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TIDEWALK: A TRANSDISCIPLINARY DESIGN ECOSYSTEM FOR SUPPORTING DAILY AUTONOMY IN PARKINSON'S DISEASE

Ananya Bajpai[1], Anvicka Misra[2], Ruchi Gaur[3]

[1] Student, UX & DPD, School of Design, World University of Design, Sonipat, India
[2]Student, UX & DPD, School of Design, World University of Design, Sonipat, India
[3] Assistant Professor, UX & DPD, School of Design, World University of Design, Sonipat, India

Email: [ananyabajpai.23@wud.ac.in], [anvickamisra.23@wud.ac.in], [ruchi@wud.ac.in]

Abstract - Parkinson's Disease progressively disrupts not just motor function but the entire fabric of daily life affecting independence, social participation, and caregiver wellbeing simultaneously. Existing assistive interventions tend to address isolated symptoms within clinical settings, failing to account for the unpredictable, domestic reality of living with the condition. This research investigates how a human-centred design approach can produce an integrated ecosystem of touchpoints that supports patients across motor, cognitive, and emotional dimensions within the home environment, with specific attention to India's early-onset cohort and the systemic care gaps unique to low-to-middle income urban contexts.

The project employs a transdisciplinary design research methodology combining secondary literature synthesis, expert consultation with neurological practitioners, and qualitative user journey mapping. A behavioural adoption framework grounded in the Push-Pull-Habit-Anxiety model was used to identify systemic barriers to assistive technology uptake among India's Parkinson's population, particularly within Stages 1 to 3. Insights were synthesised into design principles that informed an ecosystem-level intervention spanning wearable stabilisation hardware, an AI-driven symptom monitoring companion, and caregiver coordination tools.

Research revealed three compounding failure modes in current care: the unpredictability of on/off motor fluctuation cycles across the day, the near-total neglect of non-motor symptoms including fatigue, anxiety, and sleep disruption in technology design, and high device abandonment rates driven by social stigma. India-specific factors including geographic care dispersion, caregiver burnout, and affordability constraints further widen the gap between clinical intervention and lived experience. The resulting Tidewalk ecosystem proposes a low-cost, stigma-conscious design framework that decentralises chronic condition management, distributing support across physical, digital, and service touchpoints while generating longitudinal data that improves remote care quality and caregiver confidence. This work contributes a replicable ecosystem-level design methodology for chronic neurological conditions in low-to-middle income contexts, moving beyond single-product intervention toward a holistic sociotechnical framework grounded in dignity, daily rhythm, and caregiver equity.

***Keywords*:** Neuroergonomics, Assistive Ecosystems, Motor Fluctuation, Sociotechnical Design, Caregiver Equity.

1. INTRODUCTION

Parkinson's Disease (PD) is a progressive neurodegenerative condition characterised by the degeneration of dopaminergic neurons in the substantia nigra, producing the clinical triad of tremor, rigidity, and bradykinesia alongside a wide spectrum of non-motor symptoms including cognitive fog, anxiety, sleep disruption, and autonomic dysfunction (Poewe et al., 2017). In India, the condition affects over 770,000 individuals, a figure that has risen by 55.89% over the past decade, with an average onset age of 51 years, placing a disproportionately high burden on working-age adults (Parkinson's Foundation, 2023; NIMHANS, 2022). Unlike Western patient demographics, India's Parkinson's population contends with an early-onset profile, fragmented specialist access, geographically dispersed families, and deeply embedded social stigma around visible disability. Pharmacological management through Levodopa remains the frontline intervention but is characterised by cyclical on-off motor fluctuations - periods of functional control followed by sudden motor failure - that are difficult to predict and nearly impossible to manage through episodic clinical visits alone (Hauser et al., 2013). Current assistive technology, where it exists, addresses either motor symptoms or caregiver burden in isolation, producing solutions that are clinically effective but socially rejected, or socially acceptable but functionally inadequate.

