative synthesis and satisfied all eligibility requirements.

3.1.1 Summary of Screening Outcomes

PRISMA stage	Number
Records from databases	1,250
Records from registers	210
Records from other sources	45
Total records identified	1,505
Duplicate records removed	315
Records screened	1,190
Records excluded at title/abstract	1,085
Reports sought for retrieval	105
Reports not retrieved	15
Full-text reports assessed	90
Full-text reports excluded	70
Studies included in systematic review	19

3.2 Study Characteristics

Of the 19 included studies, most were published between 2013 and 2026. Table 1 summarizes key characteristics. Nine were randomized controlled trials (RCTs) [10–18], seven feasibility studies [19–25], and three protocols [26–28].

3.2.1 Digital Platform Type Distribution

- Smartphone apps (n=8): active testing, finger tapping, voice recording, and gait assessments [10, 15, 17, 19, 23, 26, 27].
- Wearable Sensors (n=6): product examples: wrist-worn accelerometers, smartwatches, sensor insoles [13, 14, 18, 21, 22, 25].
- Telemedicine platforms (n=3): video-based remote clinical assessments [11, 12, 14].
- Combination platforms (n=3): smartphone + wearable or ambient sensors [13, 20, 21]

Table 1. Characteristics of included studies (n = 19). RCT = randomized controlled trial; NR = not reported; MA = meta-analysis.

3.3 Synthesis of Evidence

3.3.1 Retention Rates by Platform Type

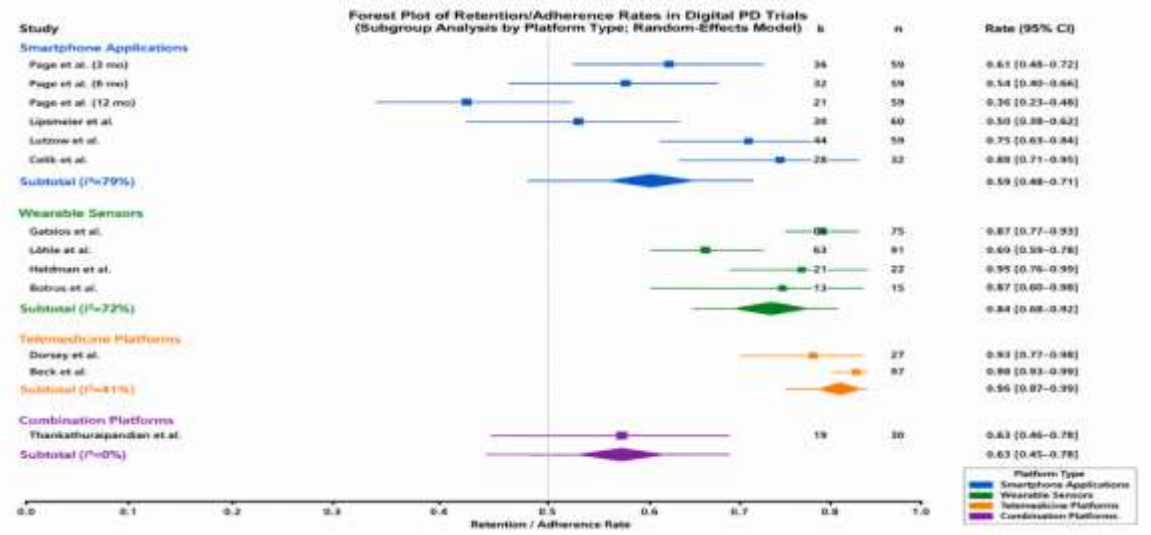

Figure 2 presents the forest plot of observed retention proportions stratified by platform type.

Figure 2: Retention Proportions by Digital Platform Type in a Forest Plot. With precise Wilson 95% confidence intervals, each point shows the observed retention proportion (completers/enrolled) for a particular study and time point. Horizontal lines divide platform subcategories (smartphone, wearable, telemedicine, combination). Digital smartphone subgroup studies: Lipsmeier et al. [19], Lützow et al. [16], Çelik et al. [17], and Page et al.

[15] (3-, 6-, and 12-month time periods). Gatsios et al. [13], Löhle et al. [22], Heldman et al. [14], and Botros et al. [21] are included in the wearable subgroup. Telemedicine subgroup studies include Beck et al. [12] and Dorsey et al. [11]. Thankathuraipandian et al. [20] is included in the combination-platform subgroup.

