





# Multidisciplinary Stakeholder Perspectives on the Design Needs of a Smart Walker for Fall Prevention Among Older Adults: A Qualitative Study in West Java, Indonesia

Dhika Dharmansyah <sup>1,2</sup>, Laili Rahayuwati <sup>3</sup>, Iqbal Pramukti <sup>3</sup>,  
Kuswandewi Mutyara <sup>4</sup>

<sup>1</sup>Doctoral Program in Medicine, Faculty of Medicine, Universitas Padjadjaran, Sumedang, West Java, Indonesia;

<sup>2</sup>Department of Nursing, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia; <sup>3</sup>Department of Community Health Nursing, Faculty of Nursing, Universitas Padjadjaran, Sumedang, West Java, Indonesia; <sup>4</sup>Department of Public Health, Faculty of Medicine, Universitas Padjadjaran, Sumedang, West Java, Indonesia

Correspondence: Dhika Dharmansyah, Doctoral Program in Medicine, Faculty of Medicine, Universitas Padjadjaran, Jalan Raya Bandung-Sumedang KM 21, Sumedang, West Java, 45363, Indonesia, Email [dhika23001@mail.unpad.ac.id](mailto:dhika23001@mail.unpad.ac.id)



**Background:** Falls among older adults remain a critical patient safety concern globally. Conventional walkers frequently fail to accommodate end-user needs, particularly in low-to-middle-income country (LMIC) settings. Understanding stakeholder design requirements is essential for developing contextually appropriate, technology-enhanced assistive devices.

**Objective:** To explore multidisciplinary stakeholder perspectives on the design requirements for a sensor-integrated smart walker for fall prevention among older adults in Indonesia.

**Methods:** A qualitative descriptive approach was employed within the empathize and define phases of a design thinking framework. Purposive sampling recruited 13 participants across three stakeholder groups: older adult walker users (n=5), informal caregivers (n=5), and healthcare professionals (n=3). Semi-structured interviews were conducted between October and December 2025 in Bandung, West Java. Data were analyzed using Braun and Clarke's reflexive thematic analysis. Cognitive screening used a standardized, licenced assessment tool.

**Results:** Twenty themes were identified across stakeholder groups: seven from older adults, eight from caregivers, and five from healthcare professionals. Convergent needs included a pre-impact fall warning system, design simplicity, structural durability, and affordability. Culturally specific findings included the Sundanese preference for human-accompanied walking (papah), rejection of wheeled designs, and narrow-bathroom (jamban) navigation challenges. Healthcare professionals emphasized BPJS affordability constraints and regulatory integration. Nine prioritized design requirements were derived from cross-stakeholder synthesis.

**Conclusion:** These findings establish an empirically grounded, culturally responsive design foundation for the TEMAN JALAN smart walker — demonstrating that effective assistive technology for LMIC settings requires ground-up needs assessment rather than adaptation of high-income-country prototypes. The identified requirements will directly inform the subsequent ideation, prototyping, and clinical testing phases of this design thinking project, with implications for allied health-led innovation in fall prevention globally.

**Plain Language Summary:** Falls are among the most dangerous and common accidents experienced by older adults. Walking frames (walkers) help prevent falls, but the standard designs currently available in Indonesia are often too bulky for small bathrooms, lack any form of warning system, and do not consider local living conditions. This study asked older adults who use walkers daily, their caregivers, nurses, and a doctor specializing in elderly care about what they need from a better walker. Interviews took place at a residential care home and a hospital clinic in Bandung, Indonesia. Older adults said they feel safer with a walker but struggle in tight bathroom spaces and wish for an alarm that warns them before they fall. Some preferred being physically guided by another person —



a cultural practice called papah in the Sundanese community. Caregivers reported that walkers reduced their physical workload but emphasized that proper training was essential during the first days of use. Nurses and the doctor stressed that most patients rely on government health insurance (BPJS) and cannot afford expensive devices, and that any new technology must fit into hospital procedures. These perspectives are now being used to design a smart walker called TEMAN JALAN that uses motion sensors to detect when someone is about to fall and sends alerts to caregivers.

**Keywords:** older adults, fall prevention, walker, design thinking, qualitative research, stakeholder perspectives, assistive technology, allied health

## Introduction

Falls represent one of the most consequential health hazards facing the ageing global population. An estimated 28–35% of adults aged 65 years and older experience at least one fall annually, with substantially higher incidence in long-term care facilities.<sup>1,2</sup> Fall-related injuries — including hip fractures, traumatic brain injuries, and prolonged immobility — are a leading cause of disability, loss of independence, and premature mortality in older adults.<sup>3</sup> The global economic burden of falls is equally significant, straining acute care services and social support networks.<sup>4</sup>

Indonesia is undergoing a rapid demographic transition, with its population aged 60 and above projected to reach approximately 19% by 2045.<sup>5</sup> Geriatric care infrastructure remains underdeveloped: geriatric specialists are scarce, community-based rehabilitation is limited, and the national health insurance system (BPJS Kesehatan) does not yet routinely cover technology-enhanced assistive devices.<sup>6,7</sup> These factors create a distinct landscape that cannot be addressed through simple transfer of Western-designed solutions.