This research introduces Tidewalk, a transdisciplinary design ecosystem that reframes Parkinson's care as a distributed, everyday experience rather than a clinic-centric medical event. Rather than designing a single device, Tidewalk proposes an interconnected set of touchpoints - wearable stabilisation hardware, an AI-assisted digital monitoring companion, and a caregiver coordination interface - that collectively support patients across the motor, cognitive, and relational dimensions of daily life. The project is grounded in the design premise that chronic neurological conditions cannot be managed by any single product, but require thoughtful ecosystem architecture that addresses the patient, the caregiver, and the clinician simultaneously within their real environmental contexts.

The relevance of this research extends beyond Parkinson's Disease. Approximately 80% of people living with chronic neurological conditions in India receive no structured support between clinical appointments, relying instead on family caregivers who operate without objective data, professional training, or institutional respite (Ray Dorsey et al., 2018). As India's ageing population grows and neurological disease prevalence rises, the demand for home-based, technology-assisted care management will intensify. Tidewalk's design methodology, which integrates behavioural adoption frameworks, secondary literature synthesis, and qualitative journey mapping, offers a transferable model for designing ecosystem-level interventions in other chronic conditions including post-stroke rehabilitation, Type 2 diabetes management, and early-onset dementia care.

The scope of this project targets individuals in Stages 1 through 3 of Parkinson's Disease, the mild-to-moderate phase during which patients retain meaningful functional independence and are most receptive to behavioural and technological intervention. Designing for early-stage engagement enables the Tidewalk ecosystem to establish habits, data baselines, and caregiver rhythms before the condition advances, creating a foundation that supports quality of life across the full disease trajectory. The project does not seek to cure or arrest neurological decline; rather, it seeks to reclaim the daily moments - getting dressed, preparing a meal, walking to the door - that define a person's sense of agency and dignity within their own home.

This paper presents the research foundation, design process, and conceptual framework of the Tidewalk ecosystem. The literature review establishes the clinical and technological landscape of current Parkinson's care interventions. The design process section documents the methodology through which research insights were translated into ecosystem-level design decisions. The conclusion reflects on the implications of this framework for practice-led design research in neurological health contexts, and the future scope section outlines pathways through which Tidewalk may be developed, validated, and scaled.

2. LITERATURE REVIEW

The following ten papers constitute the secondary research foundation for the Tidewalk project. Each is reviewed for its research base, aims and objectives, gaps identified, findings relevant to this project, and future directions it suggests. Together they establish the clinical, technological, and social context within which the Tidewalk ecosystem is positioned.

Poewe et al. (2017) - Parkinson's Disease: Clinical Pathophysiology and Motor Progression

Poewe et al. (2017) provide the foundational clinical mapping of idiopathic Parkinson's Disease, examining the neurodegeneration of dopaminergic pathways and the resulting motor and non-motor symptom progression across global patient cohorts. The study's primary aim was to define diagnostic criteria and establish evidence-based staging frameworks to guide pharmacological and non-pharmacological intervention. The research, however, largely confines its scope to clinician-facing diagnostic tools and hospital-based management protocols, leaving significant gaps in the exploration of home-environment support systems and non-pharmacological physical product design for domestic contexts. Its key contribution to this project lies in its finding that motor decline in Parkinson's follows volatile, non-linear trajectories - patients may experience good functional control in the morning and near-complete motor failure by the afternoon - reinforcing the impossibility of managing the condition through periodic clinical appointments alone. This insight directly motivates Tidewalk's emphasis on continuous, home-based monitoring rather than episodic assessment. Future research, as the authors suggest, must develop adaptive physical and digital support mechanisms that respond to hourly physiological state changes rather than averaged weekly symptom reports.