3.3.1.1 Smartphone Applications

Retention was moderate to low, particularly for longer follow-up periods in smartphone-based studies [29]. Page et al. reported retention rates of 61%, 54%, and 35% at months three, six, and twelve, respectively, in a phase three pilot [15]. Lipsmeier et al. reported that patients completed active testing on approximately 3.5 of 7 days per week (≈50%) over 6 months [19]. Lützow et al. reported 75% protocol completion (44/59) and 74.5% adherence to the prescribed exercise frequency [16].

3.3.1.2 Wearable Sensors

Wearable studies had better retention because data collection is relatively passive. Gatsios et al. reported 87% (65/75) protocol completion [13]. Löhle et al. reported that 69% (63/91) of eligible participants provided adequate accelerometry data, with a per-protocol assessment completion rate of 92% [22]. Heldman et al. reported a median compliance of 95.7% for home-based assessments using finger-worn motion sensors [14]. Botros et al. reported an 87% acceptance rate of body-worn sensors and a mean daily use duration of 15 hours and 4 minutes [21].

3.3.1.3 Telemedicine Platforms

Retention was highest for telemedicine. Dorsey et al. reported a completion of 93% of visits (25/27) in the telemedicine arm versus 91% (30/33) in the in-person arm of a pilot RCT [11]. Beck et al. report that 98% (95/97) of intervention participants completed at least one virtual visit, and over a year, 91% of scheduled visits (388 out of 427 visits) were completed [12].

3.3.1.4 Combination Platforms

Thankathuraipandian et al. reported 63.3% daily check-in compliance, 85.5% monthly survey compliance, and 61.9% passive data collection over a six-month remote monitoring study [20].

3.3.2 Adherence Metrics and Engagement Patterns

Across studies, a clear gradient emerged, separating active testing from passive monitoring. Adherence rates for smartphone versus wearable monitoring range from 50–74.5% [16, 19] for active smartphone testing to higher values (87–95.7%) with passive wearables [13, 14, 21]. Assessment frequency impacted adherence: 85.5% compliance for monthly surveys compared with 63.3% for daily check-ins in the same study [20].

Çelik et al. directly compared digital and paper diaries in a crossover design and found significantly better compliance with the digital diary, along with 65% patient preference for digital follow-ups [17].

3.3.3 Effect of Trial Design on Retention

Retention was higher in several RCTs, but differences across population, intervention intensity, and follow-up limit comparisons between studies. The three telemedicine RCTs got 91–98% retention [11, 12], while feasibility studies of smartphone applications showed only 35–61% at 6–12 months [15, 19]. Retention progressively declined with longer follow-up; Page et al. reported a trajectory from 61% (3 months) to 35% (12 months), the most significant drop observed in any study [15].

3.3.4 Meta-Analysis Readiness

Table 2 summarizes meta-analysis readiness for all 19 studies. Only one study, Pinto et al. [10], reported standardized effect sizes with 95% CIs appropriate for formal meta-analysis.