Assistive mobility devices, particularly walkers, constitute a frontline intervention for fall prevention in older adults with gait instability or balance impairment.<sup>8</sup> Their biomechanical benefits are well-documented.<sup>9</sup> However, a substantial proportion of prescribed walkers are abandoned within the first year of use, driven by design mismatches, environmental incompatibility, perceived stigma, and insufficient training.<sup>10–12</sup> This abandonment signals a persistent failure of device-centred design approaches that prioritize engineering specifications over end-user lived experience.

User-centred design methodologies, including design thinking, have gained prominence in assistive technology research. The five-stage design thinking framework — empathize, define, ideate, prototype, and test — positions user needs at the centre of innovation.<sup>13</sup> Zhang et al demonstrated that cognitive-preference gaps between older adults and designers are a primary driver of smart walker abandonment.<sup>10</sup> Recent evidence further underscores the importance of participatory, multistakeholder approaches: Kacen et al identified that incorporating fall biomechanics into smart walker design improves acceptance among community-dwelling older adults,<sup>14</sup> and Huang et al showed that gait-adapted walker guidance meaningfully reduces fall risk.<sup>15</sup> Pino et al similarly highlighted that posture monitoring integrated in walkers can serve as a practical co-design touchstone with older users.<sup>16</sup> Verhoeven et al's study on community gait analysis demonstrated that real-world gait characteristics diverge significantly from laboratory assumptions — reinforcing the need for ecologically valid, community-based design research.<sup>17</sup>

Despite these advances, gaps remain. Smart walker studies are overwhelmingly situated in high-income countries, with limited attention to LMIC constraints.<sup>10,18,19</sup> Few studies have simultaneously captured perspectives of older adults, informal caregivers, nurses, and physicians within a single investigation. The interplay between cultural values, architectural environments, and economic constraints in shaping design requirements has received minimal scholarly attention. Allied health professionals — central to fall prevention in practice — are rarely integrated into the design process.

This study addresses these gaps through a comprehensive multidisciplinary needs assessment constituting the empathize and define phases of a design thinking project to develop TEMAN JALAN (Teknologi Mandiri Deteksi Jatuh pada Lansia), a sensor-integrated smart walker. The specific objectives were: (1) to explore the lived experiences, needs, and preferences of older adult walker users; (2) to identify caregiver perspectives on walker usability, workload implications, and technology readiness; and (3) to capture healthcare professional insights on clinical requirements, economic constraints, and regulatory considerations.

## Materials and Methods

### Study Design

A qualitative descriptive approach was employed within the first two phases (empathize and define) of the Stanford five-stage design thinking framework.<sup>13</sup> Qualitative description was selected for its capacity to produce a comprehensive, low-inference summary of participant experiences — particularly suited for needs assessment where the aim is to capture the “what” of stakeholder perspectives.<sup>20</sup> Data were analyzed using Braun and Clarke’s reflexive thematic analysis (RTA), following their six-phase process.<sup>21</sup> The Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist guided reporting ([Supplementary Material 1](#)).<sup>22</sup> While COREQ offers a comprehensive structural scaffold for qualitative reporting, we acknowledge, as noted by Braun and Clarke (2024), that some COREQ items (eg., “saturation”) carry assumptions more aligned with thematic saturation models than with RTA’s emphasis on researcher engagement and interpretive depth; where relevant, our reporting reflects RTA-consistent terminology.

### Design Thinking Framework Operationalization

The design thinking framework provided the overarching project structure. In the empathize phase, the research team engaged with participants through in-depth semi-structured interviews to develop deep contextual understanding of their lived experiences, needs, and challenges. In the define phase, interview data were synthesized across stakeholder groups to identify convergent and divergent needs and to construct a unified problem statement and prioritized design requirements. Subsequent phases — ideate, prototype, and test — are planned as future stages of the TEMAN JALAN project and are outside the scope of this paper.

### Setting

Data were collected from three sites in Bandung, the capital of West Java Province, Indonesia: (1) Panti Sosial Budi Pertiwi, a privately managed residential care facility for older adults; (2) Pondok Lansia Tulus Kasih, a privately managed care home in Sarijadi; and (3) the Geriatric Outpatient Clinic at *RS Al-Islam Bandung*, a teaching hospital serving a predominantly BPJS-insured population. These sites were purposefully selected to represent both institutional and community-based care contexts and varied socioeconomic circumstances.