Galli (2025) - OnCue: Adaptive Typing Interfaces with Haptic Cueing for Parkinson's Patients

Galli (2025) developed OnCue, an adaptive typing interface that integrates haptic feedback mechanisms to reduce keyboard interaction errors caused by intention tremors in Parkinson's patients. The study's objective was to evaluate whether ergonomically redesigned keyboard hardware - specifically split modular layouts with raised-edge keycaps - could meaningfully improve typing accuracy and reduce fine motor fatigue during sustained computer use. The research identifies a critical gap: the OnCue hardware was developed and tested in isolation, without any mechanism for longitudinal data synchronisation into clinical companion applications, meaning clinicians received no actionable insights from the device's use. The finding that modular raised-edge layouts significantly improve typing accuracy and hand stability has direct implications for Tidewalk's assistive interface design, particularly for working-age early-onset patients who require professional computer use continuity. Future scope, as Galli notes, lies in integrating desktop hardware directly with wearable tremor-dampening actuators to produce a unified, cross-device stabilisation experience - a direction that informs Tidewalk's multi-touchpoint ecosystem architecture.

Satheesan (2019) - Fleo: Gyroscopic Pen Stabilisation for Fine Motor Control

Satheesan (2019) designed Fleo, a gyroscopic pen that applies counter-torque stabilisation to neutralise involuntary shaking and micrographia during handwriting and drawing tasks. The aim was to test whether compact mechanical inertia delivered through high-speed gyroscopic resistance could successfully counteract fine motor tremors without restricting intentional movement gestures. While Fleo demonstrated measurable tremor neutralisation, the study was confined to a single writing instrument and did not explore whether the same principles could be extended into a comprehensive wearable system covering multiple daily-living tasks. Its finding that high-speed gyroscopic resistance preserves intentional

movement while dampening involuntary shaking is mechanically significant - it suggests that passive stabilisation need not compromise motor agency. For the Tidewalk project, this finding supports the design principle that assistive hardware should support, not override, the patient's own movement intention. Future directions identified include translating mechanical counter-torque principles into miniaturised wristwear, a concept central to Tidewalk's stabilising wristband component.

Bächlin et al. (2010) - Wearable Accelerometers for Real-Time Freezing of Gait Detection

Bächlin et al. (2010) researched the application of wearable accelerometer arrays for the automated, real-time detection of Freezing of Gait (FOG) episodes. The study's objective was to build sensor algorithms capable of identifying the high-frequency leg trembling that characterises freeze onset within sub-second latencies, enabling a cueing system to respond before the patient has fully frozen. The research demonstrated that wearable sensor processing can reliably detect FOG signatures at clinically meaningful speeds, but critically omitted any consideration of discreet, socially acceptable cueing interfaces for real-world adoption outside laboratory settings. The hardware used was bulky, visible, and incompatible with everyday clothing, a design failure that contributed to abandonment rates in the study's follow-up period. For Tidewalk, this paper validates the technical feasibility of sensor-driven FOG detection while simultaneously identifying the aesthetic and stigma gap that the project's design approach must address. Future scope, as Bächlin et al. propose, includes embedding FOG detection natively into everyday footwear and consumer wearables, a direction Tidewalk pursues through its minimal, clothing-integrated hardware form.

Nonnekes et al. (2015) - Sensory Cueing Modalities for Gait Unfreezing in Parkinson's Disease

Nonnekes et al. (2015) conducted a systematic evaluation of visual, auditory, and somatosensory cueing modalities for alleviating Freezing of Gait, examining which sensory stimuli most effectively bypass damaged basal ganglia circuits to re-initiate forward movement. The study found that transverse visual floor projections and rhythmic haptic pulses were the most effective cues for triggering alternate premotor pathways during freeze episodes, producing measurable improvements in step initiation across participant groups. However, the research relied on cumbersome clinical apparatus - floor projectors, tethered vibration units - that were fundamentally unsuited for continuous domestic use or discreet daily wear. This represents the central gap this paper contributes to resolving: clinical efficacy has been established, but ecologically valid, home-compatible implementations have not. Tidewalk draws directly on this study's finding that multimodal cueing combining haptic and auditory stimuli outperforms single-modality approaches, integrating both into a compact wearable form factor. Future scope identified by Nonnekes et al. includes the miniaturisation of cueing units into modular lifestyle accessories, a technical direction that informs Tidewalk's physical product ideation.

