PREDICTORS OF USER SATISFACTION WITH MASTECTOMY BRAS AND EXTERNAL BREAST PROSTHESES: IMPLICATIONS FOR FUNCTIONAL APPAREL DESIGN IN A TROPICAL CONTEXT

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ABSTRACT

This study aims to identify the key functional and material determinants influencing user satisfaction with mastectomy bras and external breast prostheses among Vietnamese breast cancer survivors living in a tropical climate. A cross-sectional survey was conducted with 157 post-mastectomy women recruited from breast cancer support organizations across Vietnam. The questionnaire collected demographic information, product usage characteristics, and satisfaction ratings using a five-point Likert scale covering functional, ergonomic, and aesthetic attributes. Data were analyzed using descriptive statistics, Gaussian distribution analysis, Pearson correlation, and multiple linear regression, while multicollinearity was assessed through the variance inflation factor (VIF). The regression models explained a substantial proportion of the variance in overall satisfaction for both product categories. For mastectomy bras (R^2 = 0.642), fit (β = 0.428, $p < 0.001$) and physical comfort (β = 0.365, $p < 0.001$) emerged as the strongest predictors of satisfaction, while material performance showed a smaller but statistically significant contribution ($p < 0.05$). In contrast, tactile softness alone was not a significant independent predictor ($p = 0.106$). For external breast prostheses, thermal comfort (β = 0.328, $p < 0.001$), weight (β = 0.312, $p < 0.001$), and positional stability (β = 0.245, $p = 0.002$) were identified as the primary determinants of user satisfaction. Silicone-based prostheses were frequently associated with thermal discomfort under hot and humid conditions. Although the study is limited by its reliance on self-reported data and a cross-sectional design, the findings provide evidence-based insights for developing climate-responsive mastectomy apparel and prostheses. The research contributes to a user-centered design framework emphasizing adaptive fit, pressure reduction, thermal regulation, and moisture management for post-mastectomy women in tropical environments.

KEYWORDS

Mastectomy bra; External breast prosthesis; User satisfaction; Functional apparel design; Tropical climate; Multiple linear regression.

INTRODUCTION

Mastectomy is a life-saving treatment for breast cancer but often leads to changes in body shape that negatively affect body image, confidence, and daily clothing experience [1]. Post-mastectomy women commonly face physical and psychological challenges related to asymmetry, altered silhouette, and discomfort when wearing conventional garments [2] [3]. In this context, mastectomy bras and external breast prostheses play a crucial role in restoring visual balance and providing physical support. From a clothing and textile science perspective, these products function as specialized apparel requiring appropriate fit, comfort, aesthetics, and adaptability to the post-surgical body [4] [5]. However, post-mastectomy clothing needs remain underrepresented in mainstream apparel research, highlighting the need for user-centered investigations into functional design and satisfaction [6].

Many existing mastectomy bras and external breast prostheses are designed based on Western body standards and may not adequately fit Asian women, resulting in poor comfort and wearability [7] [8]. Additionally, limited consideration of hot and humid climates can lead to heat retention and skin

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discomfort [9]. The increasing reliance on online shopping further exacerbates sizing and fit issues, as many products are not optimized for remote purchase. Common user complaints include poor fit, excessive weight, thermal discomfort, and inadequate positional stability, underscoring the need for context sensitive, user-centered apparel design [2].

Previous studies on post-mastectomy apparel and prostheses mainly provide descriptive assessments of user satisfaction, offering limited guidance for product improvement. Few studies have systematically identified key predictors of satisfaction or developed predictive models from a clothing and textile science perspective [10]. Moreover, empirical user data are rarely translated into concrete design implications. This gap highlights the need for data driven, user-centered research linking statistical analysis with functional apparel design.

This study aims to identify key predictors of user satisfaction with mastectomy bras and external breast prostheses from a clothing and textile science perspective. Using quantitative statistical analysis, the research seeks to establish predictive relationships between design-related factors and user experience, and to translate empirical findings into practical design implications.

RQ1: Which factors most strongly predict satisfaction with mastectomy bras?

RQ2: Which factors significantly predict satisfaction with external breast prostheses?

RQ3: How do material characteristics and shopping channels influence overall user experience?

Current mastectomy apparel and external prostheses often fail to meet the diverse needs of breast cancer survivors, particularly in tropical contexts like Vietnam. Research indicates that existing mastectomy bras frequently lack an anatomical fit, leading to discomfort and breast form displacement during daily activities [4]. Furthermore, high performance materials are often underutilized, resulting in poor thermal regulation and moisture management, which causes heat buildup and skin irritation. Regarding prostheses, traditional silicone models are often criticized for their excessive weight, causing shoulder strain and postural imbalance. Additionally, limited availability of diverse shapes and sizes, combined with high costs, restricts users' access to products that effectively restore body symmetry and psychological confidence.

LITERATURE REVIEW

Mastectomy apparel and functional clothing design

Mastectomy apparel, particularly mastectomy bras, has increasingly been recognized within apparel research as a form of functional clothing designed to address specific physical and psychological needs following breast surgery. Unlike conventional intimate apparel, mastectomy bras are required to provide not only aesthetic support but also functional performance related to fit, comfort, and adaptability to post-surgical body conditions. Previous studies have emphasized fit as a critical design criterion for mastectomy apparel. Proper fit is essential to accommodate post-mastectomy asymmetry and variations in body shape, and it directly influences both physical comfort and wearer confidence. Poor fit has been consistently associated with discomfort, limited mobility, and reduced satisfaction among users. Comfort has also been identified as a central concern in the design of post-mastectomy clothing. Research highlights the importance of pressure distribution, skin contact, and the absence of irritation during prolonged wear. These factors are particularly important for women with heightened skin sensitivity following surgery. In addition, material performance plays a significant role in the effectiveness of mastectomy apparel. Fabric properties such as softness, breathability, moisture management, and thermal regulation have been shown to influence wearer comfort and daily usability, especially in warm or humid climates [11]. Finally, the structural design of mastectomy bras, including garment construction, support mechanisms, and pocket integration for external prostheses, has been discussed as a key factor affecting functional performance [4]. Well-designed structural elements contribute to positional stability, ease of movement, and overall satisfaction with the garment.