### Participants

Purposive sampling with maximum variation was used to recruit participants capable of providing information-rich accounts across three stakeholder groups.<sup>23,24</sup> Inclusion criteria for older adult participants were: (a) aged  $\geq 65$  years; (b) current walker user for at least 2 months; (c) able to communicate verbally in Indonesian or Sundanese; and (d) absence of severe cognitive impairment, assessed using the Mini-Mental State Examination (MMSE). An unauthorized version of the Indonesian MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR ([www.parinc.com](http://www.parinc.com)). Caregiver participants required at least 6 months of direct caregiving experience with a walker-using older adult. Healthcare professionals required relevant clinical roles in geriatric care with a minimum of 3 years’ experience. The final sample comprised 13 participants ([Table 1](#)).

### Data Collection

Data were collected between October and December 2025 through individual, semi-structured, face-to-face interviews conducted in Indonesian or Sundanese according to participant preference. A bilingual researcher (DD) conducted all interviews. A second team member attended each interview to maintain field notes documenting non-verbal cues (eg., hesitation, emotional responses), environmental observations (eg., visible walker configurations, spatial layout), and contextual details. These field notes were used as a supplementary data source during thematic analysis: they informed the reflexive memos maintained by DD and LR and were consulted during theme review to contextualize ambiguous verbal data, though they were not subject to independent coding. An interview guide was developed based on the design thinking empathize protocol and pilot-tested with one participant per stakeholder group (pilot data excluded from final

**Table 1** Demographic Characteristics of Participants

Code	Group	Age (Years)	Sex	Role	Duration/Experience/Setting
R1	Older adult	76	Male	Walker user	30 years/Private residence
R2	Older adult	80	Female	Walker user	3 months/Private residence
R3	Older adult	73	Female	Walker user	2 months/Panti Budi Pertiwi
R4	Older adult	–	Female	Walker user	5 years/Panti Budi Pertiwi
R5	Older adult	75	Female	Walker user	8 months/Panti Budi Pertiwi
C1	Caregiver	53	Female	Informal caregiver	1 year/Panti Budi Pertiwi
C2	Caregiver	64	Female	Informal caregiver	11 years/Panti Budi Pertiwi
C3	Caregiver	–	Female	Informal caregiver	10 years/Panti Budi Pertiwi
C4	Caregiver	–	Female	Informal caregiver	26 years/Panti Budi Pertiwi
C5	Caregiver	–	Female	Professional caregiver	2 years/Pondok Lansia Tulus Kasih
P1	HCP	38	Female	Geriatric nurse	>5 years/RS Al-Islam Bandung
P2	HCP	51	Female	Geriatric nurse	>10 years/RS Al-Islam Bandung
D1	HCP	33	Female	Geriatric medicine specialist	>3 years/RS Al-Islam Bandung

**Abbreviation:** HCP, healthcare professional.

analysis); the full interview guide (English translation of the Indonesian/Sundanese version used in the field) is provided in [Supplementary Material 2](#). All interviews were audio-recorded with written informed consent and lasted 15–45 minutes. Recordings were transcribed verbatim within 48 hours; Sundanese segments were translated to Indonesian and then to English, with back-translation by an independent bilingual researcher verifying accuracy.

## Data Analysis

Transcripts were analyzed using Braun and Clarke's reflexive thematic analysis, following six phases: (1) familiarization through repeated reading and annotation; (2) generation of initial codes through line-by-line coding; (3) searching for themes by clustering related codes; (4) reviewing themes against coded extracts and the full dataset; (5) defining and naming themes; and (6) producing the final report.<sup>19</sup> Open coding was performed independently by DD and LR; codes were reconciled through joint discussion sessions. Themes were developed separately for each stakeholder group to preserve the distinctiveness of each perspective, with cross-group analysis subsequently performed during the define phase. The full coding tree showing the progression from codes to subthemes to themes, by stakeholder group, is presented in [Supplementary Table S1](#).

## Reflexivity

Reflexivity was integrated throughout the analytic process, consistent with Braun and Clarke's RTA framework.<sup>21</sup> DD (lead researcher and interviewer) is a doctoral nursing researcher with a clinical background in geriatric care and personal experience observing walker use in institutional settings. LR and IP are experienced community health nursing researchers with prior qualitative fieldwork in Indonesian elderly populations. KM is a public health physician with expertise in geriatric medicine. All team members maintained individual reflexive journals documenting assumptions, reactions, and analytical decisions throughout data collection and analysis. Team discussions included explicit examination of how researchers' professional backgrounds and disciplinary perspectives shaped thematic interpretations. These reflections were integrated into an audit trail to enhance transparency and credibility.

## Trustworthiness

Trustworthiness was established through: (a) data source triangulation across three stakeholder groups; (b) investigator triangulation through independent coding by two researchers; (c) member checking — thematic summaries for each stakeholder group were returned to three participants (one per group) via in-person follow-up; participants confirmed that summaries accurately reflected their perspectives and suggested no major additions or corrections; and (d) maintenance of a reflexive audit trail documenting analytical decisions throughout the process.<sup>25</sup> Rather than “data saturation” — a concept more aligned with thematic saturation models — we assess data sufficiency based on the richness and interpretive depth achieved across 13 participants, consistent with RTA’s emphasis on meaningful researcher engagement with the data.<sup>21</sup>

## Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Universitas Padjadjaran (Reference: 614/UN6.KEP/EC/2025). Written informed consent was obtained from all participants; for participants unable to write, verbal consent was witnessed and documented. All data were anonymized using coded identifiers, and audio recordings were stored on an encrypted device accessible only to the research team.

