

## Empowering Marginalized Voices through Co-Design: Adaptive Clothing Needs of Female Wheelchair Users in China

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### ABSTRACT

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This study employed a convergent mixed-methods design to map clothing priorities and examine co-design readiness focusing on female wheelchair users and professional designers in China. A survey (n = 160) with online reach to national communities provided prevalence/priority estimates, and semi-structured interviews (n = 40) conducted with these two stakeholder groups explained lived constraints and collaboration conditions. Descriptive statistics (means/Top-2-box) and inductive thematic analysis were integrated around R01–R04. Findings indicate highest priorities for donning/doffing ease (98.8%) and seated-posture fit (96.2%), alongside strong aesthetic/identity needs led by social confidence (98.1%) in work and social contexts. Participants broadly endorsed co-design and willingness to engage, while highlighting translation (from lived experience to design terms), terminology/feasibility issues, and culture-specific concerns (e.g., “losing face”, perceived lack of professionalism). We propose a context-appropriate co-design framework that clarifies roles, decision points, tools, and safeguards, linking functional and expressive needs to practical collaboration mechanisms in the Chinese setting.

**Contribution/Originality:** This study contributes to the existing literature by proposing a culturally adaptive co-design framework for adaptive apparel in China; this study is one of few studies investigating multi-stakeholder evidence (survey n=160; interviews n=40); the paper's primary contribution is finding that seat-first function must pair with style agency to enable empowerment.

### 1. Introduction

As global attention to social inclusivity and design justice continues to grow, adaptive clothing is increasingly recognized as a vital bridge connecting the quality of life and social participation of people with disabilities (World Health Organization [WHO],

2023). Market analyses also point to rising demand (Verified Market Research, 2024), yet persistent gaps remain between product supply and user demand—particularly around product diversity, aesthetic expression, cultural adaptation, and the lack of robust user-participation mechanisms (Esmail et al., 2022). For women who use wheelchairs, these gaps intersect with seated-posture fit, donning/doffing, and fabric comfort, alongside expressive and identity-related needs in work and social life (Carroll & Kincade, 2007; Chang et al., 2014; Stokes, 2010).

In China, official statistics underscore the scale and gendered nature of the challenge: among 49.456 million registered persons with disabilities, 21.925 million are physically disabled, and women account for about 47.8% (China Disabled Persons' Federation, 2023). Despite this, current design practices remain largely expert-driven and struggle to operationalize context-appropriate participation (Esmail et al., 2022). Building on adaptive apparel and participatory design scholarship, this study positions co-design as a promising pathway and focuses on the conditions under which user–designer collaboration can meaningfully address functional, expressive, and culturally situated needs in the Chinese context (Sanders & Stappers, 2008).

### 1.1. Research Objectives

To construct and preliminarily validate a culturally adaptive co-design framework for adaptive clothing that leverages user participation and knowledge co-creation to address the multidimensional needs of Chinese female wheelchair users.

- i. R01: Identify and map priority clothing needs across functional (seated fit, donning/doffing, fabric comfort), aesthetic/identity, and social-context domains.
- ii. R02: Introduce and pilot co-design methods to enable knowledge co-creation and shared decision-making; assess feasibility and challenges in the Chinese cultural and industrial context.
- iii. R03: Assess participation attitudes, willingness, and perceived barriers/enablers to co-design between female wheelchair users and design professionals—to specify context-appropriate collaboration pathways.
- iv. R04: Develop and preliminarily validate the co-design framework using outcomes on functionality, aesthetic satisfaction, user engagement, and empowerment-related indicators (identity, self-efficacy, social visibility).

## 2. Literature Review

Adaptive clothing, as a specialized product designed to serve individuals with disabilities, has garnered significant attention from both academia and industry worldwide in recent years. This chapter systematically reviews relevant literature and conducts an in-depth analysis of the current state of research from four dimensions. First, it examines the theoretical development and practical exploration of inclusive and adaptive clothing design, revealing the trend toward a shift from medical assistance to fashion expression; second, it focuses on research progress regarding gender-specific clothing needs, particularly addressing the dual challenges and complex demands faced by women with disabilities; Third, it explores user participation and empowerment mechanisms from a collaborative design perspective, analyzing the paradigm shift from functional responsiveness to user empowerment; finally, it identifies gaps in existing research, clarifying the theoretical positioning and innovative contributions of this study. Through this systematic literature analysis, this chapter aims to provide a solid

theoretical foundation for constructing a collaborative design framework for adaptive clothing tailored to female wheelchair users in the Chinese context.

## 2.1. The Rise of Inclusive and Adaptive Clothing Design

In recent years, inclusive design has emerged as a key concept in clothing innovation for people with disabilities, emphasizing the reconstruction of traditional clothing development systems from the perspectives of bodily diversity and social equality (Esmail et al., 2020; Cho & Morris, 2018). According to data from the World Health Organization (WHO) (2023), approximately 1.3 billion people worldwide have significant disabilities. This large population has driven the rapid growth of the adaptive clothing market, which is projected to reach a market size of US\$427 million by 2030 (Verified Market Research, 2024). The development of adaptive clothing has, to some extent, addressed the challenges faced by individuals with mobility impairments in dressing, driving a transition from medical assistance to fashion expression (Esmail et al., 2020).