User satisfaction and predictive factors in clothing research

User satisfaction has been widely examined in functional apparel research as a multidimensional construct reflecting users' evaluations of product performance, comfort, and usability. In the context of post-mastectomy apparel, satisfaction is associated not only with aesthetic outcomes but also closely linked to functional performance and daily wearing experience. Previous studies have commonly adopted a descriptive approach to assess user satisfaction, focusing on overall satisfaction levels or general perceptions of mastectomy bras and external breast prostheses. These studies provide valuable baseline information regarding user needs and common issues; however, they often fall short of identifying specific factors that predict satisfaction. Within the broader functional clothing literature, several design related attributes have been suggested as potential predictors of satisfaction. Fit and comfort are consistently identified as central determinants, as they directly influence physical ease and confidence during wear [12]. Material performance, including fabric softness, breathability, and moisture management, has also been associated with positive user experiences, particularly during

prolonged use. In addition, structural features such as support mechanisms and stability during movement contribute to perceived functionality and overall satisfaction. Despite these insights, relatively few studies have employed predictive analytical approaches, such as regression models, to examine the relative influence of multiple design criteria on user satisfaction in the post-mastectomy context. Consequently, the extent to which different design factors jointly or independently contribute to satisfaction remains insufficiently understood. Moreover, limited attention has been paid to contextual factors shaping user experience, including material types and shopping channels. With the increasing prevalence of online purchasing for functional apparel, understanding how these factors interact with design attributes is essential for developing user-centered, data-driven design strategies.

Breast prostheses: material and wear experience

External breast prostheses are essential components of post-mastectomy apparel systems and play a critical role in restoring body balance and supporting daily clothing wear [13] [14]. From a clothing and textile science perspective, breast prostheses are evaluated not only in terms of appearance but also through material characteristics and wear experience [15]. Existing breast prostheses can be broadly categorized into silicone-based and non-silicone alternatives. Silicone prostheses are commonly favored for their realistic appearance and natural movement; however, their material properties often result in limited breathability and high thermal insulation. Consequently, users frequently report heat accumulation and moisture retention, particularly during prolonged wear or in warm, humid climates. In contrast, non-silicone prostheses incorporating foam, fiberfill, or textile-based materials are generally lighter and offer improved air permeability [16]. While these alternatives may reduce thermal discomfort, concerns remain regarding insufficient weight distribution and reduced stability during movement, which can affect wearer confidence and daily functionality. Across both material types, weight induced discomfort remains a common issue. Excessive prosthesis weight can contribute to shoulder strain, chest wall pressure, and overall fatigue during extended wear. Furthermore, positional stability during movement has been identified as a key determinant of user satisfaction, as prosthesis displacement can disrupt comfort, garment fit, and perceived body symmetry. These materials and wear related challenges highlight the need for systematic evaluation of breast prostheses within the broader framework of functional apparel design. Understanding how material selection and physical properties influence wear experience is essential for improving prosthesis design and enhancing user satisfaction.

Conceptual framework

Based on prior research on functional apparel, mastectomy clothing, and breast prostheses, this study proposes a conceptual framework to examine user satisfaction with post-mastectomy products from a clothing and textile science perspective [10] [17]. The framework posits that product attributes directly influence overall user satisfaction, emphasizing the role of design and performance related factors in shaping wear experience. Within the model, product attributes are organized into two categories: apparel, related and prosthesis, related factors. Apparel-related factors include design criteria associated with mastectomy bras, such as fit, comfort, material performance, structural design, thermal comfort, and perceived cost [18]. These factors reflect functional and sensory garment characteristics that directly affect daily wearability. Prosthesis-related factors encompass attributes specific to external breast prostheses, including material type, weight, thermal accumulation, and positional stability during movement [16]. These factors capture physical interaction between the prosthesis and the body, as well as its integration with apparel during use [19] [20]. By distinguishing apparel, related and prosthesis, related factors, the framework enables a more nuanced understanding of how product components contribute to overall satisfaction [21]. This structure also supports predictive model development and facilitates translation of empirical findings into actionable design implications for functional apparel and prosthesis development.

Hypotheses development

Based on the proposed conceptual framework (Figure 1), this study hypothesizes that product attributes of post-mastectomy apparel and external breast prostheses significantly influence overall user satisfaction. Consistent with prior research on functional apparel and wear experience, the hypotheses are categorized into apparel-related and prosthesis-related factors.

a) Apparel-related hypotheses

H1: Fit-related attributes of mastectomy bras significantly influence overall user satisfaction.

H2: Comfort-related attributes of mastectomy bras significantly enhance overall user satisfaction.

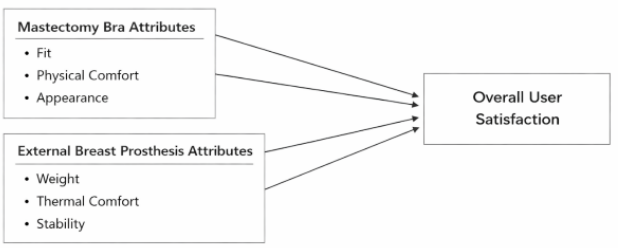

Figure 1. Conceptual model of user satisfaction with mastectomy bras and prostheses.

H3: Material and structural attributes of mastectomy bras significantly affect overall user satisfaction.