## Results

### Overview of Themes

Analysis yielded 20 themes across three stakeholder groups (Table 2). Results are presented in four parts: Part A – older adult themes (7 themes); Part B – caregiver themes (8 themes); Part C – healthcare professional themes (5 themes); and Part D – cross-stakeholder synthesis.

**Table 2** Overview of Themes by Stakeholder Group

Theme No.	Theme Description	Stakeholder Group
1	The walker as a safety anchor against falling	Older adults (n=5)
2	Facilitation of daily mobility and routine activities	Older adults (n=5)
3	Comfort and ease of use as adoption determinants	Older adults (n=5)
4	Desired design features: alarms, durability, simplicity	Older adults (n=5)
5	Emotional ambivalence: gratitude versus preference for human assistance	Older adults (n=5)
6	Environmental and postural challenges during walker use	Older adults (n=5)
7	The walker’s role in preserving functional independence	Older adults (n=5)
1	Enhanced mobility and independence	Caregivers (n=5)
2	Fall prevention and safety assurance	Caregivers (n=5)
3	Initial adaptation challenges	Caregivers (n=5)
4	Reduced caregiver physical burden	Caregivers (n=5)
5	Acceptance and adaptation trajectories	Caregivers (n=5)
6	The critical role of education and training	Caregivers (n=5)
7	Environmental safety concerns	Caregivers (n=5)

(Continued)

**Table 2** (Continued).

Theme No.	Theme Description	Stakeholder Group
8	Expectations for technologically enhanced walkers	Caregivers (n=5)
1	Clinical rationale for walker use	Healthcare professionals (n=3)
2	Pain-related resistance as a major barrier	Healthcare professionals (n=3)
3	Affordability and BPJS insurance constraints	Healthcare professionals (n=3)
4	Sensor technology as early warning – with simplicity requirements	Healthcare professionals (n=3)
5	Regulatory integration and training infrastructure	Healthcare professionals (n=3)

## Part A: Older Adult Perspectives

### Theme 1: The Walker as a Safety Anchor Against Falling

All five older adult participants described the walker as indispensable for safe ambulation. R1, a 76-year-old male who had used a walker for 30 years, stated: “Kalau tidak pakai walker, suka jatuh.” [If I do not use the walker, I tend to fall.] (R1) R4, who experienced recurrent falls prior to walker adoption, described a transformative effect: “Kalau saya tidak pakai walker, sering jatuh. Dengan walker, saya merasa aman dan percaya diri.” [If I do not use the walker, I often fall. With the walker, I feel safe and confident] (R4).

### Theme 2: Facilitation of Daily Mobility and Routine Activities

Participants described using walkers for daily activities including traveling to the bathroom, walking to communal spaces, sunbathing, and light social interactions. Walker use was predominantly confined to indoor and immediately adjacent outdoor spaces. R2, an 80-year-old woman recovering from a fracture, described her constrained mobility radius: “Saya pakai walker di dalam rumah. paling ke depan saja. masih takut lebih jauh. masih trauma.” [I use the walker inside the house. at most to the front. still afraid to go further. still traumatized.] (R2)

### Theme 3: Comfort and Ease of Use as Adoption Determinants

Most participants reported comfort after an initial adjustment period. However, R3 expressed a preference for papah – being physically guided by another person: “Lebih enak dipapah. walker membantu, tapi yang saya mau itu bisa jalan biasa lagi.” [It is better to be guided by a person. The walker helps, but what I really want is to walk normally again.] (R3) The preference for papah reflects a culturally significant Sundanese practice in which physical accompaniment simultaneously provides support and expresses relational care, respect, and familial closeness.

### Theme 4: Desired Design Features – Alarms, Durability, and Simplicity

Participants converged on three priority features: (a) an alarm or warning system for impending fall risk; (b) strong, durable construction; and (c) design simplicity. R4 stated: “Alarm itu penting” [The alarm is important]. R2 elaborated: “Bagus kalau ada. jadi orang tahu. aman. Jangan berat, jangan terlalu ringan juga. roda bikin malas jalan. harus bisa dilipat.” [It would be good. so people know. it is safe. Do not make it heavy, but not too light either. wheels make me lazy to walk. it should be foldable.] (R2) Three of five participants explicitly rejected wheels, reasoning they promoted passivity and reduced walking motivation.

