Jurnal Teknik Industri, Vol. 27, No. 1, June 2025
ISSN 1411-2485 print / ISSN 2087-7439 online
DOI: https://doi.org/10.9744/jti.27.1.51-76

Integration of Kansei Engineering and Nudge Based Design Thinking for Patient Comfort in Healthcare Services

Markus Hartono[1*], Wyna Herdiana[2], Guguh Sujatmiko[2], Hairunnas[2], Christabel Annora Paramita Parung[2], Brian Kurniawan Jaya[2]
[1)] Faculty of Engineering, Industrial Engineering Department, University of Surabaya
Jl. Raya Kalirungkut, Tenggilis, Surabaya 60293, Indonesia
[2)] Faculty of Creative Industries, Product Design Department, University of Surabaya
Jl. Raya Kalirungkut, Tenggilis, Surabaya 60293, Indonesia
Email: markus@staff.ubaya.ac.id[1], wynaherdiana@staff.ubaya.ac.id[2], guguh.sujatmiko@staff.ubaya.ac.id[2], annashairunnas@staff.ubaya.ac.id[2], christabelannora@staff.ubaya.ac.id[2], briankurniawan@staff.ubaya.ac.id[2]
[*]Corresponding author

Abstract: Healthcare often struggles to obtain patient comfort and autonomy, leading to confusion, frustration, and dependency on healthcare staff. In addressing this concern, this study is conducted to propose an integrative framework of Kansei Engineering (KE) and Nudge Theory (NT) within the Design Thinking (DT). It is a novel approach called KENT-DT. Utilizing a human-centric design methodology, this study implemented semi-structured interviews and direct observations with hospitalized patients to assess their emotional responses and interactions with existing beds and hospital staff. The data disclosed some critical pain points, including lack of intuitive control, discomfort, and restricted patient autonomy in bed adjustments, which too often led to dependency on hospital staff. To address these issues, this study proposed an improved hospital bed prototype utilizing KE for patient emotional design considerations and NT to subtly encourage positive patient behaviors, such as maintaining ergonomic bed positions to prevent pressured body portions. Some features of the redesigned bed are offered, such as visual cues, intuitive control location, and ergonomic support enhancements. It is to reduce dependency on staff and increase patient autonomy. According to an evaluation by a doctor and a hospital staff member, it has been concluded that there is an expected increase in patient satisfaction and autonomy. This study brings expected implications. It suggests that integrating KE and NT in medical and hospital product design can foster a more patient-centred healthcare experience, encourage speedy recovery, and reduce staff burden. Future study is highly encouraged to implement the prototype of redesigned beds and evaluate the long-term impact of them on patient recovery. The adaptability of patients across diverse healthcare facilities may be considered as well.

Keywords: Design thinking, hospital bed design, Kansei Engineering, Nudge Theory, patient comfort, patient autonomy.

Introduction

Background and Motivation

Human-centered design is a methodology that prioritizes the needs and desires of end users, including patients, families, providers, and stakeholders, innovative healthcare. It comprehends both human capabilities and limitations. According to Patel *et al.* [1], there are several research prospects in healthcare, notably in telemedicine, artificial intelligence in diagnosis and treatment, precision medicine, mental health and emotional well-being, and healthcare systems and policies. Telemedicine is revolutionizing healthcare delivery, especially for rural or underdeveloped areas. Artificial intelligence-based applications in diagnoses and personalized treatment plans are expanding, and studies on accuracy, ethical implications, and long-term effects will help define future medical practices. It indicates that a human-centered approach is promising in various healthcare design fields, and healthcare should adopt it to address real-life problems and create innovative solutions.

Ergonomics (known as human factors engineering) plays a crucial role in healthcare by ensuring patient safety and supporting the productivity and well-being of healthcare personnel. The design of healthcare

facilities, equipment, and systems should prioritize minimizing physical strain, reducing damage risks, and maximizing overall efficacy. Hignett *et al.*'s [2] study shows that human factors and ergonomics (HFE) techniques are being used more and more in healthcare, mainly in occupational ergonomics and surgical safety. These techniques help enhance patient and clinician performance, safety, and cost control, ultimately improving healthcare efficiency.

Beyond physical aspects, emotional design is also integral to healthcare. A study by Vinagre & Neves [3] highlights that a positive patient-doctor relationship fosters empathy, leading to the emergence of positive emotions. Kansei Engineering (KE), one of prominent methods in addressing emotions into physical products and services, can potentially address patients' emotional needs by addressing their expectations of joy and comfort. KE may translate patients' emotional demands into tangible design features that improve their healthcare experience. This approach helps create environments where more empathetic and responsive nurses and staff are inevitable.

Initially, Kansei Engineering (KE) aims to translate psychological demands, sentiments, and emotions, referred to as "Kansei," into concrete design elements such as texture, color, shape, and sound. Originally developed in Japan, KE finds widespread application in industries such as consumer electronics, fashion, and automotive, where emotional appeal plays a crucial role in ensuring user satisfaction. For example, KE can be used in automobile design to ensure that the dashboard's appearance and feel enhance the driver's sense of control and safety [4; 5].