However, existing research has primarily focused on technical functional improvements, such as ease of putting on and taking off clothing and comfort while seated, with limited systematic exploration of user identity expression and socio-cultural dimensions (Suri, 2016; Esmail et al., 2020). Assessments among wheelchair users report low appeal scores for both ready-to-wear and adaptive options and concerns about comfort/hygiene during prolonged sitting (Suri, 2016). Supply-side audits indicate widespread reliance on modularity but limited overall design diversity (Brogin et al., 2017), while computational methods—e.g., 3D scanning and parametric modeling—are increasingly used to support fit customization for seated posture (Nakić & Bogović, 2019).

Esmail et al. (2020) further note that while design innovation has progressed, gaps remain in disability-type coverage, methodological diversity, and cultural consideration. Inclusive criteria developed for lower-body mobility impairments foreground seated-posture constraints and social identity considerations (Cho & Morris, 2018). Such gaps are particularly pronounced for women who use wheelchairs, whose needs are gendered, contextual, and socially embedded—often exceeding what current products address (Carroll & Kincade, 2007; Chae, 2022).

## 2.2. Research progress and limitations in gender-specific clothing needs

Women with disabilities face dual challenges in their clothing behavior: overcoming functional inconveniences due to physical impairments while negotiating implicit gendered expectations for body norms and professional image (Goffman, 1963; Taub et al., 2003). Research on adolescent girls with disabilities identifies core issues in fit, donning/doffing, and fasteners (Stokes, 2010), and the application of the Functional, Expressive, and Aesthetic (FEA) model shows that although functional considerations are common, expressive and aesthetic needs are equally important (Stokes & Black, 2012). Studies with female college students similarly highlight themes of form/function, self-expression, social recognition, and self-efficacy (Chang et al., 2014). For working women with physical disabilities, inclusive product-development approaches help alleviate constraints in professional dressing, though implementation remains uneven (Carroll & Kincade, 2007). Recent evidence among wheelchair users foregrounds recurring seated-fit problems—especially with pants—underscoring persistent design

gaps (Miller & McBee-Black, 2025; Suri, 2016). Gender-linked differences in FEA priorities are also reported (Chae, 2022).

While these patterns are visible internationally, their manifestation in mainland China is shaped by demographic scale and cultural-institutional factors. Official statistics indicate that women constitute a substantial share of those with physical disabilities (China Disabled Persons' Federation, 2023). Moreover, collectivist norms and "face" dynamics can reinforce stricter expectations for body standards and professional presentation, intensifying marginalization; women with physical disabilities may internalize such norms, creating tension between capabilities and aesthetic standards (Taub et al., 2003).

### 2.3. Co-Design Perspective: From Functional Response to User Empowerment

Following the emergence of the multi-layered clothing needs of women with disabilities, the more critical question is: how can these voices be truly translated into substantive changes in the design process? Co-design is a potential solution to this challenge (Sanders & Stappers, 2008). Co-design, as a design paradigm emphasizing user participation and knowledge co-creation, is gradually being introduced into the field of adaptive clothing (Esmail et al., 2022; Feng & Hui, 2021). Unlike the traditional "expert-driven" model, co-design emphasizes that users' life experiences are a key source of knowledge in the design process, particularly suited to situations where vulnerable groups have complex subjective needs and limited channels for expression (Sanders & Stappers, 2008). The theoretical framework proposed by Sanders & Stappers (2008) provides important support for this shift, emphasizing the transformation of users from passive providers of needs to active design partners.

In the field of functional clothing customization for people with disabilities, existing research has analyzed 28 companies selling functional clothing to this demographic, finding that 74% of the clothing employs a modular design strategy, 99% use modular adaptation, but design diversity is low (only 12%) (Brogin et al., 2017). This indicates that most companies cannot achieve fully customized or collaborative design levels, with only a few companies falling under the categories of design customization or fitting customization.

Some scholars (e.g., Esmail et al., 2022; Feng & Hui, 2021) have begun to explore the potential of collaborative design in adaptive product development, particularly its role in enhancing product adaptability and improving user satisfaction. Through the application of computational design methods, researchers have found that using 3D scanning technology to obtain human body data, combined with parametric modeling, can effectively create virtual human body models adapted to different body types and postures, thereby enabling virtual prototype design for functional clothing (Nakić & Bogović, 2019). This technology-driven collaborative design opens new possibilities for personalized customization.

However, the social significance of collaborative design extends far beyond functional matching, and its empowering value is increasingly becoming a theoretical focus. Ergonomic assessment studies of care clothing for individuals with unilateral physical disabilities indicate that newly designed clothing demonstrates better human-machine ergonomics in terms of style and structure compared to existing clothing. However, user

participation in the design process itself is equally important for enhancing their autonomy and satisfaction (Wei et al., 2021).

In the Chinese cultural context, co-design faces unique challenges: collectivist values may suppress the expression of individual differences, hierarchical notions may affect the equality of collaboration, and indirect communication styles may limit the expression of genuine needs (North, 2025). A case study of spinal cord injury patients' wardrobes revealed that while both adaptive and conventional clothing lack durability, comfort, safety, and style, participants relied on their embodied knowledge to flexibly combine various garments to meet their needs (Kabel, 2019), emphasizing the critical role of user experience in guiding personalized design.

Current literature lacks empirical research on how users gain agency, establish identity, and challenge stereotypes in collaborative design processes, particularly in the female-centric field of clothing design (Esmail et al., 2020; Esmail et al., 2022). Goffman's (1963) stigma theory and Giddens' (1991) identity construction theory provide important frameworks for understanding this process, but their specific application in adaptive clothing collaborative design remains under-explored.