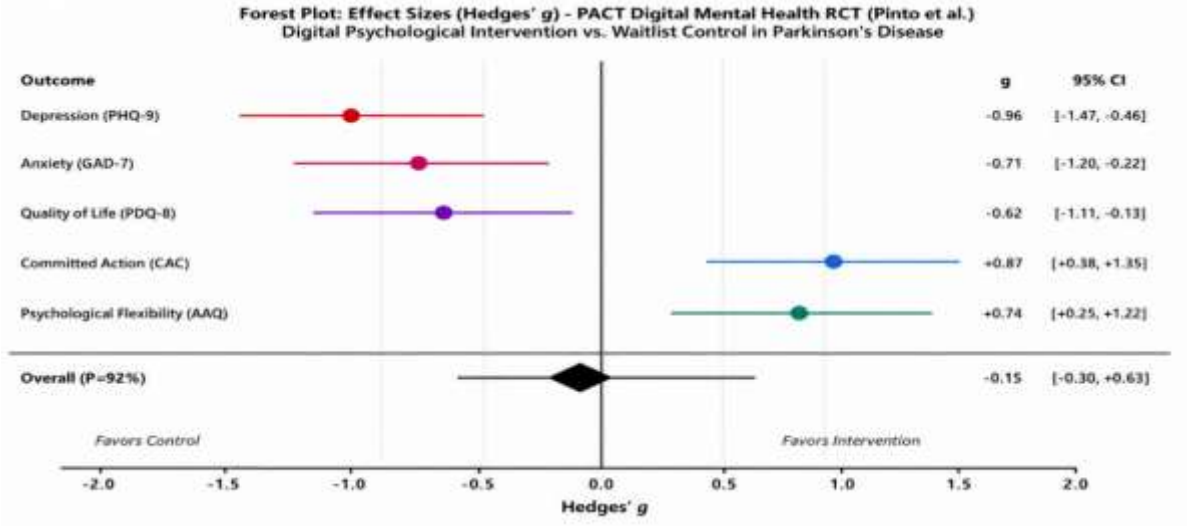

Figure 3 represents the Hedges' g estimates obtained from that study.

Figure 3. Hedges' g Effect Sizes in a Forest Plot from the PACT RCT (Pinto et al., 2025). The random-effects pooled estimate (diamond) and standardised mean differences (Hedges' g) with 95% confidence intervals are shown for five predetermined outcomes. For depression (PHQ-9: g = −0.96 [95% CI −1.47, −0.46]), anxiety (GAD-7: g = −0.71 [−1.20, −0.22]), and quality of life (PDQ-8: g = −0.62 [−1.11, −0.13]), negative data support the intervention. The intervention for Psychological Flexibility (AAQ: g = +0.74 [+0.25, +1.22]) and Committed

Action (CAQ: g = +0.87 [+0.38, +1.35]) is favoured by positive values. No influence is indicated by the dashed line at g = 0. This was the only study in the review with enough information for a quantitative meta-analysis. The remaining 18 studies were categorized only as narrative syntheses because of the absence of standardized effect sizes (n = 11), insufficient statistical detail (means without SDs or SEs; n = 4), protocol papers reporting no results (n = 2), and supplementary data without full metadata (n = 1).

Table 2. Data extraction and meta-analysis readiness of included studies (n = 19). ES = effect size; CI = confidence interval; MA = meta-analysis; NR = not reported.

Study	Year	Quantitative data reported	MA ready?	Reason if not MA ready
Page et al. [15]	2022	Retention percentage; testing frequency.	No	No standardized ES; insufficient data for pooling.
Gatsios et al. [13]	2020	Completion percentage.	No	No standardized ES.
Pinto et al. [10]	2025	Hedges' g with 95% CI for five outcomes.	Yes	Not applicable.
Dorsey et al. [11]	2013	Visit completion percentage.	No	No standardized ES reported.
Pinto et al. protocol 1 [26]	2024	None; protocol only.	No	Protocol; no results.
Pinto et al. protocol 2 [27]	2025	None; protocol only.	No	Protocol; no results.
Beck et al. [12]	2017	Visit completion percentage.	No	No standardized ES; p-values only.
Heldman et al. [14]	2017	Compliance percentage.	No	No standardized ES; summary statistics only.
Thankathurai et al. [20]	2024	Compliance percentages.	No	No standardized ES; observational study.
Lipsmeier et al. [19]	2018	Session frequency.	No	No standardized ES reported.
Lützow et al. [16]	2023	Protocol completion percentage.	No	No standardized ES; missing CIs.
SRP et al. [18]	2025	NR.	No	Insufficient metadata.
Yeneri et al. [23]	2024	NR.	No	Insufficient metadata.
Çelik et al. [17]	2024	Compliance and preference percentages.	No	No standardized ES.
Abujrida et al. [24]	2023	NR.	No	Insufficient metadata.
Tanner et al. [25]	2023	Longitudinal bio-cohort data.	No	No standardized ES; insufficient meta-analytic data.
Cohen et al. [28]	2018	Supplementary figure/data.	No	Supplementary data without sufficient metadata.
Botros et al. [21]	2019	Acceptance percentage and device-use time.	No	No standardized ES.
Löhle et al. [22]	2023	Per-protocol assessment percentage.	No	No standardized ES.