Recent studies have highlighted the evolution of KE, its integration with other methods, and emerging trends such as incorporating cultural relevance into design. For example, Liu *et al.* [6] applied the local cultural elements to design the *Mazu* crown, which resonated strongly with the target population [7]. Even the KE has been applied to services, a study conducted by Hartono [8] has shown that the integration of KE, the Kano model, and the Theory of Inventive Problem Solving (TRIZ) has gained a deeper understanding of the emotional needs of clients from various cultural backgrounds by taking a case study in a medium-sized restaurant. Diverse cultural backgrounds, as one of the demographic factors, influence formulized design strategies. For instance, in service design, it shows that changing the new service design proposal can be significantly impacted by the current service culture and its dynamics, which makes it more difficult to obtain stable customer satisfaction levels [9]. Another example is a study by Hartono [8]. Cultural backgrounds are also accounted for and integrated into the integrated model. They are deemed to lead to more diverse improvement initiatives [8]. Moreover, Hartono *et al.* [10] have proposed a structured approach for logistics service managers to better capture and analyze emotional customer needs, thus enabling a more comprehensive customer experience in the logistics service industry. It was found that almost 95% of KE studies did not take cultural factors into account. This means that more research should be done to find ways to make KE-designed products more culturally relevant. Understanding how different cultures perceive products and services is essential for improving KE's effectiveness across diverse user groups.

Hospital environments have a significant impact on patient outcomes, satisfaction, and well-being. Recent attention has been given to designing "patient-friendly" hospital environments that promote healing, reduce stress, and improve patient experiences. Douglas & Douglas [11] emphasized the importance of hospital environments in shaping patients' perceptions, highlighting the need for privacy, homeliness, and accessibility. Privacy, particularly for bedridden patients, is essential, with many patients expressing their desire for personal control, such as the ability to draw curtains or access quiet areas for relaxation.

Hospital bed design plays a pivotal role in patient comfort and safety. A study by Drayi [12] in Ghana has uncovered issues such as bed shortages, poor bed conditions, and inadequate bedding materials, leading to compromised patient care. The study revealed that bed shortages resulted in patients being treated on the floor, increasing the risk of infections and discomfort, even negative feedback. Furthermore, 30.5% of patients experienced unnecessary referrals due to bed shortages, which delayed care and worsened outcomes [12]. Only 9.6% of patients reported their beds as very comfortable, while a majority found them uncomfortable, largely due to the lack of hand control, which hindered patients' ability to adjust their posture independently. Addressing patient comfort and autonomy in bed design is critical. Drayi [12] proposed installing modern hospital beds equipped with hand control buttons to enhance comfort and promote independence. The study also recommended frequent maintenance, proper bedding, and hygiene measures to improve patient care quality and reduce infection risks.

Patient comfort deals with the quality of emotional, physical, and psychological care of patients during their stay and experience in a hospital or healthcare. In this study, it might include the comfort of hospital facilities (for instance, beds and temperature control) as well as the friendliness and assistance of healthcare staff. Meanwhile, patient autonomy refers to a condition that patients have the right to make informed decisions regarding their own healthcare. It ensures that patients are encouraged to have control over their healthcare decisions. More specifically, patients are highly motivated to do something in terms of their needs independently in the healthcare [13].

The question has been raised. Taking a case study on hospital services, how to motivate patients in utilizing the bed and all related services during their hospitalization period so that they can be more independent? Apart from KE, nudge theory can further support patient autonomy and comfort. According to Cooper [14], simple product designs and clear information can encourage users to engage with products more effectively. Visual cues and reminders, as well as real-time feedback, can nudge patients toward healthier behaviors, such as adjusting their beds for better comfort.

Design may significantly influence nudging, especially in healthcare services. Nudge-based design thinking is increasingly applied in healthcare and public services to improve user experiences and outcomes. Hunnes [15] described how designers could use nudging to create environments that naturally encourage healthy decisions, such as promoting relaxation or better sleep hygiene in hospital settings.

Hence, the combination of KE and Nudge-based Design Thinking (KEN-DT) offers tremendous potential to revolutionize hospital bed design and its related service. This integrated approach can enhance both the emotional and behavioral aspects of patient care. By focusing on patient comfort and nudging patients toward healthier behaviors, these techniques allow for patient-centered designs that improve overall well-being and recovery outcomes. There were some studies conducted proving that bed redesign may have a positive impact on patient recovery. A study by Tronstad *et al.* [16] shows that two unique ICU bed spaces have been constructed and deployed. They include solutions to all identified problems, such as noise reduction, lighting optimization, digital access to nature, and patient connectivity and engagement, as well as solutions developed from a variety of specialty fields, such as IT improvements, technological innovations, and design and architectural solutions. Patients viewed sustainable health-care surroundings, including ward and bed design, to be beneficial to their health and rehabilitation [16].

Research Question and Objective

The objective of this study is to develop an integrated framework combining Kansei Engineering (KE) and Nudge-based Design Thinking (NDT) for healthcare services, especially to address current design deficiencies that result in negative emotional responses, such as discomfort and frustration, and implement ergonomic solutions that nudge patients toward healthier behaviors while improving the hospital experience. In short, we call it the KEN-DT approach. More specifically, this study is also to evaluate and redesign hospital beds that enhance patient comfort, promote self-reliance in bed adjustments, and improve overall patient well-being.