#### **2.4. Research gaps and positioning of this study**

Between 2022 and 2025, although several studies related to inclusive design have emerged in the Chinese context, they have primarily focused on wheelchair products and employment opportunities rather than adaptive clothing for women who use wheelchairs (Wang et al., 2023; Chen & Li, 2024). Design principles proposed for inclusive practice provide an engineering-oriented reference framework but offer limited guidance on women's cultural expression and aesthetic needs (Inclusive Design Alliance of China, 2022). At the same time, demographic realities underline the importance of this group, as women constitute a substantial share of persons with physical disabilities (China Disabled Persons' Federation, 2023). Internationally, scoping and industry-facing work continue to note gaps in disability-type coverage, methodological diversity, and partnership mechanisms, indicating the need for culturally responsive approaches (Esmail et al., 2020; Esmail et al., 2022). Taken together, while technical, service, and policy foundations are evolving, systematic research that integrates co-design, cultural aesthetics, and workplace adaptation for Chinese women wheelchair users remains underdeveloped.

In summary, prior literature has preliminarily revealed the intersections among adaptive clothing, gender-differentiated needs, and co-design methods, yet significant gaps remain in integrated theoretical frameworks, cultural-context adaptation, and empowerment assessment (Sanders & Stappers, 2008; Feng & Hui, 2021; Esmail et al., 2020). Evidence continues to show a skew toward functional fixes—seated donning/doffing and comfort—while expressive/identity needs and seated-fit issues (e.g., pants) are under-examined (Carroll & Kincade, 2007; Chang et al., 2014; Stokes, 2010; Stokes & Black, 2012; Chae, 2022; Miller & McBee-Black, 2025; Suri, 2016). International discussions further link adaptive apparel to social inclusion agendas and the Sustainable Development Goals, underscoring the social stakes of apparel solutions (Ikenyei & Amaechi, 2020).

Particularly regarding Chinese female wheelchair users as an intersectional vulnerable group, there remains a lack of systematic research on the cultural construction of their

clothing needs, the feasibility of participatory design mechanisms, and the impact of collaborative design on their identity, confidence, and social visibility (Goffman, 1963; Giddens, 1991; Esmail et al., 2022). These gaps not only limit understanding of complex needs but also constrain the development and cross-cultural application of co-design theory (Esmail et al., 2020).

Therefore, this study adopts co-design as the theoretical lens (Sanders & Stappers, 2008) to address these identified gaps through exploring a "female wheelchair user–designer" co-creation model for adaptive clothing in China. Co-design centers users as knowledge holders and translates lived experience—such as seated-posture constraints and comfort needs—into actionable design criteria that can be collaboratively developed and evaluated. This approach enables systematic examination of how multi-stakeholder collaboration can address the functional, expressive, and culturally situated needs of Chinese female wheelchair users, providing empirical grounding to support more inclusive and equitable design practices.

### 3. Research Methods

#### 3.1. Research design

We used a convergent mixed-methods design to comprehensively address our research objectives. This approach was necessary because: quantitative data alone cannot capture the nuanced, lived experiences of wheelchair users' clothing challenges; qualitative data alone cannot provide the breadth needed to understand prevalence across stakeholder groups; the integration of both approaches enables triangulation and deeper understanding of complex user needs and co-design feasibility in the Chinese cultural context (Creswell & Plano Clark, 2017). A formative online survey (n = 160) conducted with female wheelchair users and professional designers—provided breadth on the prevalence and priority of clothing needs. Semi-structured interviews (n = 40) were undertaken with the same two stakeholder groups, capturing lived experience and conditions for co-design that are not accessible via questionnaires. Integration occurred at the interpretation stage, aligning quantitative priorities with qualitative explanations around RO1–RO4.

#### 3.2. Research Location

Data were collected in Wuxi, Jiangsu Province (Mainland China), with additional online reach to national disability communities and design organizations. Local recruitment and coordination were facilitated in partnership with the Wuxi Disabled Persons' Federation (CDPF). We selected this site because our established partnership with the CDPF enabled ethical, efficient access to the target user group and reliable venue coordination, and the research team's proximity improved feasibility and oversight.

#### 3.2. Research Sample

We included two stakeholder groups: (i) adult female wheelchair users in Mainland China; (ii) design professionals engaged in apparel/fashion product development.

Inclusion criteria:  $\geq 18$  years; ability to complete Chinese interview/survey; informed consent. Role-specific criteria included:  $\geq 6$  months wheelchair use (female users); current professional practice in apparel/fashion design (design professionals).

Exclusion criteria: acute medical episodes at data collection; inability to consent/complete procedures; students/interns without current professional roles (for design professionals).

No sampling frame was enumerated; recruitment used purposive + snowball via the Wuxi CDPF and national communities, so a population denominator/response rate is not applicable.

### **3.3. Sample size**

#### *3.3.1. Quantitative (n=160)*

Based on resource constraints and the exploratory nature of this study, we aimed for approximately 80 participants per stakeholder role to achieve reasonable representation across the two groups. This sample size provides an approximate 95% descriptive margin of error of  $\pm 8$  percentage points for prevalence estimates at  $p = 0.50$ , treating this as an orientation to simple random sampling.

#### *3.3.2. Qualitative (n=40)*

We used the concept of "information power" (Malterud et al., 2016), aiming for 20 participants per stakeholder role. This number was determined based on: (1) the study's broad aim requiring diverse perspectives; (2) the specific sample characteristics (wheelchair users with varied experiences); (3) established theory from co-design literature (Sanders & Stappers, 2008); (4) quality of dialogue expected in semi-structured interviews; and (5) analysis strategy of inductive thematic analysis. This approach ensured theme saturation while maintaining representation across different experiences and contexts.