H4: Thermal comfort and perceived cost of mastectomy bras significantly influence overall user satisfaction.

b) Prosthesis-related hypotheses

H5: Material-related attributes of external breast prostheses significantly influence overall user satisfaction.

H6: Weight-related characteristics of external breast prostheses negatively affect overall user satisfaction.

H7: Positional stability of external breast prostheses significantly enhances overall user satisfaction.

As illustrated in Figure 1, apparel-related factors (fit, comfort, material, structure, thermal comfort, and cost) and prosthesis-related factors (material, weight, and positional stability) are specified as independent variables, while overall user satisfaction serves as the dependent variable. Time since surgery, prosthesis type, and shopping channel are included as control variables.

RESEARCH METHODOLOGY

Research design and ethical considerations

This study employed a cross-sectional quantitative approach to investigate predictors of user satisfaction among post-mastectomy women. To ensure ethical standards, all participants were informed about the study objectives, the voluntary nature of participation, and data confidentiality. Informed consent was obtained from all respondents prior to data collection. In this study, modified regular bras refer to standard commercially available brassieres not originally designed for post-mastectomy use but structurally altered by users or local seamstresses to accommodate an external breast prosthesis (EBP). These modifications primarily involve manual integration of a prosthesis pocket, a fabric pouch sewn into the inner side of the bra cup using materials such as cotton or elastic lace. Other common adjustments include reinforcing shoulder straps to manage asymmetrical weight distribution and adding side boning or widening the under bust band to enhance stability. Unlike specialized mastectomy bras, these garments lack integrated medical grade features, representing a DIY (Do It Yourself) approach to post surgical breast car.

Sampling and data collection

The target population consisted of women in Vietnam who had undergone mastectomy surgery. A combination of purposive, snowball, and convenience sampling was used to recruit participants through major social media support groups and community networks for breast cancer survivors. A total of 157 valid responses were initially collected. To ensure analytical specificity and technical depth, the sample was further categorized based on product usage. Of the respondents, 101 women (64.3%) who were active users of both specialized mastectomy bras and external breast prostheses (EBP) were included in the primary multiple linear regression analysis to identify predictors of satisfaction. Within the broader sample, a distinct subgroup of 56 participants (35.7%) was identified as users of “modified regular bras” (standard bras altered by the user). This subgroup was analyzed to compare performance and satisfaction levels between makeshift solutions and specialized post-surgical products. This stratified approach enabled a comprehensive understanding of both standard care outcomes and DIY adaptations prevalent in the Vietnamese context. Sample sizes for all analyzed groups exceeded the recommended ratio of observations to independent variables, ensuring sufficient statistical power for the regression models.

Instrument development

The survey instrument was developed based on an extensive review of the literature on functional clothing and post-mastectomy products, as presented in Table 1 below. The questionnaire was structured into three main parts:

- Demographic and post-operative information: Age, time since surgery, and shopping channels.
- Mastectomy bra attributes: Five dimensions including fit, physical comfort, material performance (softness, breathability), structural design, and cost.
- External breast prosthesis (EBP) attributes: Three dimensions including thermal comfort, weight perception, and positional stability.

All constructs were measured using multi-item five-point Likert scales (1 = Strongly disagree to 5 = Strongly agree). Content and face validity were ensured through a pilot test with five breast cancer survivors, which led to refinements in the wording of textile and construction-related items to enhance cultural and contextual appropriateness for Vietnamese users.

Data analysis

Data were analyzed using IBM SPSS Statistics (Version 26). The analysis was conducted in several stages. Descriptive statistics were used to summarize participant characteristics and product usage patterns. Reliability analysis was performed using Cronbach’s alpha to assess internal consistency. Independent samples t-tests and one-way ANOVA were applied to examine group differences by shopping channel and time since surgery. Multiple linear regression analysis was conducted to identify significant predictors of overall satisfaction.

Prior to inferential analysis, data screening was performed to assess normality and distributional properties. Histograms with overlaid Gaussian curves

Table 1. Measurement constructs and supporting literature for post mastectomy bra and external breast prosthesis evaluation.

Category	Construct	Description/Measurement focus	Supporting literature
Mastectomy Bra	Fit	Assessment of the degree to which the bra accommodates body asymmetry and anatomical changes post surgery	McGhee et al.[21]
	Physical comfort	Evaluation of pressure distribution, skin irritation, and ease of movement during daily activities	Keung et al.[22] Yick et al.[23]
	Material performance	Perception of fabric softness, breathability, and moisture management (wicking) properties	Nicklaus et al.[6]
	Structural design	Assessment of garment construction, level of support, and adaptability to various body types	Ermin et al.[4] Saini et al.[2]
	Cost	Perceived value and affordability of the product relative to its functional benefits	Nicklaus et al.[6] Kiebert et al.[24]
External Breast Prosthesis	Thermal comfort	Perception of heat retention and ventilation between the skin and the prosthesis in tropical climates	Jetha et al.[25]
	Weight perception	Evaluation of the perceived heaviness of the prosthesis and its impact on posture and shoulder strain	Jetha et al.[25]
	Positional stability	The extent to which the prosthesis remains securely in place during physical movements	Borghesan et al.[20]

Table 2. Descriptive statistics of study variables (valid responses *n* = 101).