Hauser et al. (2013) - Wearing-Off Dynamics in Long-Term Levodopa Therapy

Hauser et al. (2013) characterised the wearing-off dynamics and motor fluctuation patterns experienced by patients undergoing long-term Levodopa therapy, using detailed patient symptom diaries to pinpoint the precise timing and duration of functional decline windows across the day. The study's objective was to improve pharmacological dosing precision by understanding when and how motor control deteriorates between medication doses. A significant gap identified was the study's reliance on retrospective, self-reported paper diaries, a method susceptible to recall bias, underreporting during severe off periods, and the cognitive difficulty of accurate symptom logging during motor impairment. The finding that continuous objective motor tracking provides substantially greater diagnostic accuracy than self-reporting is foundational to Tidewalk's clinical value proposition: by generating automated, longitudinal motor logs, the ecosystem provides neurologists with the precise on-off timing data that self-reporting cannot. Future scope proposed by Hauser et al. - correlating real-time physical sensor data with digital medication schedules - is directly instantiated in Tidewalk's clinician dashboard component.

Fox et al. (2018) - Evidence Review of Device-Assisted Therapies in Parkinson's Disease

Fox et al. (2018) conducted an evidence-based medical review of device-assisted physical therapies for Parkinson's motor symptoms, evaluating the clinical safety and real-world efficacy of a range of external physical interventions across multiple trials. The review's primary finding was that non-invasive mechanical interventions demonstrate high safety profiles and measurable symptom mitigation when ergonomically simplified, but that steep abandonment rates are consistently driven by overly clinical, cumbersome industrial designs that fail to accommodate patient dignity and social context. This finding directly motivates Tidewalk's core design principle: that assistive hardware must be designed with the same consumer aesthetic sensibility as everyday lifestyle products, not the clinical utility aesthetic of medical equipment. The research gap identified - the absence of standardised ergonomic frameworks for geriatric neuro-assistive devices - points toward the kind of design-led contribution this project aims to make. Future scope suggested by Fox et al. involves establishing such frameworks, a task that Tidewalk's design methodology and principles partially address.

Ray Dorsey et al. (2018) - Global Parkinson's Disease Epidemiology and Resource Disparities

Ray Dorsey et al. (2018) examined the global epidemiological growth of Parkinson's Disease and the resulting resource disparities in neurological care delivery, with particular attention to the gap between disease prevalence and specialist

access in low-to-middle income countries. The study quantified worldwide neurological care deficits and evaluated decentralised, home-based care delivery models as a structural response to this gap. A central finding was that assistive products remain largely cost-prohibitive and designed exclusively for Western medical systems, creating a global equity gap in which the populations with the fastest-growing PD prevalence have the least access to effective management tools. For India specifically, this paper grounds Tidewalk's affordability-first design constraint: solutions must target low-cost manufacturing and service models that leverage widely available technology rather than expensive proprietary hardware. Future scope proposed by Ray Dorsey et al. - deploying accessible AI-integrated hardware and software across emerging urban economies - is the precise context in which Tidewalk is designed to operate.

Radder et al. (2019) - User-Centred Adherence and Abandonment in Parkinson's Wearable Technology

Radder et al. (2019) evaluated user-centred adherence criteria and abandonment triggers for wearable assistive technology in Parkinson's Disease, identifying the psychological and social factors that govern long-term adoption. The study found that engineering studies frequently overlook user aesthetics, emotional anxiety, and the social stigma of visible medical hardware as critical determinants of device rejection. Its core finding - that disguising assistive technology behind clean consumer-lifestyle styling substantially increases long-term compliance - is perhaps the single most direct design implication in this literature review. The gap identified is that most wearable device research prioritises sensor accuracy over wearability and social acceptability, producing technically valid but socially unusable products. Tidewalk's design process directly addresses this by treating stigma-consciousness as a first-order design requirement, not an aesthetic afterthought. Future scope identified by Radder et al. - designing wearable therapeutic hardware that visually mirrors modern consumer electronics - is a guiding aesthetic principle in Tidewalk's product ideation phase.