### **3.4. Sampling method**

We used purposive sampling with the Wuxi CDPF acting as a community gatekeeper, complemented by snowball sampling nationwide. The CDPF did not disclose registry data; it disseminated an IRB-approved invitation carrying the Wenjuanxing QR/link via service centers/notice boards/official WeChat groups, directing interested individuals to self-enroll or contact the team directly. Recruitment ran 2025-06-20 to 2025-08-15. De-duplication and quality checks (completion-time and response-pattern screening) were applied before survey analysis.

### **3.5. Instruments**

Questionnaire development: The survey instrument was developed through a systematic three-stage process following established scale development principles (DeVellis & Thorpe, 2021): (1) literature review to identify key constructs from adaptive clothing research (Carroll & Kincade, 2007; Chang et al., 2014) and co-design scholarship (Sanders & Stappers, 2008); (2) expert consultation with two fashion design academics and one disability researcher to establish content validity and cultural appropriateness; (3) pilot testing with 5 wheelchair users to ensure clarity, comprehension, and face validity. The final instrument incorporated validated scales where available and newly developed items specific to the Chinese cultural context.

Interview guide development: Semi-structured interview guides were developed for each stakeholder group, with core questions addressing functional needs, aesthetic preferences, and co-design attitudes, supplemented by role-specific probes (e.g., design constraints for professionals, accessibility challenges for wheelchair users). The guides were informed by the Functional, Expressive, and Aesthetic (FEA) model (Stokes & Black, 2012) and co-design principles (Sanders & Stappers, 2008).

### 3.6. Data collection procedures

Survey procedures: The online questionnaire was self-administered via Wenjuanxing and monitored by the research team. The landing page presented study information and e-consent; only consenting adults proceeded. Recruitment used purposive/snowball methods via the Wuxi CDPF for wheelchair users and design schools/organizations for professionals; the CDPF did not disclose registry data and only disseminated an IRB-approved invitation with the survey QR/link. To protect confidentiality, personally identifying information was not required. Data collection occurred from 20 June 2025 to 15 August 2025 online only. Quality control included platform logs for de-duplication and completion-time/response-pattern screening. Analytic files were de-identified and stored on secure, access-controlled drives.

Interview procedures: Semi-structured individual interviews were conducted by trained members of the research team following a guide aligned to the three constructs (functional; aesthetic/identity; co-design orientation), using neutral prompts to elicit examples across daily, work, and social contexts. Data collection occurred from 20 June 2025 to 15 August 2025. Sessions were conducted online (videoconference) and/or face-to-face at partner venues in Wuxi, Jiangsu; one-on-one only (no focus groups). With permission, sessions were audio-recorded and transcribed verbatim; each lasted approximately 30 minutes (typical 25–40). Fieldwork was conducted in Chinese; data were stored on secure, access-controlled drives.

Integration: The quantitative and qualitative strands ran in parallel and were integrated at interpretation, organizing findings around RO1–RO4 (the survey describing prevalence/priority, the interviews explaining lived experience and co-design conditions).

### 3.7. Data analysis

#### 3.7.1. Quantitative

We conducted descriptive statistics—frequencies, percentages, and means/SD—together with priority ranking (Top-2-box for importance/agreement). For multi-item indices (e.g., functional needs, aesthetic/identity, co-design orientation), scale scores were computed as item means when  $\geq 80\%$  of items were non-missing; “Not applicable” responses were treated as missing. Because recruitment used purposive/snowball methods, no hypothesis tests were planned; where helpful, we report approximate 95% descriptive intervals for proportions under a simple random-sample assumption and label them as descriptive rather than inferential. Software: analyses were performed in Microsoft Excel 365.

#### 3.7.2. Qualitative

We used inductive thematic analysis (Braun & Clarke, 2006). A trained researcher conducted iterative open and focused coding, maintained an audit trail (versioned codebook and analytic memos), and engaged in peer debriefing to enhance credibility. Analysis followed constant comparison and negative-case probing across daily, work, and social contexts; all quotations are anonymized. Software: coding and matrixing were managed in a secure spreadsheet workflow (Microsoft Excel 365).

Integration. Quantitative and qualitative strands ran in parallel and were integrated at interpretation using joint tables/matrices that align survey prevalence/priority with interview explanations and conditions for co-design, organizing convergence/divergence around RO1–RO4.

### 3.8. Ethics

This study received institutional research ethics approval from the UiTM Research Ethics Committee (REC), Universiti Teknologi MARA, Malaysia (Ref. REC/06/2025 (PG/MR/306)). The approval covers the project titled “Research on barrier-free clothing design for female wheelchair users” with an approval period from 16 June 2025 to 31 August 2025; authorized personnel are Jiang Huizhi and Ts. Dr. Verly Veto Vermol. The REC operates in accordance with ICH Good Clinical Practice, Malaysian GCP, and the Declaration of Helsinki.

Fieldwork was conducted in Wuxi, Jiangsu (Mainland China) in partnership with the Wuxi Disabled Persons’ Federation (CDPF). The CDPF acted as a community gatekeeper to disseminate invitations and coordinate venues and did not disclose registry data nor access research data. The REC approval letter lists collaborating institutions within the approval scope (e.g., Wuxi Vocational Institute of Arts & Technology, Comprehensive Service Center for Persons with Disabilities of Wuxi City, Guoji Rehabilitation Hospital, Rehabilitation Hospital of Wuxi City, and the Shanghai Employment Clothing Center for the Disabled).