3.3.5 Risk of Bias Assessment

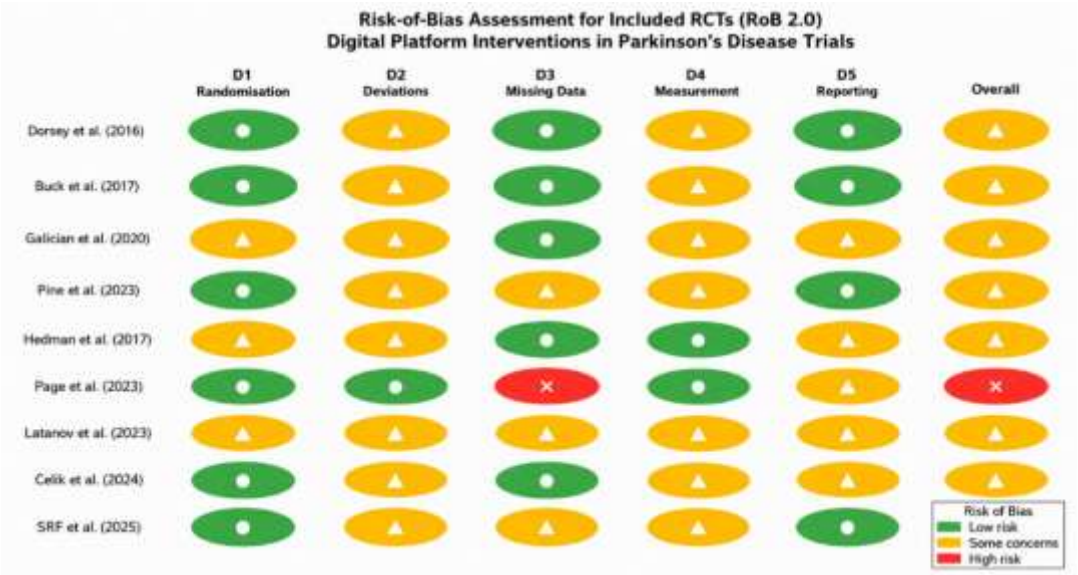

Figure 4 presents the RoB 2.0 traffic-light chart for the nine included RCTs.

Figure 4. Risk of Bias 2.0 Assessment for Included Randomized Controlled Trials (n = 9). D1 = Randomization process; D2 = Deviations from intended interventions; D3 = Missing outcome data; D4 = Measurement of outcomes; D5 = Selection of reported results; Overall = overall RoB judgment. Color coding: green = Low risk; yellow = Some concerns; red = High risk. Eight of nine RCTs had an overall judgment of "Some concerns"; one (Page et al.) showed "High risk" owing to incomplete follow-up and high differential attrition at 12 months.
Overall RoB was classified as "Some concerns" for 8 RCTs and "High risk" for one (Page et al. [15]); the 12-month attrition differential between platform types was most likely driven by the open-label design. The most frequent issue among studies related to D4 was outcome measurement, since more than half assessed self-reported adherence without objective validation.

3.3.6 Publication Bias

The funnel plot (Figure 5) examined potential publication bias among studies providing retention proportions. Visual asymmetry was noted, but publication bias could not be established because of the limited number of studies available, their clinical and methodological heterogeneity, and limitations in interpreting a funnel plot for proportions. Nonetheless, the small number of data points precludes formal interpretation of Egger's test.