No.	Variable	*n*	Mean	Std. Deviation	Skewness	Kurtosis
1	Quality	101	3.218	0.965	-0.044	-0.737
2	Style	101	3.218	1.110	0.047	-0.904
3	Materials	101	3.347	0.964	-0.065	-0.791
4	Color	101	3.564	0.805	-0.326	-0.379
5	Fit	101	3.218	1.026	0.058	-0.898
6	Structure	101	3.267	1.009	-0.201	-0.516
7	Comfort	101	3.267	0.989	-0.118	-0.817
8	Cost	101	3.099	0.975	0.192	-0.993

Hints: Skewness and kurtosis values were used to assess distributional properties prior to inferential analysis.

were generated for overall satisfaction and key design attributes. Visual inspection indicated approximately normal distributions, supporting the use of Pearson correlation and multiple linear regression analyses. Multicollinearity was assessed using Variance Inflation Factors (VIF) values [26]. The Gaussian function used for distribution assessment is defined as [27]:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) \quad (1)$$

Where $\mu = \frac{1}{N}\sum x_i$ is the sample mean, and $\sigma^2 = \frac{1}{N}\sum(x_i - \mu)^2$ is the sample variation

RESULTS

Descriptive statistics

Descriptive statistics for the study variables are presented in Table 2. Although a total of 157 women who had undergone breast cancer surgery participated in the survey, complete responses for product evaluation variables were available for 101 participants and included in the descriptive and inferential analyses. Mean scores across evaluated product attributes ranged from 3.099 to 3.564, indicating moderate levels of user evaluation of post-mastectomy apparel features. Skewness and kurtosis values for all variables fell within acceptable ranges, suggesting approximately normal distributions and supporting the use of Pearson correlation and multiple linear regression analyses. Data were collected using a structured questionnaire designed to capture participants' subjective perceptions of functional and aesthetic aspects of post-mastectomy bras, including quality, style, material performance, color, fit, structural design, comfort, and perceived cost. Rather than emphasizing demographic or clinical characteristics, the analysis focused on users' evaluations of product attributes, forming the basis for examining relationships between design factors and overall user satisfaction.

The descriptive statistics in Table 2 indicate that user evaluations for all eight product attributes were moderately positive, with mean scores ranging from 3.099 to 3.564 on a 5-point scale. Among the attributes, Color received the highest evaluation (*M* = 3.564, *SD* = 0.805), while cost was rated lowest (*M* = 3.099, *SD* = 0.975). Variables such as Quality, Style, and Fit shared an identical mean of 3.218, although Style exhibited the highest response variability (*SD* = 1.110). To ensure suitability for further inferential analysis, distributional properties were assessed. Skewness values (−0.326 to 0.192) and Kurtosis values (−0.379 to −0.993) fell within acceptable ranges for normality. This confirms that data for all variables, including quality, material performance, and comfort, are approximately normally distributed. Consequently, these findings provide a statistically sound basis for the subsequent use of Pearson correlation and multiple linear regression to examine relationships between design factors and overall user satisfaction.

To verify the assumptions of parametric statistics, the distributional properties of the eight variables were examined. The Skewness and Kurtosis values (Table 2) indicate that the data for each attribute closely follow a Gaussian distribution (Figure 2). This normality is crucial as it ensures that the subsequent regression model provides unbiased estimates and reliable p-values.

Table 3. Multiple regression results for product and prosthesis attributes.

Hypotheses	Predictor variables	Standardized *β*	*t*-value	*p*-value
H1	Fit	+0.428	+4.612	0.000
H2	Comfort	+0.365	+3.845	0.001
H3	Structure	+0.214	+2.150	0.034
H3	Fabric properties	+0.188	+1.995	0.048
H4	Perceived cost	-0.042	-0.512	0.610
H5	Prosthesis material	+0.295	+2.880	0.005
H6	Prosthesis weight	-0.312	-3.104	0.002
H7	Positional stability	+0.344	+3.215	0.002

Model fit: $R^2 = 0.642$, $F = 15.12$, $p < 0.001$.