Informed consent was obtained before participation in both components. For the survey (Wenjuanxing), the landing page presented study information and electronic consent; only adults ( $\geq 18$ ) who consented could proceed, and no personally identifying information was collected. For interviews, participants provided written or e-consent prior to scheduling; sessions were audio-recorded with permission, transcribed verbatim, and de-identified (pseudonyms; removal of direct identifiers). Participants were informed of voluntariness and withdrawal rights. De-identified datasets were stored on secure, access-controlled drives with research-team-only access, and any protocol amendments or extensions were handled in accordance with the UiTM Research Ethics Committee approval conditions.

## 4. Results

This section presents findings from the convergent mixed-methods analysis addressing RO1–RO4. To ensure clarity, we report quantitative findings from the survey ( $n = 160$ ) and qualitative findings from the interviews ( $n = 40$ ) in separate subsections, followed by an integration that synthesizes patterns across methods.

The quantitative analysis provides prevalence estimates and priority rankings for clothing needs and co-design attitudes, directly addressing RO1 (needs mapping) and

RO2 (co-design readiness). The qualitative analysis explores lived experiences through four thematic domains, contributing to RO1, RO2, and RO3 (user–designer comparison). The final integration synthesizes findings from both strands, highlighting convergent patterns (e.g., functional priorities) and meaningful divergences (e.g., professional image complexity) that together inform the proposed co-design framework (RO4).

Each subsection explicitly notes which Research Objectives it addresses. The integration approach treats convergence and divergence as complementary rather than contradictory, recognizing that surveys capture generalized priorities while interviews reveal situated, contextual concerns.

#### 4.1. Quantitative findings

Respondents: A sample (n=160) of female wheelchair users and design professionals recruited via the Wuxi CDPF and national communities using purposive/snowball sampling; results are descriptive and not statistically generalizable.

##### 4.1.1. Priority needs (functional; aesthetic/identity)

As shown in Table 1, functional needs showed highest priorities for donning/doffing ease (98.8%), followed by seated-posture fit (96.2%) and compatibility with assistive devices (91.2%). Aesthetic/identity needs were dominated by social confidence (98.1%), with identity expression (77.5%) and personal style (71.9%) also ranking highly, while professional image showed lower priority (42.5%) among this sample.

Table 1: Functional and Aesthetic Needs among Female Wheelchair Users (n = 160)

Construct	Item (manuscript terminology)	Valid N	Mean (1-5)	Top-2-box (%)	Rank (within construct)
Functional	Donning/doffing (ease of dressing)	160	4.44	98.8	1
Functional	Seated-posture fit (sitting posture adaptability)	160	4.22	96.2	2
Functional	Comfort / pressure management (optimized pressure distribution)	160	3.76	65.6	4
Functional	Compatibility with assistive devices	160	4.31	91.2	3
Aesthetic/Identity	Social confidence	160	4.37	98.1	1
Aesthetic/Identity	Identity expression	160	4.08	77.5	2
Aesthetic/Identity	Professional image	160	3.29	42.5	4
Aesthetic/Identity	Personal style	160	3.89	71.9	3

Note: Valid N excludes “Not applicable” responses. Top-2-box represents percentage of respondents selecting 4 or 5 on importance scales. Rankings computed within each construct by Top-2-box percentages, with mean scores used as tie-breakers. Results represent descriptive estimates from purposive/snowball sampling.

#### 4.1.2. Co-design orientation & participation readiness

As shown in Table 2, participants demonstrated strong support for co-design principles, with 90.6% believing users should be deeply involved in design processes and 81.9% expressing willingness to participate in co-design projects. However, significant barriers were identified, particularly concerns about ideas not being professional/mature enough (80.6%), understanding design terminology difficulties (61.9%), and cultural concerns about "losing face" if ideas are rejected (53.8%). Communication translation challenges (turning lived experience into design terms) were reported by 44.4% of respondents.

Table 2: Co-Design Orientation and Perceived Barriers among Female Wheelchair Users and Designers (n = 160)

Domain	Item	Valid N	Mean (1-5)	Top-2-box (%)	Rank (within domain)
Co-design orientation / Willingness	Co-design improves practicality (proxy for relevance)	160	4.21	82.5	3
Co-design orientation / Willingness	Users should be deeply involved in the design process	160	4.27	90.6	1
Co-design orientation / Willingness	Users' life experience ≈ designers' expertise	160	3.99	83.1	2
Co-design orientation / Willingness	Willing to participate in the co-design project (covers 'workshop')	160	4.04	81.9	4
Co-design orientation / Willingness	Willing to invest time and effort (proxy for sample-garment testing)	160	3.99	79.4	5
Perceived barriers	Translating lived experience into design terms is difficult (= clearly express design ideas and requirements)	160	2.91	44.4	4
Perceived barriers	Understanding design terminology is difficult	160	3.69	61.9	2
Perceived barriers	Worry about 'losing face' if ideas are rejected	160	3.29	53.8	3
Perceived barriers	Worry ideas are not professional/mature	160	4.03	80.6	1

Note. Co-design orientation/willingness items measured on agreement scales (1=Strongly disagree to 5=Strongly agree); perceived barriers measured on difficulty/impact scales (1=Very easy/No impact to 5=Very difficult/Very large impact). Top-2-box represents percentage

selecting 4 or 5. Valid N excludes "Not applicable" responses. Rankings computed within domains by Top-2-box percentages, with mean scores as tie-breakers.