Methods

Recent Kansei Engineering (KE) and its Applications in Healthcare Services

KE's applications have historically focused on tangible products, but its scope has expanded to include services and work processes. According to Hakim *et al.* [7], 85% of KE research still focuses on physical products, with only 12% focusing on services and 2% on work systems. This highlights a gap in KE's application to service design, despite the growing recognition of emotional needs in areas like healthcare service delivery.

KE has evolved by integrating with other techniques and technologies, particularly artificial intelligence (AI), to enhance its capabilities in design. AI technologies such as machine learning and neural networks have been applied to improve the accuracy of KE models by managing large data sets and predicting optimal design attributes. For instance, Lian *et al.* [17] used neural networks to refine design features based on KE inputs, demonstrating how AI can advance KE's precision. However, despite these advancements, 56% of studies still rely on traditional KE methods, indicating room for development and innovation.

The AI-KE (Artificial Intelligence-Kansei Engineering) approach, or how the AI-driven KE model improves healthcare design, is explained as follows. The AI-powered KE models utilize machine learning algorithms to process big datasets of patient emotional responses, complaints, and preferences. Through identified patterns in patient sentiment and feedback, the models can predict the relevant and effective design elements or attributes. The models may be enhanced by incorporating neural networks by refining the weightings of selected Kansei attributes. It will provide more relevant and adaptive models to the real patient experiences. Clearly, AI can facilitate the transformation of qualitative emotional responses (Kanei) into quantifiable design elements. In addition, the AI-driven KE models can generate virtual prototypes of beds and their related features incorporating improved comfort, ergonomic designs, and intuitive control designs. Several case studies of AI-driven KE in healthcare are as follows. In a case of AI-based bed design. Using machine learning-based KE models may improve comfort, usability, and autonomy. AI may help bed adjustments and control mechanisms by analysing data of patient complaints, preferences, and emotional impressions. Another case is the use of Virtual Reality (VR) for AI-driven KE for healthcare design. AI-assisted VR simulation has been utilized in a hospital context to accommodate the interaction between patients, healthcare staff, and doctors with the design prototypes. As this is cost-effective; it will boost some potential improvements and feedback before the implementation stage (e.g., before finalizing healthcare equipment).

Visualization plays a critical role in translating emotional responses into actionable design elements. Recent advancements have introduced tools like virtual reality (VR) to create immersive experiences during the design process. Fu *et al.* [18] demonstrated that VR enhances KE by allowing designers and consumers to engage with product designs in a simulated environment. Despite these advancements, many studies (41%) still rely on 3D images, while 37% do not use visualization tools at all, revealing a gap in the effective use of emerging technologies. There are several opportunities to explore how VR enhances healthcare design with the KE application. In a simulated environment, VR may allow patients and staff to interact with 3D hospital space and ambience. It is important to see and evaluate the visualization of functional design elements connected to emotional responses before the implementation stage takes place. VR also enables prompt real-time feedback collection from the diverse stakeholders (e.g., patients, doctors, nurses, staff, and guests) regarding emotional responses (Kansei) due to some alternative designs of hospital layouts, colour schemes, and furniture arrangements. The use of more advanced devices, such as eye-tracking and biometric feedback embedded in VR, may capture subtle emotional responses and cues apart from Kansei words. It enhances the proposed design that meets both psychological (emotional) and physical needs. For example, some potential cases represent the use of VR in healthcare facility design that may offer some potential benefits. They include redesigning hospital rooms for more patient well-being. Using VR for room visualization will promote comfort, privacy, and accessibility for patients. Patients will experience a virtual walk-through and provide feedback on ergonomic environments and physical factors such as noise, lighting levels, and physical facility arrangements. It will boost patient-friendly healthcare environments. More specifically, in the case of VR-assisted patient bed redesign, the VR simulation will enhance patients in refining the adjustment mechanism and control placement for the bed. Through various settings of parameters, designers could optimize side rail accessibility, bed height, and ergonomic support based on patient emotional preferences.

Human factors engineering (HFE), also known as ergonomics, focuses on understanding human abilities and limitations. This approach is crucial in designing environments, products, and systems that enhance human performance, safety, and well-being [19] and even in the industrial revolution era [20]. In healthcare, ergonomics plays a critical role in ensuring patient safety and staff productivity by minimizing physical strain and optimizing functionality. Kansei Engineering (KE), on the other hand, addresses the emotional aspects of human needs. It involves capturing customer emotions and translating them into engineering characteristics for product and service design. KE's process begins with defining emotional needs and incorporating them into design elements to ensure that the final product or service resonates with users on both functional and emotional levels.

Inherently, Kansei Engineering (KE) and Human Factors Engineering (HFE) in healthcare design have the potential to offer a comprehensive approach addressing both emotional and functional patient needs. To balance both principles (i.e., KE and HFE) without one overshadowing the other, the researchers and designers are highly required to apply a more structured, human or patient-centric approach considering both emotional well-being and usability. There are some strategies to be implemented. First, it is urged to ensure that HFE tackles safety and usability issues, while KE addresses emotional satisfaction through psychological factors. For instance, in a case of healthcare bed redesign, HFE arranges bed height control and intuitive buttons that improve patient physical comfort, whereas calming and more-natural colour schemes for

surroundings will enhance emotional well-being. Second, we can apply multi-sensory design concepts. It refers to the sensitivity of human senses. The main sensory channels (i.e., visual, auditory, and tactile cues) will reinforce emotional experience while ensuring usability. For instance, the beds designed with clear color-coded controls, symbols, and smooth touch surfaces will improve both emotional and functional involvement.