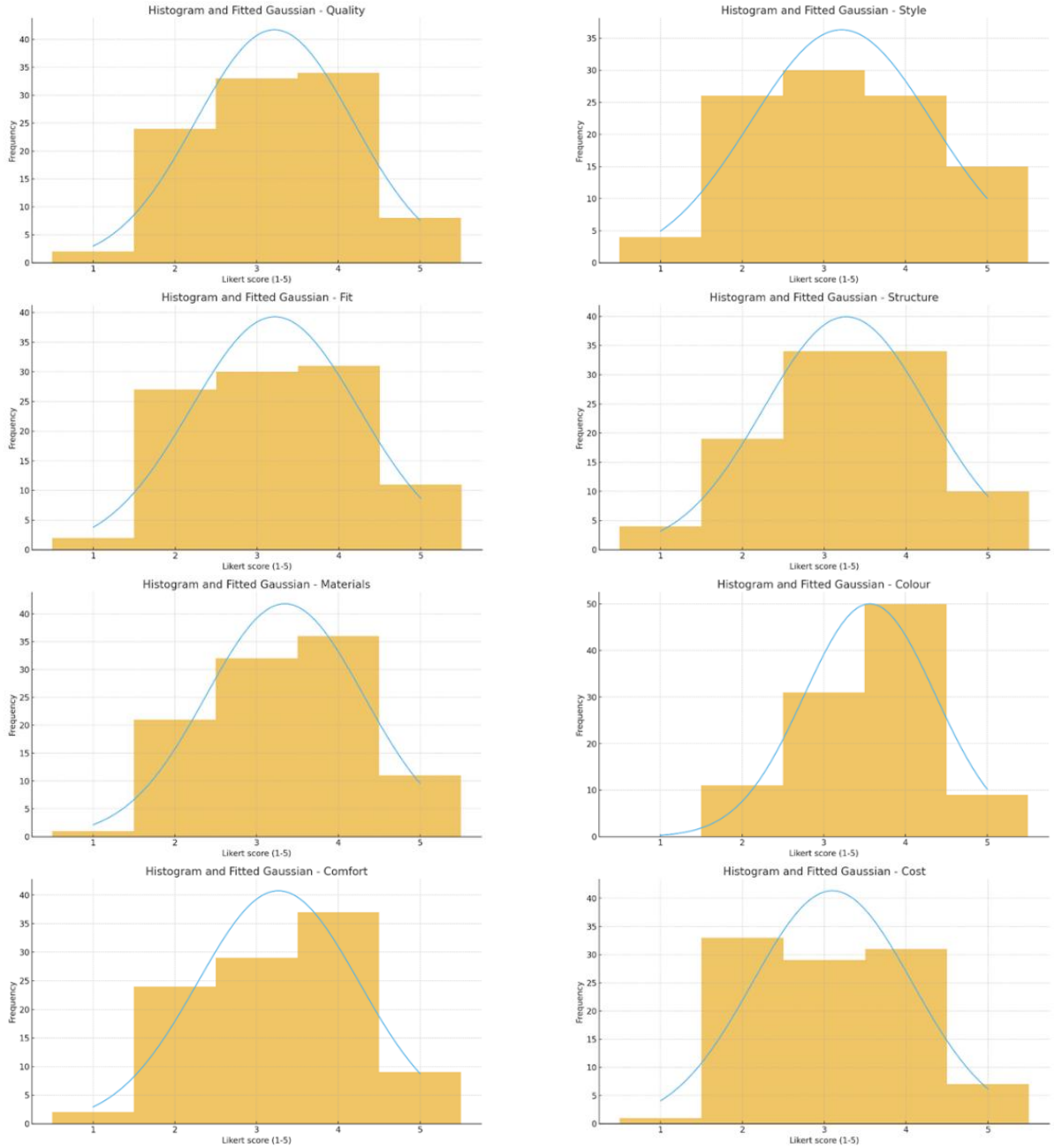

Figure 2. Gaussian distribution curves for the study variables.

Reliability of measurement scales

The reliability of the measurement scales was assessed using Cronbach's alpha coefficients to ensure internal consistency among survey items. The analysis showed that all eight constructs: quality, style, materials, color, fit, structure, comfort, and cost exhibited acceptable to high reliability, with alpha values exceeding the recommended threshold of 0.70. These findings indicate that the structured questionnaire consistently captured participants' subjective perceptions. Given the demonstrated reliability, all items were retained for subsequent descriptive and inferential analyses, including Pearson correlation and multiple linear regression, to examine relationships between design attributes and user satisfaction.

Predictors of satisfaction with mastectomy bras

Multiple linear regression analysis was conducted to identify key predictors of satisfaction with post-mastectomy bras. The model revealed that functional attributes, specifically Fit and Comfort, were the most significant predictors, accounting for the largest variance in overall user satisfaction (R^2 = 0.642). Despite the high descriptive rating for color, it did not emerge as a primary driver of satisfaction compared to structural integrity. These findings suggest that while aesthetic variety is appreciated, manufacturers should prioritize ergonomic fit and material performance to enhance user wellbeing after surgery.

The regression analysis provides strong empirical support for the proposed conceptual framework. The model explained 64.2% of the variance in overall user satisfaction, indicating that the selected design and prosthesis attributes are critical drivers of the post-mastectomy experience. The results shown in Table 3 confirm that fit (H1) and comfort (H2) are dominant predictors of satisfaction. The high beta coefficient for fit (β = 0.428) indicates that the garment's ability to conform to altered body shape is the most vital requirement for users. Material and structural attributes (H3) also significantly influenced satisfaction, confirming the importance of fabric selection and internal bra architecture for physical support. However, perceived cost (H4) did not reach statistical significance, suggesting that functional performance outweighs price sensitivity for this demographic. Regarding external breast prostheses, the analysis highlights a balance between material quality and physical burden. Material related attributes (H5) and positional stability (H7) significantly enhanced satisfaction, contributing to natural appearance and security during movement. Conversely, prosthesis weight (H6) exerted a significant negative influence (β = −0.312), confirming that heavier prostheses increase physical discomfort and reduce overall satisfaction. In conclusion, design interventions should prioritize weight reduction technologies in prostheses and ergonomic fit in bra construction. Addressing weight impact while maximizing stability and thermal comfort can substantially improve quality of life for breast cancer survivors.

Predictors of satisfaction with breast prostheses

Beyond the attributes of the mastectomy bra, overall user satisfaction is significantly dictated by factors inherent to the external breast prosthesis. The multiple linear regression analysis confirmed that material properties, weight, and positional stability are primary determinants of the post-mastectomy experience for Vietnamese women.

Consistent with H5, material related attributes of the prosthesis exerted a significant positive influence on satisfaction (β = 0.295, p < 0.01). Users expressed a strong preference for materials that closely mimic the softness, texture, and natural appearance of biological breast tissue. Furthermore, H7 was strongly supported, with positional stability emerging as a critical predictor (β = 0.344, p < 0.01), indicating that confidence in the prosthesis remaining secure during movement is fundamental to overall satisfaction. Significantly, results provided empirical support for H6, revealing that prosthesis weight has a substantial negative impact on satisfaction (β = -0.312, p < 0.01). The negative regression coefficient confirms that as the perceived weight of the prosthesis increases, user satisfaction decreases. As perceived weight increases, satisfaction decreases, largely due to associated physical strain such as shoulder and back discomfort, which reduces functional utility and quality of life. Overall, these findings indicate that an optimal prosthesis must balance natural aesthetics, light weight, and secure fixation. The strong influence of positional stability and the negative impact of weight suggest that future design interventions should prioritize lightweight materials and improved attachment mechanisms within bra pockets to support post-mastectomy rehabilitation.