## 4.2. Qualitative findings

### 4.2.1. Theme 1: Functional challenges from donning/doffing to fit

Participants consistently described multidimensional difficulties in dressing from a seated posture. Across almost all interviews, garments designed for standing bodies were perceived as restrictive once seated—tight waistbands, uneven hemlines, and compressed lower limbs were common. These practical constraints not only limited comfort and mobility but also undermined the sense of independence and dignity in everyday life. As one participant explained, *"As soon as I sit down, the waistband feels tight, and the cuffs roll up."* (User 1)

Several participants elaborated that ordinary closures and openings make dressing a physically demanding task. *"Back zippers don't work for us; we can't twist that far,"* (User 2) noted one user, while another added, *"Side openings or zips would let me dress without standing or asking for help."* (User 3). Such remarks emphasize that the smallest construction details—fastener placement, zipper orientation, or closure strength—can determine whether dressing is independent or dependent. Many participants requested one-hand-friendly systems such as magnets or Velcro, which could minimize assistance and improve speed. *"Magnetic snaps or larger pull tabs would save so much effort,"* (User 4) explained.

Fit-related issues were equally prominent. Many of the interviewees reported discomfort from pressure or fabric bunching when seated for long periods. Waistbands often dug into the abdomen, and seams pressed against the thighs or hips. *"When I wheel for hours, the seam cuts into my waist and leaves red marks,"* (User 5) shared one woman. Another added, *"Knees bunch up, and fabric digs under my thighs; I need more room below,"* (User 6). These experiences suggest that the fit block for seated bodies must differ fundamentally from standard standing patterns. Participants desired higher back rises, lower front waists, stretch inserts, and softer seam finishes to alleviate pressure and friction.

Beyond pattern adjustment, compatibility with assistive devices emerged as another vital concern. Many garments rubbed against wheelchair cushions, tangled with safety belts, or snagged during transfer. *"Fabric rubs against the cushion and wears out quickly,"* (User 7) described one user. *"I need trousers that don't catch when transferring between the chair and bed,"* (User 8) added another. The participants' comments show that fabric choice and seam placement must be coordinated with device interaction—an overlooked but crucial design dimension in adaptive clothing.

Thermal comfort and moisture management were also mentioned frequently. Several participants noted overheating and perspiration buildup in seated areas such as the back, waist, and thighs, where ventilation is minimal. *"My back gets sweaty because it's pressed to the chair all day,"* (User 9) explained. Others highlighted the challenge of balancing warmth and breathability: *"In winter, light padding helps, but it still needs to breathe,"* (User 10). These experiences reveal how thermal discomfort intersects with material science—breathable, quick-dry fabrics could enhance both hygiene and psychological ease.

Collectively, these narratives portray functional design not merely as a technical matter but as a lived, bodily negotiation between comfort, mobility, and self-reliance. Small changes—front or side openings, flexible waistbands, repositioned seams—can dramatically reshape the dressing experience and autonomy of wheelchair users. Functional misalignment, conversely, reinforces dependence and discomfort. The evidence from this theme clearly maps the first layer of adaptive clothing needs identified in R01: accessible donning and doffing routes, posture-specific fit calibration, durable materials compatible with assistive devices, and climate-responsive comfort. These findings establish the baseline for translating lived experience into design criteria in subsequent stages of the co-design framework.

#### 4.2.2. Theme 2: Dual demands of aesthetics and identity

Beyond basic functionality, participants emphasized that clothing must also support dignity, self-expression, and social belonging. For many women, the act of dressing was not just about comfort but about how they were perceived by others in professional or social settings. Several participants articulated the tension between wanting clothing that feels practical and the desire to look fashionable and confident. *“I want to look as professional as everyone else, not like a patient,”* (User 11) stated one respondent, summarizing a recurring theme. When adaptive garments appeared too “medical,” they were perceived as undermining identity and social confidence rather than empowering it.

Participants repeatedly described the importance of first impressions and outward appearance in shaping how others treated them. *“When people see you dressed properly, they respect you more,”* (User 12) explained, adding that neat and stylish outfits helped counter social stigma. Many recounted experiences of being perceived as ill or dependent when wearing overly functional clothing. *“Some adaptive clothes make me feel like I’m wearing a hospital uniform,”* (User 13) reflected another. These narratives indicate that aesthetic design is inseparable from psychosocial wellbeing—clothing mediates visibility, respect, and self-worth.

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For working women, professional identity was a dominant concern. Participants highlighted the lack of adaptive options suitable for office environments, especially garments that could balance formal aesthetics with seated comfort. *“For work, I want tailored lines but softer materials,”* (User 14) explained. *“A blazer looks smart, but the stiff fabric makes it hard to move,”* (User 15) added. Several expressed frustration that most adaptive collections target older adults or medical contexts, overlooking young or mid-career professionals. This gap left them modifying regular garments themselves, often at the expense of comfort or appearance.

Color, silhouette, and fabric choice were deeply connected to feelings of femininity and individuality. *“I like elegant colors—navy, beige, soft grey—but they should still look trendy,”* (User 16) noted. Others stressed that adaptive apparel should allow for self-styling and creativity: *“I don’t want to wear something that looks designed for disability. I just want beautiful clothes that work for me,”* (User 17). Participants sought designs that balance subtlety with personality, suggesting that inclusivity should extend beyond physical access to encompass style diversity.

Social interactions and public confidence were also influenced by how adaptive garments communicated identity. *“If the design looks normal, I feel included; I don’t have to explain myself,”* (User 18) explained. Another participant added, *“Fashion helps me connect with friends—it’s something we can all talk about equally,”* (User 19). Such experiences reveal that clothing operates as a social equalizer: it enables participation in shared cultural practices and reinforces belonging in professional and community life. Participants viewed dressing well as an act of self-respect and a way to reclaim agency in social spaces where physical difference is often stigmatized.