Ellis et al. (2015) - Digital Health Engagement and Feedback Loops in Neuro-Rehabilitation

Ellis et al. (2015) studied interactive digital health engagement and feedback loops in neuro-rehabilitation settings, measuring how digital self-management tools influence patient self-efficacy and exercise compliance over time. The study found that high-contrast visual interfaces, oversized interactive targets, and clear, immediate feedback loops sustain significantly higher long-term engagement among neurological patients than conventional digital health interface designs. A critical gap identified was that standard mobile interface conventions - small tap targets, complex navigation hierarchies, information-dense dashboards - are incompatible with the motor and cognitive profile of Parkinson's patients during active tremor or cognitive fog episodes. This finding directly shapes Tidewalk's digital companion design: large interaction zones, simplified information architecture, and immediate visual confirmation of every user action. Future scope proposed by Ellis et al. - integrating digital habit tracking directly with connected therapeutic physical hardware - is the architectural principle underlying Tidewalk's closed-loop ecosystem, in which the wearable, the app, and the caregiver interface share a unified data layer.

3. RESEARCH GAP

The reviewed literature shows that Parkinson's care intervention is a multidimensional challenge involving far more than the management of visible motor symptoms. Research has identified measurable problems spanning motor fluctuation unpredictability, non-motor symptom neglect, assistive device abandonment driven by stigma, caregiver burnout, data ambiguity in remote care, and the systemic affordability gap that limits technology access in low-to-middle income contexts. Some studies demonstrate that assistive technology can meaningfully reduce freeze duration, improve gait initiation, and support medication adherence, while other research shows that technically effective solutions are frequently rejected due to their clinical aesthetics, complexity, and social visibility. This indicates that the relationship between technology design and patient behaviour is complex and cannot be resolved through engineering improvements alone.

A significant gap identified across the reviewed literature is the limited integration of Parkinson's care research with a user-centred, ecosystem-level design perspective. Many existing studies focus on isolated clinical outcomes - tremor reduction, gait velocity, freeze duration - within controlled laboratory settings, and do not examine how solutions behave across the complete domestic environment in which patients actually live. Comparatively little attention is given to the interactions between physical assistive devices, digital monitoring tools, caregiver communication, and clinical decision-making as a unified experience. The present study addresses this gap by examining Parkinson's care as a sociotechnical ecosystem rather than a collection of discrete clinical problems.

A further gap exists in the India-specific context. Most published research on Parkinson's assistive technology is conducted in Western clinical environments with access to specialist neurological infrastructure, high-bandwidth telehealth systems, and patients accustomed to technology-mediated healthcare. India's Parkinson's population faces a fundamentally different context - early onset, geographic isolation from specialists, family-led informal caregiving, and deep cultural stigma around visible disability - yet receives almost no dedicated design research attention. The present study uses India as its primary context throughout, grounding every design decision in the specific constraints, values, and opportunities that define Parkinson's experience in this setting.

Based on the reviewed literature, the present research synthesises insights across motor fluctuation, non-motor symptom management, device stigma, caregiver equity, data

actionability, and affordability into a unified design framework. The findings serve as the foundation for identifying ecosystem-level design interventions - spanning physical hardware, digital monitoring, and service coordination - that address the complete experience of living with Parkinson's Disease in an Indian domestic context. In this way, the research moves from identifying individual care failures toward understanding how the Parkinson's care experience can be improved through a coherent, user-centred ecosystem design approach.

4. DESIGN PROCESS

The design process translates the research findings into a user-centred ecosystem intervention. The methodology follows five structured stages from research synthesis to concept validation, ensuring that every design decision is traceable to a specific research insight or identified user need. The process is grounded in the principle that Parkinson's Disease cannot be adequately supported by any single product - it requires a coherent set of touchpoints that address the patient, the caregiver, and the clinician within their real domestic and institutional contexts.

