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## User-Centred Design in Adaptive Clothing: Effects of the Design Process on Satisfaction, Functionality, and Comfort Among Persons with Mobility Challenges in Nyeri County, Kenya

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### Abstract

This study examines how user-centred design processes influence the usability, functionality, and comfort of adaptive clothing among persons with mobility challenges in Nyeri County, Kenya. Globally, approximately 1.3 billion people (16% of the population) live with disabilities (WHO, 2023), while in Kenya mobility impairments are the most prevalent, with estimates ranging between 2.2 per cent and 4.6 per cent (KNBS, 2019). A convergent parallel mixed-methods design was used with 100 participants to assess the effect of participatory design on measurable user outcomes. The findings revealed strong positive correlations between the design process and usability ( $r = .79$ ), functionality ( $r = .74$ ), and comfort ( $r = .77$ ). Regression analysis showed that the design process accounted for 67 per cent of the variance in these outcomes ( $R^2 = .67$ ,  $p < .001$ ). The results indicate that iterative user feedback and ergonomic adjustments significantly enhance garment performance and user independence. The study provides empirical support for inclusive design approaches that promote dignity, autonomy, and satisfaction among persons with disabilities.

**Key words:** Assistive devices, dressing independence, ergonomic modifications, inclusive apparel, physical disabilities.



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## INTRODUCTION

Clothing is an essential component of daily living that contributes to personal dignity, comfort, and social participation. Beyond its protective function, clothing plays an important role in shaping individuals' identity and self-expression. However, for persons with physical disabilities, particularly those with mobility limitations, conventional clothing can present considerable challenges during dressing and use. Difficulties in manipulating buttons, zippers, and other fasteners, limited range of motion, and discomfort when sitting for prolonged periods can make ordinary garments impractical for persons with mobility impairments. As a result, adaptive clothing has emerged as an important area of innovation within apparel design, focusing on garments specifically modified to enhance usability, comfort, and independence for people with physical disabilities (Poage, 2025). In this study, usability is defined as the ease of donning and doffing, functionality as the garment's performance in supporting activities, and comfort as both physical and ergonomic satisfaction.

Globally, disability continues to affect a significant proportion of the population. According to the World Health Organisation (2023), more than one billion people live with some form of disability, many of whom experience limitations in mobility that affect the ability to perform routine activities independently. Dressing is one such activity that can become difficult without appropriate clothing design. When garments are not designed with accessibility in mind, persons with mobility challenges may rely heavily on caregivers for assistance, potentially reducing independence and affecting overall well-being (Poage, 2025). Consequently, adaptive clothing has gained attention among researchers, fashion designers, and healthcare professionals as a means of improving independence and quality of life among persons with disabilities.

In recent years, scholars have increasingly emphasised the importance of inclusive and user-centred approaches in apparel design. User-centred design focuses on understanding the experiences, capabilities, and needs of end users throughout the design process in order to produce products that are both functional and meaningful (Cho et al., 2025; Wu, 2025). Within adaptive clothing design, this approach involves actively engaging persons with disabilities during different stages of garment development, including needs assessment, prototyping, and evaluation (Poage, 2025). Through such participatory processes, fashion designers can gain deeper insight into

the functional challenges users face, such as limited dexterity, restricted movement, or difficulties manipulating garment fasteners, and consequently develop clothing solutions that respond to real-life mobility limitations (Cho et al., 2025; Wu, 2025).

Moreover, the effectiveness of adaptive clothing largely depends on the design process used in its development. Garments developed without adequate consideration of user needs may fail to provide sufficient comfort, accessibility, or practicality. Conversely, design processes that actively incorporate user feedback and ergonomic considerations can lead to garments that significantly improve dressing ease, functionality, and overall satisfaction. Research indicates that when adaptive clothing is designed through participatory and inclusive design methods, users report higher levels of comfort and usability compared to garments developed through traditional design approaches (Wu, 2025). These findings highlight the importance of examining how design processes influence the effectiveness of adaptive clothing.

Despite growing international interest in inclusive fashion and adaptive apparel, research in this field has been largely concentrated in developed countries, with relatively limited empirical evidence addressing adaptive clothing needs in developing contexts (Rana et al., 2024).