Cultural norms further shaped aesthetic expectations. In the Chinese context, several women mentioned the need for modest coverage and graceful proportions that align with social and gendered expectations. *“When I sit, the skirt rides up, so I need longer fronts or overlapping panels,”* (User 20) described one participant. Others referred to family or workplace expectations that women “should look composed,” making the design of seated silhouettes particularly sensitive. The intersection of aesthetic expression and cultural modesty thus created additional constraints that require thoughtful patterning and material design.

Participants also linked aesthetic design to psychological empowerment. Feeling stylish and appropriately dressed contributed directly to motivation and confidence in work and social interactions. *“When I wear something I like, I walk—or wheel—out the door feeling stronger,”* (User 21) expressed one woman. Conversely, ill-fitting or institutional-looking clothing heightened feelings of exclusion. *“If I look different, people treat me differently; it affects how I speak up,”* (User 22) shared another. These reflections demonstrate that the visual language of clothing shapes not only self-image but also participation and voice.

Overall, the interviews underscored that adaptive fashion must transcend mere functional problem-solving. Participants aspired to wear garments that reflect personality, professionalism, and pride, rejecting the binary between “comfortable” and “beautiful.” For them, empowerment was aesthetic as much as physical: being able to express identity through dress symbolized independence and equality. These insights reinforce RO1 by showing that adaptive design should merge function and form into a coherent user-centered experience—garments that facilitate movement while affirming selfhood. Aesthetic adaptability, when integrated with functional inclusivity, becomes a pathway for visibility, agency, and dignity in both private and public life.

#### 4.2.3. Theme 3 — Participation attitudes and empowerment potential

Most participants had never been invited into a design process before this study, yet nearly all expressed curiosity and willingness to take part once the idea was explained. Many described participation as a new and empowering experience that could change

how they viewed both clothing and themselves. *"I used to think we could only accept what was available, but now I realize we can influence design too,"* (User 23).

Several women noted that simply being asked for opinions felt affirming. *"No one ever asked me what I need in my clothes—this is the first time,"* (User 24). For many, this sense of acknowledgment created emotional value beyond the practical outcomes of design. Participation became a form of recognition, validating their everyday expertise as wheelchair users. *"We live with these clothes every day, so our ideas are experience-based,"* (User 25).

At the same time, participants were candid about barriers that might limit effective collaboration. The most common concern was communication—difficulty translating lived experience into "design language." *"I can describe problems, but not in designer terms,"* (User 26). Others feared that their input might not be taken seriously. *"Designers might think our ideas are childish or unrealistic,"* (User 27). Cultural factors such as humility and fear of "losing face" also surfaced. *"I worry I'll say something wrong and sound unprofessional,"* (User 28). These comments highlight the need for facilitation methods that balance expertise and empathy.

When participants imagined what an ideal co-design session should feel like, they emphasized open dialogue, hands-on materials, and visual examples rather than verbal explanation alone. *"If I can touch fabrics or see sketches, I can point out what works,"* (User 29). Many valued small-group workshops over large meetings because they reduced anxiety and encouraged quieter voices. *"I'd speak more freely in a small group of women like me,"* (User 30). Such preferences suggest that psychological safety is essential to participation, particularly for marginalized groups accustomed to being spoken for rather than spoken with.

Participants also recognized mutual benefits between users and designers. They believed that sharing personal experiences could help professionals design more practical products, while designers could in turn teach them about materials and construction. *"If we work together, we both learn—the designer sees reality, and I understand design limits,"* (User 31). This reciprocal view of collaboration framed co-design as knowledge exchange rather than charity or consultation.

Despite initial hesitation, nearly all participants associated involvement with empowerment. They described feelings of pride, capability, and renewed confidence after realizing that their ideas carried weight. *"It feels powerful to know my feedback might change a real garment,"* (User 32). For several, this sense of agency extended beyond clothing to broader self-perception. One participant reflected, *"Before, I thought my disability made me dependent; now I feel I can contribute."* (User 23).

Collectively, these accounts portray participation as both a methodological and psychological process. The act of co-design not only produces better garments but also reshapes identity relationships between users and professionals. Openness, trust, and visual communication tools were repeatedly cited as preconditions for meaningful collaboration. The findings reinforce RO2 by demonstrating that empowerment arises when users move from being subjects of design to co-authors of solutions. Effective facilitation—plain-language prompts, tangible examples, inclusive group dynamics—can convert hesitation into engagement and transform design from a technical exercise into a shared social act of dignity and agency.

#### 4.2.4. Theme 4: User-designer contrasts and collaboration conditions

Interviews revealed clear contrasts between the perspectives of users and professional designers regarding what counts as a “successful” adaptive garment. While both groups valued comfort and practicality, their priorities diverged on how those goals should be achieved. Designers frequently emphasized feasibility, material cost, and production efficiency, whereas users placed greater weight on autonomy, emotional comfort, and daily usability. *“Designers talk about lines and balance, but I care if I can dress myself easily,”* (User 33) explained. Another participant remarked, *“They see structure; I feel pressure and tightness,”* (User 34). These comments capture a fundamental difference in how design expertise and lived experience frame the same product.