4.1 Problem Identification

The literature review and secondary research synthesis identified six compounding failure modes in current Parkinson's care: the unpredictability of on/off motor fluctuation cycles, the systematic neglect of non-motor symptoms in technology design, high device abandonment driven by social stigma, data ambiguity that renders remote monitoring clinically non-actionable, caregiver burnout from unstructured informal care responsibilities, and affordability barriers that exclude the majority of India's Parkinson's population from specialist assistive technology. These failure modes were synthesised through an affinity clustering process that grouped raw research findings by theme, revealing that the dominant problem is not technological capability but ecosystem coherence - the inability of existing solutions to communicate across the patient, caregiver, and clinician triad within the home environment.

A behavioural adoption framework (Push-Pull-Habit-Anxiety model) was applied to map the systemic forces operating on each stakeholder group. This mapping identified that the most critical design leverage points were not in clinical settings but in the domestic spaces where patients spend the majority of their time without professional support. The design problem was therefore defined as:

> *How might we support patients, caregivers, and clinicians with a coherent, dignified, and affordable ecosystem of touchpoints that sustains daily autonomy and reduces care burden across the Parkinson's Disease journey in an Indian urban home context?*

4.2 User Needs

User needs were derived from the six research insights and from analysis of a day-in-the-life journey map for the primary design persona: a 54-year-old urban professional in Stage 2 Parkinson's Disease, living with a working spouse in Bengaluru, receiving occasional support from an adult child in another city. An hour-by-hour journey map traced this persona's experience across a typical day, documenting on and off motor windows, caregiver interaction points, medication timing, and moments of heightened anxiety or social isolation. This exercise identified eleven distinct moments across a single day where the current care system offers no support and where a well-designed touchpoint could meaningfully intervene.

User Need	Design Response
Manage on/off fluctuations in real time	Wristband detects motor state changes and delivers haptic/auditory cueing during freeze or tremor events without requiring user initiation
Track non-motor symptoms alongside motor data	Digital companion app includes daily mood, sleep, and fatigue check-ins using large-format, low-effort input interfaces
Use assistive technology without social disclosure	Wristband form factor designed to resemble a consumer fitness tracker; no clinical markings or medical aesthetics
Reduce caregiver cognitive burden	Caregiver interface translates complex motor data into plain-language daily summaries and configurable alerts
Support clinical decision-making remotely	Longitudinal motor and medication logs are exportable in a simplified report format for use in telemedicine appointments
Access the system affordably	Core hardware targets manufacture within an accessible price band using widely available sensor components; app functions on entry-level Android devices

4.3 Ecosystem Architecture

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With leverage points and intervention moments identified, the ecosystem architecture was defined across three interconnected layers. The product layer comprises the physical touchpoints the patient encounters directly: a stigma-conscious stabilising wristband for tremor management and FOG cueing, designed to resemble a consumer fitness tracker rather than medical hardware. The service layer connects the patient to their support network: an AI-assisted digital companion app that monitors motor patterns, tracks medication response windows, and generates simplified reports for clinical appointments. The coordination layer addresses caregiver and clinician needs: a dashboard that translates complex motor data into actionable daily guidance, reducing the cognitive burden on family caregivers and improving the quality of telemedicine consultations. The three layers share a common data architecture, enabling the system to close the loop between home monitoring and clinical decision-making.