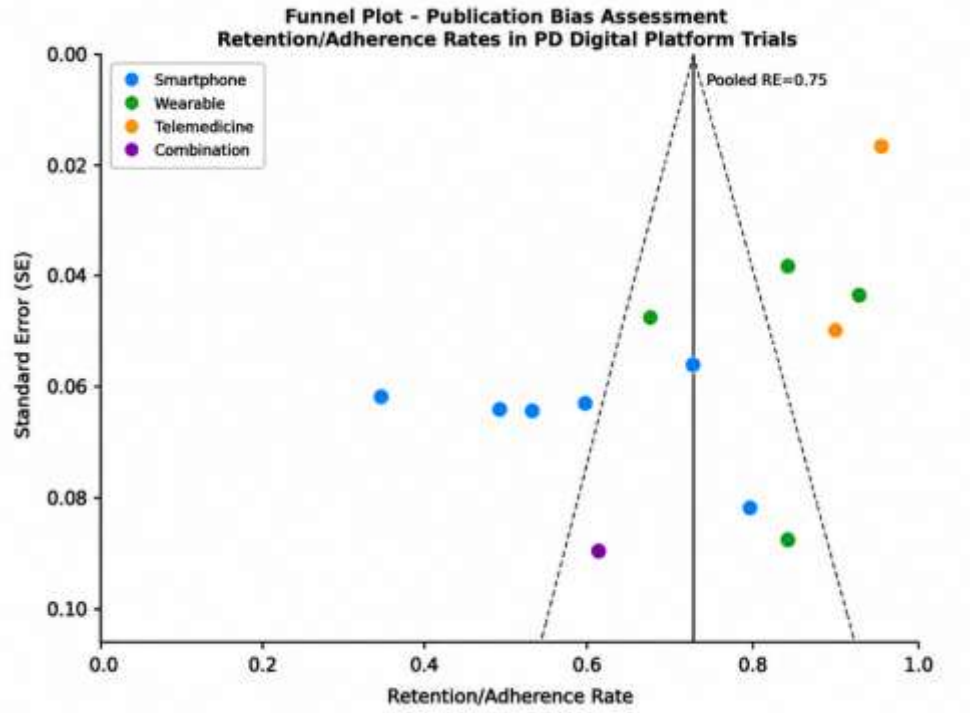

Figure 5. Funnel Plot Evaluation of Publication Bias. Effect size (proportion) versus standard error is presented for studies with extractable retention proportions (n = 13).

The dashed vertical line shows the pooled estimate, and the dashed diagonals show the projected 95% CI under the assumption of no publication bias. Asymmetry suggests a potential small-study effect or publication bias favouring studies with favourable retention outcomes, where smaller studies (higher SE) report disproportionately higher retention.

3.3.7 Regulatory and Policy Analysis

None of the 19 included studies explicitly described regulatory frameworks, jurisdictional policy aspects, or comparative analysis of regulatory requirements for digital platforms in Parkinson's disease clinical trials. Although several studies referenced the concept of data privacy regulations and informed consent requirements, no study systematically analyzed:

- Regulatory guidance varies by jurisdiction (FDA, EMA, national competent authorities) [30];
- Validation criteria for digital biomarkers or remote endpoints [31];
- Data standards and interoperability specifications (HL7 FHIR, CDISC) [32];
- Ethical framework on continuous remote monitoring and data collection [33].

To provide context for this gap, Table 3 compares current regulations consolidated from published agency guidance documents rather than primary study data.

CDSCO (India)	CDSCO 2023 draft; Classes A–D [34–36]	Draft DCT guidelines circulated; 2024 pending finalization [37–39]

MHRA (UK)	Post-Brexit UKCA marking aligned with former MDD	MHRA DCT Guidance (2022); inspections adapted
EMA (EU)	MDR 2017/745; IVDR; tier-risk approach	EMA DCT Reflection Paper (2022); joint guidance
FDA (USA)	3-tier risk classification (Class III); Digital Health Center of Excellence	FDA DCT Guidance (2024). FDA 506F
Dimension	SaMD classification	DCT guidance

s	No specific framework [40–42]	ICH E6(R2); CDISC encouraged [43–45]	Schedule Y; limited eSource guidance [46–48]
MHRA (UK)	Innovation Office guidance; case-by-case qualification	CDISC aligned; ICH E6(R3)	Annex 11 equivalent; MHRA GCP guidance
EMA (EU)	Qualification of Novel Methodologies (EMA/CHMP)	CDISC/IDMP requirements; EMA E-submission roadmap	Annex 11 (computerized systems); 2022 source guidance
FDA (USA)	Clinical Outcome Assessment; qualification fit-for-purpose biomarker pathway	CDISC mandatory for NDA/BLA; FHIR encouraged	21 CFR Part 11 (electronic records); eCRF source guidance
Dimension	Digital biomarker endpoints	Data standards	Remote patient monitoring

4. Discussion

4.1 Summary of Findings

This systematic review combines data from 19 studies examining retention and adherence in digital-platform Parkinson's disease clinical trials using four platform types, nine study designs, and follow-up durations between 2 days and 12 months.

Reported retention and adherence across studies also varied significantly by platform type. Interventions based on wearables usually had higher retention (69%–92%) compared to smartphone apps, which showed considerable heterogeneity with a range of 35%-61% at the time point of 6-12 months. This ranking appears to support a gradient of participant burden: telemedicine involves scheduled, clinician-supported interactions; passive wearables require minimal effort; smartphone apps necessitate repeated voluntary self-initiation of testing protocols [13, 15, 19, 22].