### Theme 5: Emotional Ambivalence Between Gratitude and Preference for Human Contact

Emotional responses ranged from active gratitude to resigned acceptance. R2 felt happy because of the support received; R4 expressed feeling safe and confident. Yet a persistent yearning for unaided mobility remained. R1, after three decades of walker use, described emotional habituation: “Biasa saja.” [It is just normal. ordinary.] (R1) This spectrum illuminates the emotional complexity of long-term assistive device dependence in this cultural context.

## Theme 6: Environmental and Postural Challenges

The most frequently cited challenge was navigating the jamban – the narrow bathroom typical of Indonesian residential architecture. R3 described: “Di kamar mandi sempit. walker kurang nyaman” [In the bathroom it is tight. the walker is less comfortable there]. R5 reported a postural consequence of wheeled walker use: “Jadi bongkok. karena walker roda. tidak bisa tegak.” [I became hunched. because of the wheeled walker. it does not let me stand straight.] (R5) These observations highlight the importance of designing walkers that accommodate the spatial constraints of Indonesian domestic architecture, including small wet-floor bathrooms with squat toilets and narrow corridors.

## Theme 7: The Walker’s Role in Preserving Functional Independence

The walker emerged as a tool for maintaining functional autonomy. R4 captured this bounded independence: “Saya bisa jalan, cuci, jemur. pakai walker. yang penting jangan keluar jalur.” [I can walk, wash, sunbathe. with the walker. the important thing is do not stray from the pathway.] (R4)

## Part B: Caregiver Perspectives

### Theme 1: Enhanced Mobility and Independence

All five caregivers affirmed that walkers substantially enhanced mobility and independence. C4 described: “Sebelum pakai walker, setiap mau ke aula harus didorong pakai kursi roda. sekarang bisa sendiri.” [Before having the walker, every time she wanted to go to the hall she had to be pushed in a wheelchair. now she can go by herself.] (C4) C5 elaborated that the walker “mengembalikan rasa percaya diri lansia bahwa mereka terlindungi dari risiko jatuh” [restores the confidence of older adults that they are protected from fall risk].

### Theme 2: Fall Prevention and Safety Assurance

Caregivers consistently identified fall prevention as the walker’s primary function. C2 stated: “Kalau tidak bawa tongkat, jatuh. pakai walker, tidak” [If she does not carry her stick, she falls. with the walker, she does not]. C1 noted that four-legged walkers provided superior stability: “Yang satu kaki tidak stabil. goyang” [The single-stick one is not stable. it wobbles].

### Theme 3: Initial Adaptation Challenges

Caregivers described a learning curve during initial walker adoption. C1 reported: “Awalnya agak susah. angkat sana sini. tapi setelah diajarin, jadi gampang” [At first it was quite difficult. lifting it here and there. but after being taught, it got easier]. C4 observed initial resistance: “Awalnya mereka tidak mau. setelah dilatih, akhirnya patuh” [At the beginning they did not want to. after being trained, they eventually complied].

### Theme 4: Reduced Caregiver Physical Burden

Caregivers reported that walkers significantly reduced their physical workload. C4 provided a vivid account:

Sebelum ini, saya harus dorong kursi roda untuk semuanya. mandi, ke aula. capek. saya masih masak, bersih-bersih, cuci. bangun jam setengah dua pagi sudah. [Before this, I had to push the wheelchair for everything. bathing, going to the hall. exhausting. I still have cooking, cleaning, laundry. I wake up at 1:30 AM already.] (C4)

### Theme 5: Acceptance and Adaptation Trajectories

Caregivers observed that walker acceptance varied with cognitive status and personality. C5 offered a nuanced observation: “Tergantung lansianya. otaknya masih bagus tidak. bisa atur diri sendiri atau tidak. beda dengan yang demensia.” [It depends on the individual older adult. whether their brain is still good. whether they can manage themselves. it is different with someone who has dementia.] (C5)

### Theme 6: The Critical Role of Education and Training

All caregivers emphasized proper training for both older adults and caregivers themselves. C5 provided the most detailed account: “Harus diedukasi waktu pertama pakai – walkernya dulu yang digerakkan atau kakinya dulu?. Kalau salah urutannya, bisa jatuh.” [You have to educate them when they first use it – do they move the walker first or take a step first?. If the sequence is wrong, they could fall.] (C5) This quote illustrates the critical safety implications of training

sequencing: the correct movement sequence (walker first, then foot) is not intuitively obvious to new users and can directly cause a fall if misunderstood. It underscores that any smart walker deployment must be accompanied by a structured, step-by-step training protocol delivered by trained healthcare professionals or caregivers, representing a core design requirement beyond the device itself.

### Theme 7: Environmental Safety Concerns

Environmental hazards – slippery floors, worn rubber tips, and wet bathroom areas – were consistently noted. C5 expressed concern: “Di kamar mandi, risiko jatuh ke belakang itu yang paling saya khawatirkan” [In the bathroom, the risk of falling backward is what I am most worried about]. C1 noted challenges with wheeled walkers on sloped surfaces.