In healthcare settings, patient preferences vary widely. For example, some patients prefer shared wards to reduce feelings of isolation, while others desire single rooms for greater privacy. This highlights the importance of offering flexible design solutions that cater to diverse patient needs and align with the principles of patient-centered care [21]. Douglas & Douglas [11] emphasize that hospital design should prioritize privacy, accessibility, and social interaction to support patient well-being. These findings are highly relevant for healthcare planners and designers tasked with creating or refurbishing hospital facilities.

As a customer-centric approach, KE focuses on understanding and integrating emotional requirements into the design process. In healthcare, this is particularly significant, as patient emotional needs, such as comfort, privacy, and security, play a vital role in recovery. KE ensures that both functional and emotional needs are addressed, whether in physical products or in intangible service systems.

Nudge Theory (NT) in Healthcare

Form and function are two essential components of any product. The product's function refers to its intended use, while its form is the designer's visual interpretation. Though function and form are inextricably linked, much research focuses on function and how it influences people's actions and choices, particularly when faced with various forms. This highlights the relevance of nudge theory in influencing behavior through subtle interventions.

Nudging, a concept from behavioral economics, involves modest interventions designed to influence behavior without restricting choices or significantly altering economic incentives. Since its introduction by Thaler & Sunstein in Fisher [22], nudging has gained traction across various sectors, including healthcare, where it encourages both patients and healthcare professionals to make better decisions. Nudging's non-intrusive approach makes it particularly effective in healthcare, where it has been successfully used to combat antibiotic overuse, promote hand hygiene, and increase immunization rates among healthcare workers. However, as Sant'Anna *et al.* [23] point out, the context and specific techniques used in nudging often determine its effectiveness.

Though research on nudging healthcare professionals is still developing, early studies indicate that certain nudging tactics can have a significant impact on patient-healthcare professional behavior. Sant'Anna *et al.* [23] identified potential nudging strategies for influencing clinical behaviors, including accountable justification, goal setting, feedback, peer comparison, and active choice, among others. The study suggests that passive nudges such as defaults and environmental cues may yield desirable outcomes, whereas active nudges, which involve doctors in the decision-making process, are more effective for fostering long-term behavioral changes.

However, the use of nudging in healthcare raises ethical concerns. Passive nudging tactics, which may go unnoticed by healthcare professionals, can alter behavior without their awareness, leading to potential ethical dilemmas. In contrast, active nudges, which require conscious decision-making, are seen as more transparent and ethically sound. Nwafor *et al.* [24] argues that despite these concerns, nudging remains a cost-effective method for improving adherence to healthcare guidelines.

Several case studies highlight the varying success of nudging tactics. For example, interventions aimed at improving antibiotic prescribing practices, such as peer comparison and accountable justification, have shown positive results. Similarly, nudging strategies like environmental cueing and priming have been found to enhance hygiene compliance among healthcare professionals [21]. Nevertheless, not all nudges are equally effective. Nudges' success often depends on how well they are integrated into the existing workflow and the specific context in which they are applied.

There are several potential ethical considerations in the context of using Nudge Theory (NT) in healthcare related to patient autonomy. One of the most prominent concerns is how nudges influence patient decision-making without impeding their freedom of choice. First, NT promotes subtle interventions to let patients do

their desirable behaviors, e.g., adjusting the height of the hospital bed for comfort. It is, however, potentially violating their autonomy when they are not fully aware of this nudge-based feature. Therefore, we ensure that patients feel empowered to make decisions that enhance their well-being. Second, the aim is to verify the transparency of nudge-based features. That is a big challenge. For instance, patients may feel manipulated if bed-adjusting features gently direct them without their knowledge and awareness. Thus, it is to ensure that patients are well informed about the nudge-based features attached in the existing product or system. This is to maintain transparency while respecting their consent. Therefore, by giving patients clear options and justifications for those options, the objective should be to empower them rather than to restrict their behavior.

Healthcare-related Product Design

Successful product design requires designers to adapt to the existing needs, conditions, and preferences of the users [25]. To effectively address design challenges, it is essential to integrate perspectives from various disciplines. Design principles such as human-centered design, gestalt theory, and product semantics provide a foundation for combining Kansei Engineering (KE) and Nudge Theory (NT) to create innovative solutions to complex problems.

NT in product design emphasizes subtle, simple, and cost-effective interventions that gradually influence human behavior. Its focus on accessibility and minimal disruption makes it a powerful tool for creating products that can instigate long-term behavioral change. In line with this, product semantics, as described by Demirbilek & Sener [26], involves integrating various disciplines such as art, ergonomics, semiotics, communication, logic, philosophy, and psychology to ensure that a product conveys its purpose and function effectively.