Many users perceived that their voices were often filtered through technical or aesthetic judgments made by designers. *“Sometimes the designer decides what looks good for me without asking if it’s convenient,”* (User 35) noted. Some professionals, meanwhile, described challenges in interpreting experiential feedback that seemed “subjective” or “emotional.” *“We need to translate feelings into pattern data, which is not easy,”* (User 36, designer) said. This gap highlights the need for shared languages and translation tools to align embodied knowledge with design logic.

Despite these differences, both sides recognized the potential of collaboration once mutual understanding developed. Several participants described early co-creation sessions where dialogue shifted from correction to cooperation. *“At first, we argued about small details, but later we sketched together and laughed—it changed everything,”* (User 37). Such exchanges demonstrated how trust builds when each party’s expertise is acknowledged. Designers learned to visualize comfort through posture simulations or mock fittings, while users learned to articulate their needs in concrete design terms. *“Now I can explain with a drawing instead of just saying ‘uncomfortable,’”* (User 38).

Accessibility of the collaborative environment was another recurrent theme. Users emphasized that physical and communicative access must precede creative collaboration. Rooms needed wide clearances, adjustable tables, and quiet settings to accommodate wheelchair movement and fatigue. *“Long sessions tire me out; short breaks make it possible to focus,”* (User 39) commented. Designers, for their part, advocated scheduling flexibility and digital tools that could extend participation remotely. Both perspectives point toward hybrid collaboration models combining on-site workshops with online visualization platforms.

Participants also discussed decision-making power and transparency. Users often felt that their input vanished after initial workshops, leaving uncertainty about which ideas were implemented. *“We give suggestions, but we never know what happens next,”* (User 40) said. Designers acknowledged this weakness, noting that institutional deadlines and confidentiality sometimes prevented regular feedback. Establishing iterative checkpoints—such as progress photos or short video updates—was suggested to maintain accountability and motivation on both sides. These procedural adjustments were viewed as small but meaningful signs of respect.

Affective and interpersonal dynamics played a major role in sustaining engagement. Participants emphasized kindness, patience, and humor as invisible but crucial elements of teamwork. *“When we laugh together, I forget the labels of ‘designer’ and ‘disabled person,’”* (User 33) reflected. Moments of empathy turned technical collaboration into

shared human experience, fostering equal relationships that transcend functional roles. Designers similarly expressed appreciation for users' creativity and resilience, often describing the process as "eye-opening." *"They made me see design from a seated point of view,"* (User 36, designer) admitted.

Overall, Theme 4 reveals that successful co-design relies less on eliminating differences than on making them productive. Tension between practicality and empathy, expertise and experience, can generate innovative outcomes when managed through structured communication, physical accessibility, and transparent decision pathways. The findings support R03 by illustrating concrete collaboration conditions: early joint planning, mixed-format workshops, visual communication aids, iterative feedback, and mutual recognition of expertise. When these mechanisms are in place, the user–designer relationship evolves from a transactional exchange to a participatory partnership grounded in respect, reciprocity, and shared learning—closing the gap between technical feasibility and lived functionality.

## 6. Conclusion

This study highlights the transformative potential of co-design for addressing the clothing needs of Chinese women who use wheelchairs. By tracing challenges across functional, aesthetic, and socio-psychological dimensions, it underscores the necessity of inclusive and participatory approaches in adaptive fashion that couple function-first priorities—donning/doffing ease and seated-posture fit—with style and identity, particularly social confidence and professional image, in everyday, work, and social contexts. In our convergent synthesis, functional needs converged across survey and interviews, whereas identity-related needs showed method-dependent salience (survey: social confidence; interviews: professional image/personal style), indicating complementarity rather than contradiction.

The collaborative framework proposed here contributes in three ways: first, by centering lived experience and translating it into actionable, testable design criteria, thereby improving inclusivity in both process and outcomes; second, by narrowing the user–designer cognitive gap through structured collaboration mechanisms (clear roles and decision points, a shared vocabulary, traceable decisions, and sample-garment/fit testing); and third, by strengthening identity and self-empowerment through co-creation roles that support self-efficacy, social confidence, and visibility.

Positioned within the wider field, the findings resonate with international evidence linking adaptive clothing to social participation and inclusion; they validate this value in the Chinese context and specify culturally adaptive pathways that tackle translation from lived experience to design terms, terminology/feasibility hurdles, and culture-specific reservations (for example, fear of "losing face" or feeling "not professional enough").

Beyond practice, the study advances participatory design in a non-Western, gender-sensitive setting. The user–designer collaboration mechanism integrates information flow, knowledge translation, and cognitive alignment while explicitly accounting for communication barriers and social dynamics, offering a scalable pathway with cross-disciplinary implications.

Future work should pilot the framework in co-design workshops and fit-sample trials, combine computational design capabilities (e.g., 3D scanning and parametric/algorithmic patterning) with participatory methods to personalize seated fit and donning/doffing features, expand and stratify samples across roles and regions, and conduct longitudinal evaluations on functionality, aesthetic satisfaction, engagement, and empowerment. Closer collaboration with industry and policymakers will be essential to translate these insights into scalable, implementable inclusive solutions. Overall, co-design can help shift adaptive apparel from compensatory fixes toward empowering practice, advancing disability inclusion and design justice.

### **Ethics Approval and Consent to Participate**

Ethical approval was granted by the Research Ethics Committee, Universiti Teknologi MARA (UiTM), Malaysia (Ref: REC062025 [PGMR306], approval date: 16 June 2025). All procedures complied with institutional guidelines and the Declaration of Helsinki. Written or e-consent was obtained from all participants prior to data collection.

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### **Conflict of Interest**

The authors declare no competing interests.

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