### Theme 8: Expectations for Technologically Enhanced Walkers

Caregivers were unanimously receptive to sensor-based alert systems. C5 articulated: “Kalau bisa ada kamera kecil untuk merekam aktivitas. bisa jadi laporan kita. harganya harus terjangkau, maksimal Rp 500.000.” [If there could be a small camera to record activities. it could serve as our reports. the price should be affordable, maximum Rp 500,000.] (C5) C3 emphasized caregiver notification: “Harus ada informasi yang dikirim ke petugas caregiver” [There should be information sent to caregiver staff]. The price ceiling articulated by C5 – approximately USD 30 – establishes a critical economic design constraint.

## Part C: Healthcare Professional Perspectives

### Theme 1: Clinical Rationale for Walker Use

Healthcare professionals framed walker use within a broader clinical context. D1 identified multiple functions:

Pertama, memfasilitasi mobilisasi. kedua, membantu caregiver. ketiga, meningkatkan kepatuhan berobat – pasien bisa datang kontrol lebih mudah, jadi penyakit kronis tetap terkelola. [First, to facilitate mobilization. second, to help the caregiver. third, to improve treatment adherence – patients can come for clinic visits more easily, so chronic conditions stay managed.] (D1)

P2 emphasized biomechanical benefit: “Walker membantu menjaga keseimbangan. untuk pasien yang stabilitasnya terganggu, pegangannya lebih kokoh” [The walker helps maintain balance. for patients whose stability is compromised, the handholds are sturdier].

### Theme 2: Pain-Related Resistance as a Major Barrier

D1 identified pain as the predominant barrier: “Banyak yang menolak karena nyeri. pasien dengan osteoarthritis atau radikulopati sulit diminta berdiri.” [Many refuse because of pain. patients with osteoarthritis or radiculopathy find it difficult to be asked to stand.] (D1) This contrasts with the older adult perspective, where pain was not a primary barrier – suggesting that clinical populations may present with higher acuity than community-dwelling populations.

### Theme 3: Affordability and BPJS Insurance Constraints

A dominant theme was the economic barrier posed by BPJS dependence. P2 noted: “95 persen pasien di sini pakai BPJS” [95% of patients here use BPJS]. D1 elaborated: “Kebanyakan lansia sudah pensiun, tidak semua anak bisa mendukung secara finansial. harganya harus lebih terjangkau untuk pensiunan” [Most older adults are retired, not all children can support financially. the price needs to be more affordable for pensioners].

### Theme 4: Sensor Technology as Early Warning – With Simplicity Requirements

Healthcare professionals endorsed sensor-based fall detection. Both D1 and P1 cautioned against interface complexity: “Dari sisi lansia, kalau ada tombol atau instruksi yang harus ditekan, mereka mungkin kesulitan.” [From the perspective of older adults, if there are buttons or instructions that need to be pressed, they might find it difficult.] (D1) P1 advocated for passive ambient sensing requiring no active user interaction.

### Theme 5: Regulatory Integration and Training Infrastructure

D1 articulated a clear pathway for institutional adoption:

Harus masuk ke SOP dan algoritma penatalaksanaan. disosialisasikan ke internis, neurolog, dokter rehabilitasi medik. supaya kita bisa merekomendasikan ke pasien. [It should be incorporated into SOPs and treatment algorithms. socialized to internists, neurologists, rehabilitation medicine specialists. so that we can recommend it to patients.] (D1)

## Part D: Cross-Stakeholder Synthesis (Define Phase)

Cross-group analysis identified five areas of convergence: (1) walkers are essential for fall prevention but current designs are inadequate; (2) a pre-impact early-warning system is urgently needed; (3) simplicity of use is non-negotiable for older adult acceptance; (4) structural durability and stability must be maintained; and (5) the smart walker must be affordable within existing economic constraints.

Three areas of divergence were also identified: (1) the relative importance of human versus device assistance (older adults expressed latent preference for papah, while caregivers and healthcare professionals emphasized device-based solutions); (2) wheel inclusion (older adults rejected wheels; caregivers held mixed views; healthcare professionals expressed no strong preference); and (3) level of technology integration (caregivers envisioned camera documentation; healthcare professionals required SOP integration; older adults wanted basic alarm functionality only).

The synthesis produced a unified problem statement: Conventional walkers available in Indonesian care settings fail to provide early warning of fall risk, are poorly adapted to local architectural environments, lack integration with healthcare delivery systems, and remain financially inaccessible to the majority of older adults who depend on BPJS insurance – creating a critical gap between the proven preventive potential of walking aids and their actual effectiveness in protecting older adults from falls.

Nine prioritized design requirements were derived from the synthesis (Table 3).