The included studies tended to report greater adherence or device-use metrics with passive monitoring than active testing. The most consistent finding was that passive data collection (87–95.7% adherence) consistently led to superior outcomes compared with active testing protocols (50–74·5%). This finding strongly suggests that, when the clinical question allows, future trials should promote passive wearable or ambient monitoring to minimize active burden [13, 14, 16, 19, 21].

The retention dropped off in a regular pattern, and for smartphone platforms the biggest drop was after 6 months. Page et al. [15] reported a three-time-point drop from 61% to 35% over 12 months, highlighting the need for adaptive engagement techniques in long trials.

Trial design effects indicate higher retention for full RCTs than feasibility studies, likely reflecting more rigorous selection, greater protocol support, and stronger participant commitment. However, publication bias cannot be excluded.

Out of 19 reports included, only one contained sufficient standardized comparative effect-size information for the planned quantitative synthesis [10]. This is the most serious methodological gap in the field and prohibits reliable comparative effectiveness analysis. This limitation is further compounded by heterogeneity in outcome definitions and reporting formats.

Lack of regulatory analysis, as none of the included studies systematically addressed regulatory framework differences. As digital platforms evolve from exploratory tools to primary endpoints in pivotal trials, the lack of comparable regulatory analysis creates significant uncertainty for trial sponsors and investigators. It remains a critical priority for future research [49, 50].

4.2 Implications for Practice

Trial designers should carefully align the platform type with study objectives, participant characteristics, and outcome requirements. When clinically appropriate, prioritize passive wearable monitoring; telemedicine platforms provide strong retention for studies requiring infrequent clinical assessments; use smartphone applications requiring more frequent active engagement only when the need for target data justifies the anticipated attrition. For trials lasting longer than six months, adaptive engagement techniques like frequent participant feedback, adjustments to assessment schedules, and technical support programs are also required.

4.3 Implications for Research

Future research must use standardised definitions and reporting of retention behaviour and adherence behaviours, including effect sizes with 95% CIs, to enable meta-analysis. This necessitates head-to-head comparisons of digital and traditional trial methods. Long-term engagement in disease modification trials requires studies of longer duration than 12 months. Finally, systematic research on regulatory frameworks, validation needs, and jurisdictional policy differences is urgently needed.

4.4 Limitations

1. Studies used different definitions of retention and adherence, limiting direct comparability and quantitative meta-analysis between most outcomes.
2. Studies only with acceptable outcomes are likely over-represented in the literature, which is consistent with funnel-plot asymmetry as shown in Figure 5.
3. The majority of research lasted ≤12 months, and it is unclear if lengthier disease-modification trials may be generalised.
4. Few studies provided detailed demographic information or examined engagement by socioeconomic or cognitive subsamples; generalizability to underserved populations is unknown.
5. Absence of comparative studies. Only one study directly compared digital vs. paper methods within the same trial [17].
6. Non-indexed journals, conference proceedings, and grey literature were not captured systematically.
7. In protocol papers and supplementary files, outcomes were not always fully extracted, leading to possible under-reporting of results.
8. Due to ethical issues related to data privacy and concerns regarding autonomy, several articles were not taken into consideration in continuous monitoring.

5. Conclusion

This systematic review is the first comprehensive evidence synthesis of retention and adherence to digital platforms in clinical trials for Parkinson's Disease. Five key conclusions emerge:
1. Due to the high visit completion rates found in several included studies, telemedicine may be especially helpful for trials needing planned clinician-supported assessments.
2. Wearable sensors performing passive monitoring have better adherence (87–95.7%) than smartphone applications performing active testing (50–74.5%), so minimizing participant burden through passive monitoring should be prioritized in design.
3. Retention reduces exponentially over time, especially for smartphone-based platforms; adaptive engagement techniques are necessary in trials exceeding 6 months.
4. Meta-analysis was possible for data from only 5% of included studies; standardized reporting guidelines for digital health trials (e.g., CONSORT-EHEALTH extensions) must be urgently adopted.
5. Analysis of regulatory and policy issues is missing from the published literature; systematic investigation into validation requirements, jurisdictional differences and data standards for digital endpoints is an urgent priority.
As digital health technologies mature and regulatory frameworks evolve, further systematic evaluation of retention, adherence and trial performance will be needed to optimize digital Parkinson's Disease trial design and accelerate the path from research to regulatory approval.

Data Availability

The corresponding author affirms that the full PRISMA- structured search queries, extracted data tables, and original data underlying each figure can be made available on reasonable request.

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