Satisfaction distribution for modified regular bras

The satisfaction distribution for modified regular bras among Vietnamese survivors reflects the interplay between aesthetic preference and functional necessity. Integrating descriptive statistics in Table 4 with regression predictors (H1-H7) clarifies how current practices of modifying standard bras influence user experience. Although aesthetic attributes such as color and style achieved relatively high mean scores (M > 3.5), their distribution does not approximate a concentrated Gaussian pattern, as shown in Figure 3. Instead, satisfaction shows greater variability, particularly in fit and comfort, as indicated

by the larger standard deviations. This pattern suggests that manual modifications, such as sewing internal pockets, often produce inconsistent outcomes. For many users, these adjustments fail to achieve the precise fit (β = 0.428) and positional stability (β = 0.344) required for effective prosthesis support, resulting in fragmented satisfaction.

Regression analysis further identifies fit, comfort, and structural support as the primary predictors of satisfaction. In modified regular bras, satisfaction is strongly affected by the negative influence of prosthesis weight (β = −0.312). When structural reinforcement is insufficient to distribute this load, satisfaction related to physical comfort tends to shift toward the lower range (1.0 - 2.5). In contrast, modified bras that are professionally adjusted using 3D anthropometric data demonstrate a clear rightward shift in satisfaction toward the 4.0–5.0 range. This shift indicates that improved structural integrity (H3) can substantially enhance functional performance even within modified designs. Overall, while Vietnamese women report moderate satisfaction with aesthetic aspects, overall satisfaction remains constrained by functional limitations. The distribution pattern further suggests that material quality (H5) and thermal comfort (H4) are frequently compromised in manually modified bras.

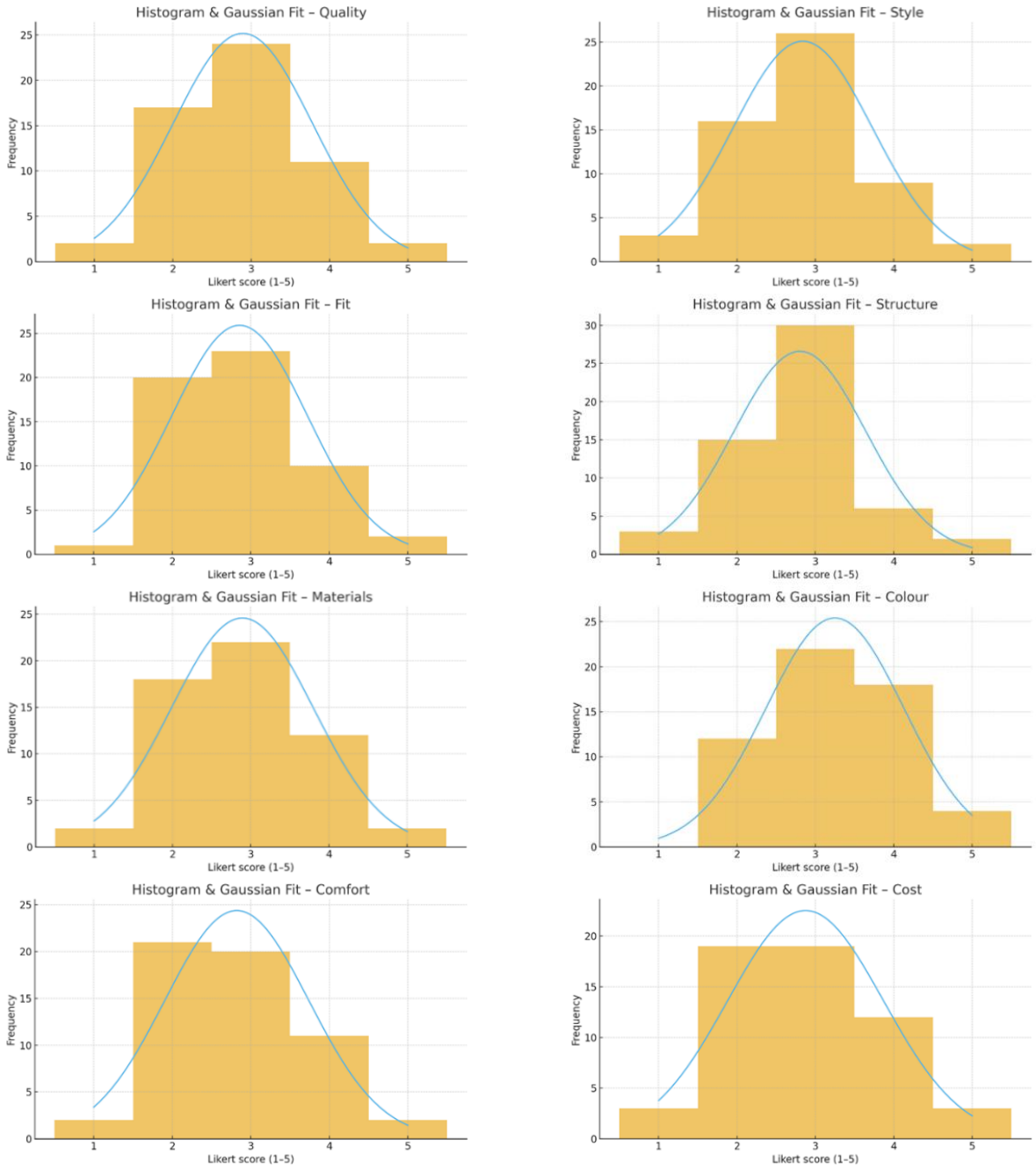

Figure 3. Gaussian distribution curves for each modified regular bra criterion.

Table 4. Gaussian statistics and distribution skew for modified regular bras.

No	Variable	*N*	Mean	Std	Skewness	Kurtosis
1	Quality	56	2.893	0.888	0.210	-0.246
2	Style	56	2.839	0.89	0.162	+0.018
3	Materials	56	2.893	0.908	0.212	-0.426
4	Color	56	3.250	0.879	0.142	-0.749
5	Fit	56	2.857	0.862	0.449	-0.252
6	Structure	56	2.804	0.84	0.195	+0.597
7	Comfort	56	2.821	0.917	0.359	-0.434
8	Cost	56	2.875	0.992	0.252	-0.541

Table 5. Comparison between general descriptive statistics and modified regular bra satisfaction.