In the context of product design, there are two key approaches that shape the perception of value: (1) Form-based design is to prioritize aesthetic appeal and falls under the hedonic classification, where users derive pleasure from the product's appearance and feel. (2) Function-based design is to focus on practicality and usability, aligning with the utilitarian perspective, where the product's effectiveness in fulfilling its intended purpose takes precedence [27; 28].

When designing healthcare-related products, the emphasis should primarily be on the utilitarian aspects to ensure that the product effectively serves its practical purposes, such as improving patient care or assisting healthcare professionals. However, integrating form as a supportive element can enhance usability, making the product more functional, user-friendly, and aesthetically pleasing. This combination increases accessibility and encourages long-term user adoption, ensuring that the product remains effective over time.

There are some relevant case studies and implementations of KE and NDT in healthcare services as follows. First, a study by Drayi [12] identified patient comfort and healthcare quality due to bed shortages. The inability for patients to adjust beds independently and inadequate bedding have been reported as the main problems. Using Kansei Engineering (KE), hospital beds with hand control buttons have been proposed. It would have been promoting patient comfort and independence and reducing infection risks. Second, the use of Nudge-based Design Thinking (NDT) for patient experience. To assist patients using beds and relevant services more effectively, visual cues and reminders are proposed. In addition, a study has been done to nudge patients towards healthier and more secure behaviors by implementing real-time feedback and user-friendly controls. For instance, it is to adjust the optimal position for patient beds in achieving comfort. Third, it is about to apply KE in hospital service design. An applicative framework by Hartono [8] that integrates KE, Kano model, and the Theory of Inventive Problem Solving (TRIZ) can capture the patient's Kansei. In this study, KE has been utilized to improve accessibility, comfort, and privacy for patients. Fourth, the KEN-DT (Kansei Engineering and Nudge-based Design Thinking) approach is proposed to be a comprehensive method to improve patient bed usability and Kansei. Intuitive bed controls, features, and human sensory design elements are integrated to enhance patient well-being and also nudge them towards autonomy.

Design Thinking in Healthcare

Healthcare has shifted from focusing solely on treating diseases to enhancing quality and safety by better understanding patients' preferences, needs, and values [29]. This shift emphasizes the importance of including patients in innovative development and decision-making processes. By adopting a patient-centered approach, Design Thinking (DT) becomes an effective tool for addressing healthcare challenges by incorporating user

needs and feedback throughout the development process [30]. This aligns with the perspective that patients' needs and experiences are essential drivers of innovation [31]. DT humanizes patient care by prioritizing patient experience and encouraging continuous improvement in services, which can enhance patient satisfaction and loyalty [32].

In the rapidly evolving healthcare sector, innovation is essential to maintain viability, much like other industries [34]. The modernization and enhancement of healthcare services heavily depend on the integration of human-centered design (HCD), particularly user experience design and design thinking. Case studies such as General Electric Healthcare and the Mayo Clinic's Center for Innovation exemplify the successful application of DT in healthcare, showcasing its potential to foster more adaptable and creative healthcare systems [33]. These examples demonstrate how user experience and design thinking can enhance the adaptability of healthcare systems, allowing them to better respond to changing needs.

Human-centered design is central to user experience theories in healthcare. Defined by ISO 9241-210, HCD is an approach that focuses on making systems more usable by considering human aspects and usability knowledge. Understanding the user's wants and experiences is crucial when developing solutions that meet the demands of patients and other stakeholders. The increased adoption of these methods offers clear opportunities for improved patient outcomes and more effective service delivery.

HCD provides a practical framework for tackling complex healthcare challenges by involving end users throughout the development process. According to Levander *et al.* [34], key components of HCD include early and continuous engagement of users, creativity, and iterative prototyping. By involving patients and healthcare providers at every stage (i.e., from initial design to testing), diverse perspectives are considered, ensuring the final product effectively addresses real-world problems. This approach also promotes creativity, allowing for broad exploration of potential solutions without immediate constraints. The iterative nature of HCD, which refines ideas based on user feedback and real-world testing, ensures solutions resonate with users and enhance their experience. This user-centered approach aligns with the broader goals of design thinking in healthcare, aiming to improve patient care, satisfaction, and overall service effectiveness by incorporating user perspectives into the heart of innovation.

Gestalt Theory

Gestalt theory plays a crucial role in patient bed design by guiding the creation of visually appealing and user-friendly products. Its core principles (i.e., proximity, similarity, closure, continuity, and symmetry) help designers organize elements in a way that is intuitive for users to interpret and interact with [35]. By applying these principles, designers can enhance the intuitiveness of patient beds, ensuring that controls and features are logically grouped and feel natural to use. This not only improves the usability of the beds but also makes the design more accessible for users, including patients and healthcare providers.

Lugo *et al.* [36] developed a method to objectively evaluate the application of Gestalt principles in two-dimensional product designs, providing designers with a tool to assess the visual coherence of their work during the design process. This approach allows designers to refine the aesthetics and functionality of their designs as they progress.

Moreover, Gestalt principles also aid in the understanding of complex design concepts by encouraging holistic thinking, which is particularly beneficial in healthcare product design [37]. In the context of patient bed design, this holistic approach helps create products that not only stand out from competitors but also provide seamless and cohesive user experience. Gestalt theory offers valuable insights for developing patient beds that are both functional and visually cohesive, ensuring that the design is simple to understand and interact with while also being aesthetically pleasing.