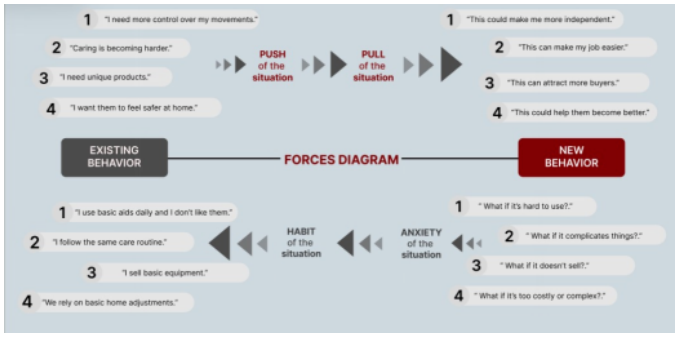


Figure 1. Behavioural adoption forces diagram (Push-Pull-Habit-Anxiety model) informing the Tidewalk ecosystem architecture

4.4 Concept Ideation and Form Development

Form ideation explored multiple directions for the physical wristband, ranging from medical-grade silicone bands to textile-integrated soft electronics. Concept selection criteria prioritised three non-negotiable requirements derived directly from research: the device must be wearable without social disclosure, operable with one hand during an off period, and manufacturable within a cost target accessible to urban middle-income families in India. The digital interface was prototyped through low-fidelity wireframes testing large-target interaction design, high-contrast visual hierarchy, and single-action medication logging. Caregiver interface concepts explored alert design that communicates urgency without inducing panic - a nuanced communication design challenge identified through the caregiver burnout research insight.

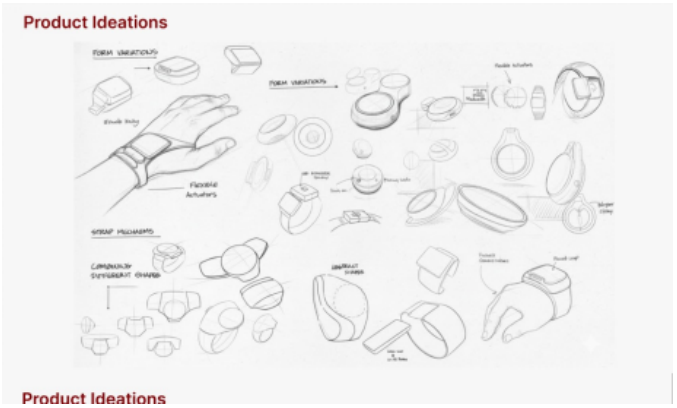


Figure 2. Product ideation - wristband form variations and strap mechanisms

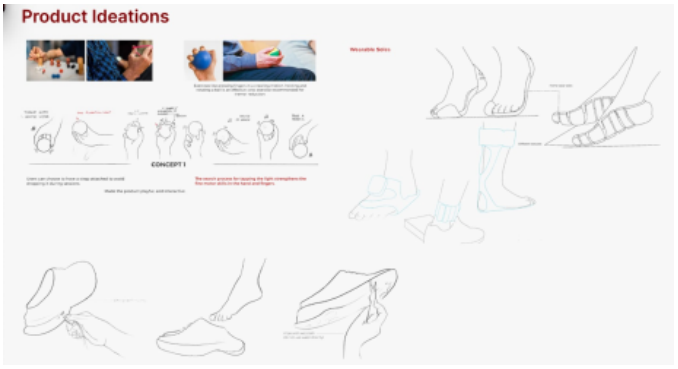


Figure 3. Product ideation - fine motor exercise concepts and wearable sole explorations

4.5 Ecosystem Integration and Scenario Validation

The finalised ecosystem concept was validated through a scenario walkthrough - a narrative simulation of the primary persona's morning routine - in which each touchpoint was tested for coherence, interaction load, and emotional resonance. This scenario revealed two refinements: the wristband cueing mechanism required a manual override option for patients who wished to manage a FOG episode independently, and the caregiver alert system required a configurable sensitivity threshold to avoid alert fatigue during predictable off periods. These refinements were incorporated into the concept before the final ecosystem diagram and product ideations were produced.