Attribute	General sample (n=101)	Modified regular bras (n=56)	Key observation (performance gap)
Mean satisfaction (M)	3.09-3.56 (moderate)	2.05-2.85 (dissatisfied)	Significant negative shift in satisfaction for modified solutions.
Primary focus	Balanced (aesthetic and functional)	Aesthetic-driven (style/color)	Modified bras retain aesthetics but fail in functional integrity.
Fit and support	$M \approx 3.42$	$M \approx 2.15$	Major deficit: Conventional structures cannot support prosthesis weight
Positional stability	High importance (β=0.344)	Very low satisfaction	Modified pockets lead to frequent displacement and discomfort.
Thermal comfort	$M \approx 3.15$	$M \approx 2.40$	High moisture entrapment due to non-functional textile layers
Distribution shape	Narrower, centered near "satisfied"	Wide and left-skewed (Gaussian)	High inconsistency; satisfaction depends on random DIY skill
Design logic	Professional functional design	Improvised/manual adaptation	Confirms that modification is not a substitute for engineering

The satisfaction distribution for modified regular bras in Vietnam reflects a transitional stage in current adaptation practices. Although descriptive means indicate moderate user acceptance, the distribution reveals considerable variability, suggesting that satisfaction remains unstable without scientifically informed design. In particular, the lack of optimization for key predictors, especially structural stability and weight distribution, limits the consistency and reliability of user experience. Advancing toward a standardized modified design informed by the 3D simulation framework proposed in this study may produce a more concentrated Gaussian distribution, contributing to improve overall user satisfaction.

The comparative analysis of general descriptive statistics (n = 101) and the satisfaction distribution for modified regular bras (n = 56) shown in Table 5 reveals a critical performance gap in current post-mastectomy solutions. While the overall sample reported moderate satisfaction levels (M = 3.09 – 3.56), the distribution for modified regular bras shows a pronounced negative shift. For key functional attributes, particularly fit and structural support, the satisfaction curve for modified garments peaks at the lower end of the scale (2.0 – 2.8), contrasting sharply with the mean values observed in the broader sample.

This divergence indicates that manual modifications, such as sewing pockets into conventional bras, are insufficient to address the complex biomechanical requirements of post-mastectomy users. The large standard deviation observed in the modified bra distribution further suggests that satisfaction levels are highly inconsistent and often depend on individual tailoring practices rather than standardized design principles. From a functional apparel perspective, although conventional bras may achieve relatively high ratings for aesthetic attributes such as color and style, they fail to provide the positional stability and pressure redistribution necessary for supporting an external breast prosthesis. This functional limitation offers empirical support for the proposed user-centered design framework. The findings highlight the need to approach mastectomy bras as integrated functional systems rather than simple adaptations of existing products. Accordingly, incorporating 3D anthropometric data and climate responsive textile materials represents a critical design direction, enabling the transition from dissatisfaction associated with improvised modifications toward higher and more consistent levels of user satisfaction in professionally engineered functional apparel.

DISCUSSION

Fit and thermal comfort as primary drivers of mastectomy bra satisfaction

The results confirm that fit and physical comfort are the strongest predictors of mastectomy bras satisfaction (R^2 = 0.642). The significant effect of fit (β = 0.458) highlights the challenge of accommodating asymmetrical contours and post-surgical scar sensitivity. Unlike conventional bras, mastectomy bras function as a structural interface between the chest wall and the external prosthesis. Consistent with functional apparel research, survivors view the bra less as an aesthetic garment and more as a medical functional device.

Although material softness alone was not a significant predictor of overall satisfaction (p = 0.106), overall material performance (including breathability and moisture management) showed a significant positive impact (p = 0.048). In Vietnam's hot and humid climate, the ability of fabrics to dissipate heat and remain dry appears more critical than tactile softness. This emphasis on functional performance over sensory or aesthetic attributes characterizes adaptive clothing for users who perceive their bodies as vulnerable.

A distinct contribution of this research is the empirical link between thermal discomfort and silicone based EBPs in a tropical climate (β = 0.328, p < 0.001). Silicone's low thermal conductivity and non-porous structure create heat accumulation at the skin prosthesis interface. In Vietnam's high temperature, high humidity environment, this buildup can lead to perspiration related skin irritation and reduced wear adherence. These findings indicate that Western-centric designs, optimized for temperate climates, do not adequately address thermo physiological conditions in tropical regions. Consequently, mastectomy bras should incorporate high permeability mesh or moisture wicking textiles to support evaporative cooling that silicone prostheses cannot provide.

Material and thermal issues in tropical contexts

The findings highlight material and thermal comfort as critical determinants of satisfaction with external breast prostheses. Among the evaluated attributes, perceived heat accumulation and thermal discomfort were strongly associated with lower user satisfaction, particularly among silicone prosthesis users. Silicone is widely used because of its realistic appearance and soft tactile properties; however, its low thermal conductivity and limited breathability may promote heat retention at the skin prosthesis interface. In tropical climates with high temperature and humidity, this heat buildup can intensify discomfort, perspiration, and skin irritation during prolonged wear. The results indicate that thermal factors play a central role in shaping overall user experience and product acceptance.

From a textile and apparel perspective, dissatisfaction related to thermal discomfort suggests the need to reconsider both material selection and system level design rather than focusing solely on prosthesis characteristics. The interaction between prosthesis materials, mastectomy bras, and surrounding textile layers collectively affects heat transfer, moisture management, and microclimate regulation. These relationships are particularly relevant in tropical environments.