Product Semantic

Product semantics is a design approach that encodes meaning into products, allowing them to communicate with users through visual elements [38]. The goal is to enhance usability, likability, and efficiency in how users interact with products by utilizing visual cues such as styles, colors, shapes, functions, and textures to convey important product information [39]. In the context of patient beds, product semantics plays a critical role in ensuring that patients and healthcare providers can easily understand and operate the bed's functions.

For instance, visual elements like symbols or color-coded buttons can clearly indicate adjustments for bed height, tilt, or other features, making the product more intuitive to use in a hospital setting.

To ensure that the visual elements are effective, product semantics techniques, such as defining semantic needs and evaluating prototypes, are particularly useful to patient bed design. These techniques help designers assess the clarity of the bed's visual elements and identify areas for improvement [40]. Researchers have even used multidimensional scaling to explore how users perceive and interpret different aspects of product design, providing insights into how a product's form and function are understood. For patient beds, applying these principles ensures that users can easily grasp the intended use of the bed's features, reducing confusion and the risk of errors.

In healthcare environments, where clear communication of a product's function is essential, product semantics enhances both functionality and user satisfaction. By ensuring that patient beds visually convey their purpose and operation effectively, product semantics contributes to improved patient care and helps streamline hospital workflows [38; 39]. In high-stress and urgent situations, product semantics may bridge the communication gap between healthcare staff and patients. Product semantics proposes the functionality of hospital equipment by clear and usable visual elements that can help bridge communication gaps. Equipment should be enhanced by recognizable and understandable symbols, icons, and color codes. For example, arrows with color coding for raising or lowering the patient bed will help staff and patients understand promptly how to operate the beds without confusion even in emergency situations. Another example is that by applying contrasting colors for handrails that are against the bed surface, it ensures patients can find them, especially in an urgent situation.

Research Methodology

The process starts with a mind map and research framework, then moves into a two-stage analysis of an existing service, including the patient's bed.

Mindmap and Research Framework

The Kansei-Nudge redesign framework for patient beds is centered around the people involved throughout the process. The framework employs Kansei Engineering (KE), Nudge Theory (NT), and Design Thinking (DT) methodologies (i.e., KEN-DT) to analyze existing conditions and define problems. It is divided into two key stages:

1. Existing condition analysis and adjustment
2. Proposed improvement strategies, implementation, and feedback

The previous conceptual framework of Kansei Engineering (KE) in healthcare has primarily focused on capturing and accommodating the emotional needs (known as Kansei) of patients by translating those needs into tangible design elements, service attributes, or physical features. However, Nudge Theory (NT) has been utilized to change patient behavior, frequently promoting healthier choices through smooth interventions (e.g., encouraging patients to practice hand cleanliness, providing hand sanitizer in front of the patient's ward to let guests or healthcare staff clean their hands before meeting the patients).

Hence, in this study, the proposed approach integrates both these methods, aiming to address emotional needs or Kansei (through KE) while simultaneously nudging behavior (via NT) to promote healthier and more independent patient actions, such as bed adjustments for comfort and pressure relief. This dual focus on Kansei and behavior makes the approach unique and accommodates both affective and cognitive human processes compared to earlier single-focus applications of KE or NT.

In Stage 1, the focus is on analyzing the customer's needs, wants, and opportunities, followed by defining the problems using Kansei-based spanning and product attribute spanning. This involves exploring the emotional needs of the users, refining the Kansei data, and evaluating the product based on these emotions. In addition, the preliminary study identified the patient bed as a critical component of the hospital experience, necessitating validation of the current bed design through this study. In Stage 2, the process shifts to ideation, prototyping, and testing to identify improvement strategies and refining engineering specifications based on critical product attributes. Methods such as brainstorming, TIPS/TRIZ (Theory of Inventive Problem Solving/*Teoriya Resheniya Izobretatelskikh Zadatch*), and sustainable development principles are used to

generate ideas. A physical prototype is then created and tested to validate conceptual improvements. Feedback is gathered from potential users to develop a KE model, which incorporates nudge-based systems aimed at improving non-critical patient care in hospitals. This model is integrated with key features of current services and products, including modified and adjusted patient beds.

The framework emphasizes a user-centered approach, ensuring that products or services are systematically improved based on user needs (Kansei), sustainability, and iterative testing (see Figure 1). It provides a structured and practical methodology for design teams aiming to enhance product attributes by focusing on user experience and sustainability goals.