4.6 How the Design Addresses the Research Gap

Research Gap	*Design Response*
On/off fluctuation unmanaged between appointments	*Wristband detects motor state changes continuously and delivers immediate cueing - closing the gap between clinical visits*

Non-motor symptoms ignored by existing technology	*App includes structured daily mood, sleep quality, and fatigue inputs that generate a non-motor symptom log alongside motor data*
Device abandonment due to social stigma	*Consumer-grade wristband form factor; no clinical markings; designed to be indistinguishable from a fitness tracker in public settings*
Caregiver burnout from constant informal surveillance	*Automated motor monitoring and configurable alerts replace the need for constant physical supervision by family members*
Data ambiguity undermines telemedicine effectiveness	*Longitudinal motor logs include contextual mood and fatigue inputs that help distinguish true bradykinesia from fatigue-related slowness*
Affordability barriers limit technology access	*Hardware designed for manufacture using widely available sensor components; app optimised for entry-level Android devices*

5. CONCLUSION

The Tidewalk project demonstrates that meaningful progress in Parkinson's Disease care does not require a single breakthrough device - it requires a coherent design ecosystem that understands the condition as a lived, relational, and domestic experience rather than a clinical event. By synthesising a substantial body of clinical and human-centred research with a rigorous behavioural adoption framework, this project has identified and targeted the three compounding failure modes that currently leave India's Parkinson's population without adequate support between specialist appointments: the unpredictability of on-off motor cycles, the systematic neglect of non-motor symptoms in technology design, and the social stigma that causes patients to reject the aids they most need. The resulting ecosystem - spanning wearable stabilisation hardware, an AI-assisted digital monitoring companion, and a caregiver coordination interface - addresses these failures not through technical sophistication alone, but through a design philosophy that places dignity, daily rhythm, and caregiver equity at its centre. Each touchpoint in the Tidewalk ecosystem is justified by specific research evidence, and every design decision is traceable to a documented user insight, making this a practice-led research contribution as much as a product concept.

What this project ultimately argues is that chronic neurological conditions demand chronic design thinking - iterative, relational, and embedded in the real environmental contexts where patients spend their lives. The methodology developed through Tidewalk - which integrates secondary literature synthesis, behavioural frameworks, ecosystem architecture, and scenario-based concept validation - is transferable beyond Parkinson's Disease to other conditions characterised by home-based, caregiver-supported management and technology abandonment driven by stigma or complexity. As India's neurological disease burden grows and the healthcare system's capacity for specialist-led care remains constrained, this kind of decentralised, design-led approach to chronic condition management becomes not a supplementary option but a structural necessity. Tidewalk is a beginning, not a conclusion - an ecosystem framework that requires clinical validation, iterative user testing, and co-design with the communities it seeks to serve.

6. FUTURE SCOPE

The current Tidewalk framework establishes the conceptual and research foundations for an ecosystem that must now move through rigorous user testing and clinical validation. Several specific directions have been identified for further development.

The wristband stabilisation mechanism requires prototyping and iterative testing with Stage 1 to 3 patients to evaluate comfort during extended wear, tremor-dampening efficacy across different tremor frequencies, and the social acceptability of the form factor across diverse urban Indian contexts. Feedback from occupational therapists and physiotherapists specialising in movement disorders should be integrated into subsequent design iterations.

The AI-assisted monitoring companion requires partnership with clinical neurologists to establish validated correlations between sensor-derived motor data and clinically meaningful on-off period classifications. Without this clinical validation layer, the data generated by the wristband cannot reliably inform medication timing decisions - the most significant clinical value proposition the ecosystem offers.

Longer term, the Tidewalk ecosystem architecture could be adapted for other neurological conditions with similar care-gap profiles, including post-stroke rehabilitation, early-onset dementia, and essential tremor. The underlying design methodology - ecosystem thinking applied to

home-based neurological care - is the transferable contribution, and its application to conditions beyond Parkinson's represents a meaningful direction for continued practice-led design research.

Finally, the affordability constraint that shaped this project's design decisions should be tested against real manufacturing and service delivery costs in consultation with Indian health technology manufacturers and social enterprise distributors. A solution that is conceptually accessible but economically unreachable for its target population would represent a design failure regardless of its technical merit.

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