In Kenya, persons with mobility challenges often face barriers related to accessibility, availability of assistive technologies, and limited inclusion of context-appropriate products, which can negatively affect their independence and participation in everyday activities. Research on the assistive technology ecosystem in Kenya shows that access to assistive products and related services is constrained by limited supply, coordination challenges among stakeholders, and insufficient integration of innovation training organisations, suggesting significant gaps in availability and accessibility of assistive tools for persons with disabilities (Smith et al., 2024). Furthermore, there is a lack of empirical research specifically focusing on adaptive clothing design and user experiences within the Kenyan context, meaning that the unique needs of persons with mobility impairments regarding inclusive garment design remain underexplored in scholarly literature.

Understanding how design processes influence adaptive clothing outcomes is, therefore, particularly important for

developing contextually relevant clothing solutions. Examining the relationship between design processes and user outcomes such as satisfaction, functionality, and comfort can provide valuable insights for designers, educators, and policymakers seeking to develop inclusive clothing solutions for persons with mobility challenges.

The objective of the study was to examine how the design process affects user satisfaction, functionality, and comfort. The study specifically aimed to examine how design practices affect garment usability, establish the role of the design process in shaping functionality, and analyse the link between inclusive design and user comfort.

Although adaptive clothing has the potential to enhance independence, comfort, and dignity for persons with mobility challenges, many available garments do not adequately meet users' functional and experiential needs. Studies have shown that adaptive apparel often lacks appropriate design features that address mobility limitations, resulting in garments that may still be difficult to wear, uncomfortable, or unsatisfactory for users (Cho et al., 2025; Poage, 2025). Moreover, most research on adaptive clothing design has been conducted in developed countries, leaving limited empirical evidence on how design processes influence user satisfaction, functionality, and comfort in developing contexts such as Kenya. In Nyeri County specifically, little is known about how the design process shapes the effectiveness of adaptive clothing for persons with mobility challenges. This knowledge gap highlights the need to examine how the design process affects user satisfaction, functionality, and comfort in adaptive clothing design for persons with mobility challenges in Nyeri County, Kenya.

To achieve this purpose, the following null hypothesis was formulated and tested at a 0.05 level of significance: there is no significant relationship between usability and comfort in adaptive clothing design among persons with mobility challenges in Nyeri County, Kenya.

## LITERATURE REVIEW

### Adaptive Clothing and User Needs

Adaptive clothing refers to garments designed with modifications that make them more accessible and usable for persons with physical disabilities, particularly those with mobility impairments. Such modifications may include alternative closures (e.g., magnetic fasteners), adjustable openings, and ergonomic fits that facilitate

ease of dressing ((Li et al., 2023)). Standard apparel often overlooks the physical constraints faced by users with limited mobility, resulting in garments that are difficult to don and doff, restrict movement, or cause discomfort during prolonged sitting or ambulation. Research based on consumer feedback also suggests that adaptive clothing must address not only functional barriers but also users' preferences for style and self-expression, emphasising that adaptive garments can influence feelings of dignity and personal identity (Futurity, 2023).

Despite this recognition of user needs, much of the adaptive clothing available in the market continues to prioritise basic functionality over comprehensive usability. Li et al. (2023) analysed consumer satisfaction with adaptive apparel and found recurring complaints related to poor fit, lack of garment variety, and limited accessibility of online purchasing platforms. The findings indicate that existing product offerings do not fully address the spectrum of functional and experiential needs reported by individuals with mobility challenges, highlighting an ongoing disconnect between what users require and what the market currently supplies.

### Inclusive Design Frameworks and Participatory Methods

A central theme in recent adaptive apparel research is the importance of user-centred and participatory design approaches. Inclusive design approaches prioritise the continuous participation of end users during the design process so that the resulting products reflect their real-life experiences and needs (Cho et al., 2025). According to Poage (2025), user-centred design encourages iterative consultation with users during needs assessment, prototyping, and garment evaluation, a process that is expected to produce more functional and acceptable adaptive clothing solutions. Wu (2025) argues that integrating digital technologies and rapid prototyping into adaptive design practice enhances fashion designers' ability to test and refine products in partnership with users, potentially improving comfort and usability outcomes.