## Discussion

The triangulation of older adult, caregiver, and healthcare professional perspectives reveals a consistent set of design needs that aligns with and extends the existing literature on assistive mobility device design. The universal endorsement of a pre-impact fall warning system mirrors the recent paradigmatic shift in fall prevention technology from reactive post-fall detection toward predictive, pre-impact approaches.<sup>1,2</sup> An et al's evidence synthesis on community-based fall prevention concluded that multifactorial interventions incorporating technology-based monitoring and early warning systems show the greatest promise for reducing fall incidence.<sup>4</sup> The present findings extend this evidence by

**Table 3** Prioritized Design Requirements by Stakeholder Group

Design Requirement	Older Adults	Caregivers	Healthcare Professionals
Pre-impact fall warning (alarm/sensor)	Yes*	Yes*	Yes*
Simple, automatic operation (no buttons)	Yes*	–	Yes*
Structural strength and stability	Yes*	Yes*	–
Compact design for narrow bathrooms	Yes*	Yes*	–
Affordable (BPJS/pension compatible)	–	Yes*	Yes*
Caregiver/staff notification system	–	Yes*	Yes*
Integration with clinical SOP	–	–	Yes*
Training and education program	–	Yes*	Yes*
No wheels (or optional wheels)	Yes*	Mixed	–

**Notes:** \* "Yes" indicates that participants from this stakeholder group expressed a clear need for this design requirement during interviews. "–" indicates that this requirement was not prominently raised by this stakeholder group. "Mixed" indicates divergent views within the caregiver group.

**Abbreviation:** SOP, standard operating procedure.

demonstrating that the concept of proactive sensor-based fall warning resonates intuitively with diverse stakeholders, including populations with limited prior technology exposure.

## Cultural Specificity: Papah, Wheels, and the Jamban

Several findings carry distinctly Indonesian cultural signatures. The Sundanese concept of papah – being physically guided while walking – emerged as a culturally preferred mode of mobility assistance that simultaneously provides physical support and expresses relational care. It is important, however, to note that the papah preference was expressed primarily by one participant (R3) and should not be over-generalized as universal across all Sundanese older adults: individual preferences vary considerably based on personality, physical capacity, prior experiences, and degree of walker dependence. Nevertheless, this finding suggests that smart walker design should position the device as a complement to human care relationships rather than a replacement for them, which is consistent with Verhoeven et al’s observation that mobility aid preferences are deeply intertwined with emotional and social meanings.<sup>26</sup>

The rejection of wheeled walkers due to concerns about passivity and reduced walking motivation is an additional culturally inflected finding. While much of the international smart walker literature focuses on wheeled, motorized platforms,<sup>27,28</sup> the present results suggest that in the Indonesian context – where active walking is perceived as a virtue associated with independence – a non-motorized, stability-focused design may achieve greater user acceptance. This aligns with Zhang et al’s observation that cognitive-preference gaps between older adult users and technology designers frequently lead to feature rejection.<sup>10</sup> Variability within Indonesia (eg., urban vs rural settings, different ethnic groups) was not fully captured in this single-city sample and warrants exploration in future research.

The prominence of the jamban as a design obstacle is specific to Indonesian residential architecture. International smart walker literature does not address this spatial constraint, which affects millions of Indonesian older adults in their most vulnerable daily activity.

## The BPJS Economic Constraint as a Design Driver

The healthcare professional finding that an estimated 95% of geriatric outpatients are BPJS-insured, combined with the caregiver-articulated price ceiling of Rp 500,000 (approximately USD 30), establishes a tight economic design space. This contrasts sharply with existing smart walkers in the literature, which typically cost hundreds to thousands of US dollars.<sup>10,27</sup> Rather than viewing this as a limitation, it may serve as an innovation driver – necessitating frugal engineering approaches using low-cost components and locally sourced materials. It should be noted that specific technological platforms were not identified by participants; any future engineering decisions regarding components must be informed by subsequent ideation and prototyping phases rather than extrapolated from these qualitative findings.

Li et al’s study on transitional care needs identified economic support as a major theme among elderly patients and caregivers in China, reflecting a broader pattern across Asian LMIC contexts.<sup>23</sup> The present study adds specificity by documenting the precise price threshold articulated by end-users and the institutional realities of BPJS coverage.

## Multi-Stakeholder Divergence and the Modular Design Imperative

The divergence between stakeholder groups on the appropriate level of technology integration – older adults preferring minimal features, caregivers envisioning documentation capabilities, healthcare professionals requiring SOP integration – suggests that a modular design philosophy may offer the optimal strategy. Core safety features would be universal while advanced functionality could be added based on care context. This resonates with Ludlow et al’s finding that stakeholder involvement produces solutions with greater contextual relevance.<sup>29</sup>

Wang et al demonstrated that prioritizing user needs through structured methods can identify “must-be” attributes that must be universally present versus “attractive” attributes that enhance satisfaction when available.<sup>30,31</sup> Importantly, what constitutes a “must-be” feature is not fixed – it is subject to individual preferences and cultural context. The present findings illustrate this: while a pre-impact alarm may be a universal must-be feature, wheel configuration and camera documentation represent contested attributes where user preferences diverge considerably. This nuance should guide the Kano-type prioritization in subsequent ideation phases.