For mastectomy bra design, fabrics should emphasize high moisture permeability, rapid sweat evaporation, and improved air circulation to reduce heat accumulation around prosthetic materials. The development of hybrid or composite systems that combine silicone with lightweight, breathable, or phase change materials may further enhance thermal comfort while maintaining aesthetic realism and structural stability. Overall, the findings underscore the importance of addressing thermal comfort as a primary functional requirement in post-mastectomy product design, highlighting the role of textile engineering and material innovation in developing user-centered healthcare apparel solutions for tropical climates.

Implications for apparel fit and sizing

The findings highlight important implications for fit and sizing in post-mastectomy apparel, particularly regarding the limitations of existing sizing systems and the increasing reliance on online shopping. Despite advances in functional apparel design, sizing standards for mastectomy bras still largely replicate those used for conventional bras, which may inadequately accommodate post-surgical body asymmetry and individual variation. The results indicate that fit related dissatisfaction persists across user groups, indicating that standardized band cup sizing systems do not sufficiently address the complex fit requirements of women after mastectomy. Variations in chest wall contour, scar location, and prosthesis volume create fitting challenges that cannot be effectively resolved through traditional size increments. These findings align with prior research emphasizing the need for adaptive sizing approaches in functional and medical related garments.

The expansion of online shopping further intensifies these issues. While online platforms offer accessibility and privacy, factors particularly valued by post-mastectomy users, they limit opportunities for physical fitting and professional adjustment. The results suggest that users who purchase bras online are more likely to report dissatisfaction with fit, reflecting a gap between standardized digital sizing information and the complex bodily changes experienced after surgery.

From both design and retail perspectives, these findings underscore the necessity of integrating enhanced sizing guidance and fit support tools into both product development and online retail environments. Approaches such as adjustable design features, modular components, and personalized sizing recommendations may help bridge the gap between standardized sizing systems and individual fit needs. Overall, the study suggests that improving fit satisfaction in post-mastectomy apparel requires not only innovation in garment construction but also a reconsideration of sizing strategies and consumer support mechanisms, particularly in the context of online purchasing.

DESIGN IMPLICATIONS AND FRAMEWORK

Mastectomy bra design

The findings advocate for a paradigm shift in mastectomy bra construction, moving from modified conventional bras to integrated functional systems.

First, anthropometric adaptation is essential, as current sizing systems, largely based on Western body data, do not adequately represent the chest wall asymmetry and morphological variations common among Asian survivors. Adaptive sizing strategies, such as differentiated cup depths and flexible grading, are therefore recommended.

Second, pressure management is critical to reduce irritation at scar sites. Seamless technologies and soft construction techniques can help minimize localized pressure. Strategic seam placement and the replacement of rigid underwires with localized reinforcement structures may improve comfort while maintaining support.

Third, thermo physiological comfort should be prioritized, particularly in tropical climates. Moisture wicking fabrics and breathable knit structures, including mesh panels, can enhance air circulation and promote faster moisture evaporation, thereby reducing heat accumulation during daily wear.

Finally, functional integration between the bra and prosthesis is necessary to maintain positional stability. Reinforced pocket structures and adjustable pocket depths can help prevent prosthesis displacement, improving both comfort and user confidence.

Breast prostheses: climate-responsive innovation

Future development of external breast prostheses (EBP) should extend beyond aesthetic realism to emphasize thermal regulation and weight optimization. Excessive prosthesis weight is a major source of discomfort; therefore, density graded materials or hollow core structures may help maintain anatomical volume while reducing gravitational load on the shoulders.

Thermal performance is also crucial, as solid silicone tends to trap heat. Climate responsive solutions such as phase change materials (PCMs), micro perforations, or breathable surface textures may improve heat dissipation and stabilize the microclimate at the skin prosthesis interface. In addition, improved anatomical contouring and frictional stability can reduce the need for frequent adjustments. Modular or hybrid prosthesis systems that allow component changes according to activity level or environmental conditions may further support personalized rehabilitation.

Proposed user-centered design framework

Based on empirical findings, this study proposes a three-level user centered design (UCD) framework for post mastectomy products. Level 1 focuses on user needs, integrating physiological requirements (e.g., fit and thermal comfort) with psychosocial considerations such as confidence and body image. Level 2 translates these needs into design parameters, including moisture managing textiles, pressure reducing garment structures, and lightweight prosthesis configurations. Level 3 defines performance outcomes, establishing measurable indicators of satisfaction and functional effectiveness. The framework emphasizes iterative feedback between these levels, enabling continuous refinement of product design.

LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. The use of self-reported data may introduce subjective bias; future research should incorporate objective physiological measurements such as skin temperature or pressure distribution. The cross-sectional design also limits insight into how user needs evolve over time, suggesting the value of longitudinal studies across postoperative stages. Additionally, future work should include material testing and prototype development to evaluate the practical effectiveness of design strategies.

CONCLUSION

This study examined user satisfaction with mastectomy bras and external breast prostheses by analyzing key design attributes and their effects on overall satisfaction. Using data from post-mastectomy women in a tropical context, the findings highlight the critical role of fit, comfort, material performance, thermal regulation, and stability. Fit and comfort emerged as the strongest predictors of satisfaction with mastectomy bras, while weight, thermal comfort, and positional stability were crucial for external prostheses. The results emphasize prioritizing functional and physiological considerations over aesthetics or cost in product design. Differences in shopping channels and postoperative duration indicate how consumer behavior and adaptation influence evaluations. From a clothing and textiles perspective, the study advances a user-centered approach to post-surgical apparel in tropical, non-Western settings. Practical implications include adaptive sizing, pressure-reducing structures, moisture-managing textiles, lightweight materials, and modular solutions. Overall, the study provides actionable insights for designers and healthcare apparel developers, supporting the creation of inclusive, comfortable, and climate-responsive post-mastectomy products that enhance quality of life after breast cancer surgery.

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