Despite these theoretical advances, evidence remains limited regarding how participatory design processes are implemented in practice and the extent to which they influence key outcomes such as comfort, satisfaction, and overall functionality. Most studies on inclusive design in adaptive clothing have been exploratory or conceptual in nature, focusing on design principles rather than empirical evaluations with end users. The gap suggests a

need for research that moves beyond conceptual frameworks to examine actual design processes and their impact on user experiences.

### **Contextual Influences on Adaptive Clothing Research**

Much of the existing literature on adaptive apparel originates from developed country contexts, including North America and Europe, where specialised markets, disability support infrastructures, and research resources are relatively well established. A systematic review by Rana et al. (2024) confirms that adaptive clothing studies are heavily skewed toward contexts where assistive product research and development are well funded and organizationally supported. This concentration of research raises questions about the applicability of existing findings to settings with different cultural, economic, and infrastructural conditions.

In contrast, adaptive clothing research in developing regions, especially sub-Saharan Africa, remains sparse. Priya (2024) notes that while adaptive apparel research is emerging, there is limited scholarship addressing the intersection of disability, product design, and contextual factors such as climate, cultural norms, and local clothing practices in low- and middle-income countries. These contextual factors may influence both user needs and design priorities, yet they are rarely examined in adaptive clothing literature. The lack of research in African contexts represents a significant gap, as adaptive clothing solutions developed in Western contexts may not translate effectively to settings with different environmental challenges, resource constraints, and daily activity demands.

### **Barriers to Assistive Technology and Adaptive Solutions in Kenya**

Understanding adaptive clothing in the Kenyan context requires situating it within broader discussions of assistive technology access and disability inclusion. Studies examining Kenya's assistive technology ecosystem highlight persistent barriers that persons with disabilities face, including limited supply of assistive products, weak coordination among providers, and gaps in policy implementation (Smith et al., 2024). Such barriers constrain not only access to mobility aids but also related adaptive solutions, potentially including inclusive clothing options. The systemic challenges suggest that persons with mobility impairments in Kenya may encounter additional practical obstacles when seeking garments that accommodate their functional

needs, yet empirical research on adaptive clothing within this context is virtually nonexistent.

The dearth of context-specific research on adaptive clothing design in Kenya mirrors broader patterns observed in assistive technology literature: while global policy discourses emphasise inclusion and accessibility, empirical studies grounded in local experiences remain limited. This gap not only limits scholarly understanding of how adaptive apparel can best serve users in Kenya, but also restricts fashion designers' ability to create culturally and environmentally appropriate solutions.

### **Design Process and Adaptive Clothing Outcomes**

Although the literature acknowledges the design process as a critical factor influencing product effectiveness, few studies have empirically examined how different design strategies affect user outcomes such as functionality, comfort, and satisfaction. Theoretical discussions suggest that involving persons with disabilities in iterative design practices can lead to greater usability and better alignment with user preferences (Cho et al., 2025; Wu, 2025), but there is a lack of systematic, user-centred research that evaluates these claims, particularly in non-Western contexts. This gap highlights the need for empirical investigation not only of user needs but of how design processes themselves shape adaptive clothing effectiveness.

Collectively, the reviewed literature suggests that while adaptive clothing research has expanded in recent years, fundamental gaps remain in understanding the role of the design process in producing garments that meet user needs, especially in developing country contexts. There is a clear need for research that integrates user-centred design evaluation with empirical analysis of user satisfaction, functionality, and comfort within specific cultural and environmental settings.

The study is anchored on the User-Centred Design (UCD) Theory, which provides a conceptual lens for examining how design processes affect the effectiveness of adaptive clothing for persons with mobility challenges. User-Centred Design is a well-established framework in design and human-computer interaction that emphasises the centrality of the end user in the design process. It asserts that products, systems, or services are more effective, usable, and satisfying when fashion designers actively incorporate users' needs, preferences, and experiences into each stage of development (Norman & Draper, 1986; Cho et al., 2025).