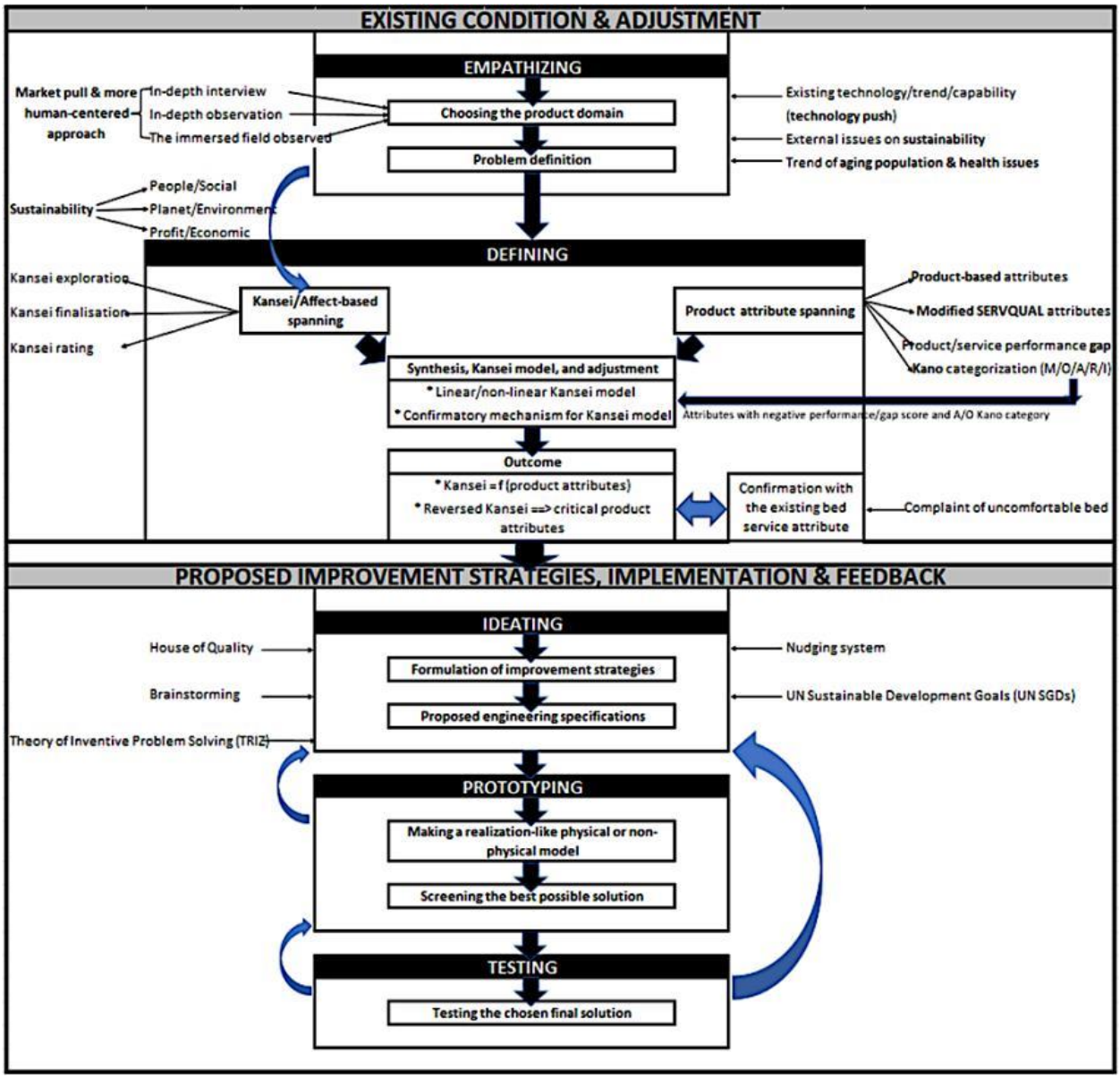

Figure 1. Integrated framework of Kansei-nudge redesign for healthcare services

Data Collection Strategy

This study applied purposive sampling for semi-structured interviews and observations. The observations were designed to capture real-time, unobtrusive insights into patient behavior, their interactions with the hospital bed, and their overall user experience within a natural hospital environment. This method targets patients who have been hospitalized within the last six months, ensuring they have recent and relevant experiences with the healthcare environment. Patients with diverse conditions and experiences were selected. Also, we provided a set of common patient beds apart from the healthcare place for exploration purposes. If

they were agreeable, the data collection was conducted. Otherwise, we cancelled it. This is to ensure privacy and ethical consideration. To adjust unobtrusive observations, we collected the data in a natural setting. It is to allow researchers to minimize interference while collecting real-time data. Thus, the data collection focused on emotional signals and expressions, physical interactions, and the frequency of bed adjustments.

To complement the observational data, we conducted semi-structured interviews with patients. These interviews were aimed at collecting subjective data regarding their emotional responses, preferences, and overall experience with the hospital bed. We applied semi-structured interviews to collect detailed and patient's subjective data related to patients' emotional responses (Kansei) due to their interactions and experiences with healthcare services and hospital beds. The interviews were supposed to explore key components, including comfort related to bed designs and features, ease of use of bed controls and adjustability, and overall emotional feedback on the healthcare service quality. The patients have been exposed to some queries in open-ended question format addressing feedback on their experiences with healthcare services, environments, and equipment interactions. More specifically, questions related to the emotional impressions (Kansei) of patients during their dependence on healthcare staff and bed adjustments were included in the interviews.

By combining the direct insights from the interviews with the structured observation checklist, we were able to gain a deeper understanding of how patients interacted with the beds, how often they needed adjustments, and their reliance on staff assistance.