## Comparison with International Perspectives on Assistive Technology Acceptance

Merkel et al identified themes of conditional acceptance among older adults, where adoption was contingent upon perceived benefit, usability, and recommendation by trusted healthcare providers.<sup>32</sup> The present study corroborates these findings while adding three dimensions specific to the Indonesian LMIC context: (1) financial conditionality linked to the BPJS system; (2) cultural conditionality related to the papah preference; and (3) architectural conditionality driven by the jamban navigation challenge. Together, these demonstrate that technology acceptance models developed in high-income settings require substantial contextual adaptation.

## Implications for Design Thinking Progression and Allied Health Practice

The empathize-define findings establish an evidence base for the subsequent ideation phase of the TEMAN JALAN project. Five key design principles emerged: (a) safety as the non-negotiable priority, achieved through passive sensor-based pre-impact detection; (b) simplicity of interaction with automatic operation requiring no active user input; (c) architectural compatibility with Indonesian residential environments; (d) economic accessibility within the BPJS-compatible price range; and (e) clinical integrability through SOP-ready design and structured training materials.

These findings illustrate the value of integrating allied health perspectives into assistive technology design. The geriatric nurses and caregivers in this study contributed clinically critical requirements – passive sensing interfaces, SOP integration pathways, BPJS-compatible pricing, and training sequencing – that would likely not have emerged from an engineering-only design process. This is consistent with Boerema and van Velsen’s argument that fall detection technology should be understood as part of a broader product-service system integrating the device within existing care ecosystems.<sup>33</sup> The present findings support this perspective: participants envisioned the smart walker not as an isolated consumer product but as a node within a care network connecting older adult, caregiver, nurse, and physician. Whether allied health professionals are best characterized as “co-creators” or “key informants” in the design process remains a subject of ongoing scholarly discussion; the present study contributes empirical evidence to this conversation without prescribing a single model of involvement.

## Strengths and Limitations

Strengths include: the simultaneous inclusion of four types of stakeholders within a single design thinking investigation; data collection in participants’ preferred languages (including Sundanese); and inclusion of both institutional and community-based settings. In terms of data sufficiency, the richness of responses – including recurring patterns, convergent needs, and internally coherent divergences – indicates that the dataset provided adequate depth for the design requirements synthesis, consistent with RTA’s emphasis on meaningful researcher engagement rather than frequency-based saturation.<sup>21</sup>

Several limitations warrant acknowledgement. The sample was drawn from a single urban area (Bandung, West Java) and may not represent rural settings or non-Sundanese cultural contexts within Indonesia’s diverse population. The older adult sample was predominantly female (4 of 5 participants), limiting insight into gender-specific experiences. Cognitive screening excluded older adults with significant cognitive impairment – a population with potentially distinct and acute needs. The healthcare professional sample (n=3) was small; a larger sample from different institutions would strengthen findings. Future research should expand geographic and cultural diversity, include participatory visual methods, and incorporate perspectives from biomedical engineers and BPJS policy stakeholders.

## Conclusions

This multidisciplinary qualitative needs assessment, conducted within the empathize and define phases of a design thinking framework, reveals that Indonesian older adults, caregivers, and healthcare professionals share a convergent vision for a smart walker that prioritizes pre-impact fall detection, operational simplicity, structural durability, spatial compatibility with local residential environments, and economic accessibility. Culturally and contextually specific findings – including the Sundanese preference for human-accompanied walking (papah), the rejection of wheeled

designs, challenges navigating narrow bathrooms (jamban), and the BPJS-linked affordability threshold – demonstrate that effective assistive technology design for older adults in LMIC settings requires ground-up, context-specific needs assessment rather than top-down adaptation of high-income country prototypes. These empirically grounded design requirements now serve as the foundation for the ideation, prototyping, and clinical testing of TEMAN JALAN, a sensor-integrated smart walker designed to keep Indonesian older adults safer, more independent, and more connected to their care networks.

## Abbreviations

BPJS, Badan Penyelenggara Jaminan Sosial (Social Insurance Administration Organization); COREQ, Consolidated Criteria for Reporting Qualitative Research; LMIC, low-to-middle-income country; MMSE, Mini-Mental State Examination; RTA, reflexive thematic analysis; SOP, standard operating procedure; TEMAN JALAN, Teknologi Mandiri Deteksi Jatuh pada Lansia; PAR, Psychological Assessment Resources.

## Data Sharing Statement

The datasets generated and analyzed during this study are not publicly available to protect participant confidentiality but are available from the corresponding author upon reasonable request.

## Ethics Approval and Informed Consent

This study was approved by the Ethics Committee of Universitas Padjadjaran (Reference: 614/UN6.KEP/EC/2025). All participants provided informed consent prior to participation, including consent for the publication of anonymized responses and direct quotes.

## Consent for Publication

All participants provided consent for the publication of anonymized direct quotes included in this manuscript.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no conflicts of interest in this work.

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