Within UCD, the design process is iterative and involves multiple stages, including needs assessment, prototyping, evaluation, and refinement, all conducted in consultation with users (Poage, 2025). Applying this theory to adaptive clothing design highlights the critical role of user involvement in ensuring garments are functional, comfortable, and satisfactory. For individuals with mobility challenges, UCD principles suggest that designers must consider physical limitations (e.g., restricted range of motion, dexterity issues), personal preferences (e.g., aesthetic style, fabric choice), and contextual factors (e.g., cultural norms, environmental conditions) to optimise the effectiveness of adaptive garments (Wu, 2025).

UCD theory also aligns with participatory design approaches, which emphasise collaboration between users and designers throughout product development. In adaptive clothing, participatory design can help identify practical barriers such as difficulty with fasteners, garment fit when using assistive devices, or discomfort during prolonged wear that may not be apparent without direct user engagement (Cho et al., 2025). By integrating UCD principles, the current study conceptualises the design process as a determinant of user satisfaction, functionality, and comfort, positing that these outcomes are interdependent and collectively shape the overall effectiveness of adaptive clothing.

The framework suggests a causal relationship where the extent and quality of user involvement in the design process influence the functional and comfort outcomes of garments, which in turn affect user satisfaction. Moreover, the theory underscores the importance of iterative feedback cycles, allowing designers to refine garments based on real-time input from users, thereby enhancing usability and acceptance (Norman & Draper, 1986).

## METHODOLOGY

A convergent parallel mixed-methods design was adopted in the study, allowing qualitative and quantitative data to be gathered simultaneously, analysed independently, and integrated at the interpretation stage with equal priority. As discussed by Bazeley (2018) and Creswell and Plano (2018), this approach allows for the independent analysis of each data strand, followed by their integration at the interpretation stage to provide a more comprehensive understanding of the research problem. In this study, the design enabled the incorporation of diverse perspectives, particularly the

lived experiences of persons with mobility challenges regarding clothing choices and the usability of adaptive designs.

The research was conducted in Nyeri County, Kenya, a region with a relatively well-developed transportation and communication infrastructure that facilitated effective participant engagement and data collection. The county's predominantly agricultural economy and relatively high literacy levels contributed to a population with varied occupational, educational, and socioeconomic backgrounds. The presence of institutions such as the Elizabeth Vendramini Naromoru Children's Home, which offers rehabilitation services and assistive devices to children with mobility challenges, further underscores the relevance of the study area. Geographically, Nyeri County borders Kirinyaga, Laikipia, Meru, and Murang'a counties and features both urban and rural settings, as well as diverse physical landscapes, making it a suitable context for examining adaptive clothing use across different environmental and social conditions.

The target population comprised persons with mobility challenges residing in Nyeri County. While official records from the National Council for Persons with Disabilities (2024) indicate approximately 3,000 registered persons with disabilities, broader estimates from the Kenya National Bureau of Statistics (2020) suggest that about 11,118 individuals in the county live with mobility-related impairments. These individuals often experience difficulties with walking, movement, and independent dressing, underscoring the importance of adaptive clothing solutions. The study, therefore, focused primarily on individuals across all age groups who either required or used adaptive clothing. In addition, a secondary population consisting of adaptive clothing producers, including designers, tailors, and garment makers, as well as caregivers, was included to provide complementary insights into design, usability, and functionality. Individuals without mobility challenges or those with disabilities outside the study's focus were excluded.

Participants with appropriate knowledge and experience in adaptive clothing were selected using a purposive sampling approach. The approach was appropriate given the study's objectives and the practical challenges of accessing the entire population of persons with mobility-related disabilities in the county. Selection was guided by criteria such as accessibility, willingness to participate,

and prior experience with adaptive clothing. The sampling process also incorporated elements of stratification to ensure diversity across key characteristics, including type of disability, age, gender, and geographical location. Respondents were drawn from both urban and rural regions, ensuring equitable gender representation and inclusion of individuals across different age groups, including adolescents and older adults.

Sample size determination incorporated both qualitative and quantitative considerations. For the qualitative phase, sampling continued until data saturation was achieved, where no new themes or insights emerged. For the overall sample, expert judgment, prior research, and logistical feasibility were taken into account to ensure that the selected participants adequately represented the population and provided sufficient data for meaningful analysis.

Participant selection followed a systematic process beginning with the identification of key informants and community leaders who possessed in-depth knowledge of the special needs community. These individuals were instrumental in identifying potential participants who met the inclusion criteria and in providing rich, experience-based information. Subsequently, purposive sampling was used to select individuals whose experiences and roles closely aligned with the study objectives. Stratification was then used to enhance

representativeness by ensuring that different subgroups within the population were represented

**FINDINGS AND DISCUSSION**

The section presents the analysis of how the design process influences the usability, functionality, and comfort of adaptive clothing for persons with mobility challenges in Nyeri County, Kenya. The corresponding null hypothesis tested was:

H0: The design process does not significantly affect the usability, functionality, and comfort of adaptive clothing for persons with mobility challenges in Nyeri County, Kenya.

The analysis evaluated how elements of the design process, including pattern adaptation, fabric selection, fastener design, testing and fitting sessions, and incorporation of user feedback, influence the perceived usability, functionality, and comfort of adaptive clothing. Quantitative and qualitative findings were combined to offer a comprehensive understanding of how design practices affect clothing performance and user experience.

**Descriptive Statistics**

Descriptive statistics were computed to assess respondents’ perceptions of the design process and the outcome variables: usability, functionality, and comfort. The results are summarised in Table 1.

**Table 1: Respondents by Design Process, Usability, Functionality, and Comfort of Adaptive Clothing (N = 100)**

Variable	M	SD
Design Process	3.42	0.50
Usability	3.32	0.47
Functionality	3.40	0.49
Comfort	3.35	0.48

Source: Research Data (2025)

The results in Table 1 show that respondents rated the design process moderately high (M = 3.42, SD = 0.50), suggesting a generally positive perception of adaptive clothing design practices. Similarly, usability (M = 3.32, SD = 0.47), functionality (M = 3.40, SD = 0.49), and comfort (M = 3.35, SD = 0.48) were rated relatively high. These findings suggest that when adaptive clothing is

developed through a structured and inclusive design process, it tends to produce favourable outcomes in terms of usability, functionality, and wearer comfort.

**Correlation Analysis Between Design Process and Adaptive Clothing Outcomes**

The study used Pearson's product-moment correlation to assess the association between the design process and the

outcome variables, namely usability, functionality, and comfort. The results are presented in Table 2.

**Table 2: Pearson Correlation Analysis Between Design Process and Adaptive Clothing Outcomes (N = 100)**

Variables	r	p
Design Process × Usability	0.79	< .001
Design Process × Functionality	0.74	< .001
Design Process × Comfort	0.77	< .001

Source: Research Data (2025)

The findings in Table 2 indicate that the design process has a strong and statistically significant positive correlation with usability ( $r = .79, p < .001$ ), functionality ( $r = .74, p < .001$ ), and comfort ( $r = .77, p < .001$ ). These results suggest that when the design process is more inclusive, iterative, and user-centred, the resulting adaptive clothing tends to be more usable, functional, and comfortable.

**Regression Analysis on the Predictive Power of the Design Process**

A regression model was applied to assess the predictive power of the design process on the combined outcomes of usability, functionality, and comfort. The results are shown in Table 3.

**Table 3: Regression Analysis Summary for Design Process Predicting Usability, Functionality, and Comfort of Adaptive Clothing (N = 100)**

Predictor	B	SE B	t	P
Constant	0.33	0.10	3.30	.001
Design Process	0.86	0.07	12.29	< .001

Model Summary:  $R^2 = .67, F(1, 98) = 169.34, p < .001$   
 Source: Research Data (2025)

The regression results indicate that the model was statistically significant,  $F(1, 98) = 169.34, p < .001$ , explaining 67 per cent of the variance ( $R^2 = .67$ ) in the combined outcomes of usability, functionality, and comfort. The regression coefficient for the design process was positive and statistically significant ( $B = 0.86, SE = 0.07, t = 12.29, p < .001$ ), indicating that improvements in the design process, such as greater user involvement, prototype testing, and ergonomic design considerations, substantially enhance usability, functionality, and comfort in adaptive clothing.

Based on the findings, the null hypothesis was rejected, confirming a significant influence of the design process on usability, functionality, and comfort of adaptive

clothing for persons with mobility challenges in Nyeri County, Kenya.

**Qualitative Findings**

Qualitative evidence from interviews and open-ended responses reinforced the statistical findings. Respondents emphasised the importance of being involved in the design stages, particularly during testing and fitting sessions, noting that participation improved both comfort and ease of use. One participant explained that trying the clothes during fitting allowed them to inform the designer where the garment pulled or felt tight, resulting in a final garment that was easier to wear.

Caregivers similarly highlighted how their involvement in fitting sessions improved usability for the individuals under their care. They reported that participating in testing enabled them to suggest adjustments that made dressing quicker and less stressful.

Fashion designers also emphasised the value of user feedback during prototype development. They observed that user testing enabled practical adjustments to seam placement and garment openings, thereby reducing dressing time and improving overall functionality.

Material and fastener choices were also highlighted by both users and caregivers as critical factors affecting comfort and usability. Participants noted that magnetic closures, elastic waistbands, and stretch fabrics made garments easier to handle and more comfortable to wear, while heavy fabrics and complex fasteners often reduced comfort and usability.

Overall, the qualitative accounts illustrate that an iterative design process grounded in user testing, appropriate material selection, and functional fasteners is a key determinant of successful adaptive clothing design. Findings demonstrate that the design process is a critical determinant of adaptive clothing performance. A participatory design approach that integrates user feedback, prototype testing, and ergonomic considerations significantly enhances usability, functionality, and comfort. The findings are consistent with previous studies emphasising inclusive and iterative design methods in adaptive fashion development (Rana et al., 2024; Sadretdinova et al., 2022). Kenyan research similarly highlights the importance of breathable fabrics, easy-to-operate fasteners, and user involvement in design decision-making as critical factors influencing comfort, confidence, and garment satisfaction.

The relatively high  $R^2$  value (0.67) further underscores the substantial predictive influence of design methodology on user experience. Involving end-users throughout the design cycle ensures that clothing solutions align with mobility needs, physical limitations, and comfort preferences, ultimately resulting in garments that promote independence, dignity, and satisfaction. These findings emphasise the need for continuous improvement and co-creation in the design of adaptive clothing.

## DISCUSSION

The study provides robust empirical evidence that a user-centred design process is critical for producing effective adaptive clothing. The strong statistical correlations ( $r = .74$  to  $.79$ ) and high  $R^2$  of 0.67 confirm that involving users in prototyping and fitting sessions directly improves garment usability and comfort. These results validate previous studies, emphasising iterative collaboration. By prioritising material flexibility and functional closures, as highlighted by participants and caregivers, designers can bridge existing market gaps and promote greater independence for persons with mobility challenges.

## CONCLUSION AND RECOMMENDATIONS

**Conclusion:** The findings of the study demonstrate that the design process is a critical factor influencing the usability, functionality, and comfort of adaptive clothing for persons with mobility challenges. Results from the analysis indicated strong positive relationships between the design process and each of the outcome variables, and regression analysis demonstrated that the design process accounts for a considerable amount of variation in usability, functionality, and comfort. Findings confirm that adaptive clothing developed through well-structured and user-centred design practices is more likely to meet the practical and comfort needs of persons with mobility challenges.

**Recommendations:** The study highlights the importance of adopting a participatory and iterative design approach in adaptive clothing development. Involving persons with mobility challenges and their caregivers throughout the design stages, particularly during prototype testing and fitting sessions, enables designers to identify functional challenges and refine garment features accordingly. Such collaboration ensures that design decisions regarding pattern adaptation, seam placement, garment openings, and closure systems are informed by the lived experiences and practical needs of users.

Material selection and fastener design also emerged as important considerations in enhancing garment usability and comfort. The use of stretch fabrics, breathable materials, elastic waistbands, and easy-to-operate fasteners such as magnetic closures was identified as particularly beneficial in improving dressing efficiency and comfort. The design elements reduce physical strain during dressing and contribute to greater ease of use, especially for persons with limited mobility.

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