Results and Discussions

As outlined in the previous chapter, this research is divided into two primary stages, called stage 1 and stage 2. Stage 1 focuses on understanding the existing conditions and making necessary adjustments. This involves a) conducting a survey on customer experience through both observation and interviews; and b) gathering Kansei words (i.e., emotional descriptions) from patient feedback obtained during interviews. Stage 2 centers on developing and testing design solutions based on the insights gained from stage one. This stage includes a) analyzing the interaction process in bed design; b) ideating around the form and function of the bed; c) creating prototypes and conducting tests; and d) collecting feedback for iterative refinement to ensure the final design meets patient needs and expectations.

Stage 1

It covers the customers' experience survey, empathy map, and Kansei words.

Customers Experience Survey

Through semi-structured interviews with 20 patients (i.e., those who have been hospitalized in the last 2 years; see Table 1 for the profile of subjects). This has been done using purposive sampling. It resulted in detailed feedback on the service quality at hospital X (anonymous), focusing on both specific incidents and general patient experiences.

Table 1. Profile of subjects interviewed

No	Demographic Factor	Results
1	Age	Minimum = 20; Maximum = 74; Average = 49.65
2	Gender	Male = 11 (55%); Female = 9 (45%)
3	Education	High school = 7 (35%); Bachelor = 6 (30%); Master = 7 (35%)
4	Marital status	Single = 7 (35%); Married = 13 (65%)
5	Patient condition	Diabetes = 3 (15%); Hypertension = 3 (15%); Heart-disease = 4 (20%); Asthma = 5 (25%); Others = 5 (25%)
6	Occupation	Employed = 11 (55%); Unemployed = 2 (10%); Retired = 3 (15%); Student = 4 (20%)

The average age of the participants is 49.65 years, with a range from 24 to 74 years old. The wide range indicates a diverse group in terms of age, which could be useful for understanding how different age groups interact with various healthcare systems or conditions. The gender distribution is balanced, with 11 males and 9 females. This relatively equal distribution allows for gender-based comparisons in terms of healthcare access, conditions, or responses to treatment. The education background shows a balance, with 7 having high school, 6 having bachelor's degrees, and 7 having master's degrees. The data indicates a broad mix of patient

conditions, including diabetes (3 subjects), hypertension (3 subjects), heart disease (4 subjects), asthma (5 subjects), and others (5 subjects). This diversity allows for the study of a range of health conditions and their implications on quality of life and treatment outcomes. The data set shows a range of occupational statuses, with the most common being employed (11 subjects).

Through the semi-structured interview and observation, we collected the general negative feedback as a basis for identifying areas of improvement, which is detailed in Table 2. We collected three types of data:
Emotional cues
We observed signs of frustration, discomfort, or ease in relation to quality service and bed usage, noting how patients emotionally responded to the experience. We investigated the emotional experience of patients due to healthcare quality services.

Integration with the hospital environment
We evaluated how the bed functioned within the overall hospital setting, including its proximity to other equipment and the ease of mobility within the space.

Behavioral patterns
It included how frequently and in what manner patients adjusted their beds, their physical interactions with the controls, and any difficulties they encountered while using the bed's features.

Table 2. List of negative feedback of healthcare services

No	Item	Description
1	The Intensive Care Unit (ICU) visitor area had no or limited air conditioning.	The patient notes that the intentional non-turning on of the air conditioning in the ICU visitor area causes discomfort for visitors. This suggests neglect of visitors' comfort and contributes to a negative experience.
2	Communication and information were lacking.	The patient highlights the lack of a security and information desk near the ICU, leading to difficulties for families in getting updates about patients. People perceive this as uninformative and unfriendly, which exacerbates feelings of neglect and frustration.
3	The nursing care was not attentive.	The patient criticizes the nursing staff for not being attentive enough, particularly in ensuring that patients are properly covered and clean. This neglect in care further exacerbates the negative experience.
4	Delays and inaccurate information	The patient expresses frustration with delays and misinformation, particularly regarding the availability and punctuality of doctors. In certain instances, the staff has provided inaccurate information. Ineffective communication significantly contributes to the negative sentiment.
5	Pharmacy delays	There are also complaints about the inefficiency in the pharmacy, where prescriptions were delayed for hours, adding to the overall dissatisfaction.
6	Unprofessional behavior of staff	The patient mentions rude and unprofessional behavior from the nursing staff, which left a strong negative impression.
7	Uncoordinated discharge process	Poor management of the discharge process leaves the patient's family to handle tasks that the hospital staff should handle, like fetching a wheelchair.

The sentiment expressed in the list above is predominantly filled with numerous complaints about service quality, communication breakdowns, and a lack of professionalism from the hospital staff. A major point of criticism revolves around the discomfort caused by poor facilities, such as non-functioning air conditioning, as well as the lack of attention to the needs of both patients and their families. These issues had a significant impact on the overall experience at Hospital X. The feedback strongly indicates that the hospital must implement substantial improvements in both service delivery and staff training to address these concerns effectively.

Empathy Map

Afterwards, we do a mapping from what (major statement) has been raised by all respondents, respecting what they say, think, feel, and do as follows:
1. Says:
   "The ICU visitor area intentionally lacks air conditioning, resulting in extreme heat."
   "There should be a security and information desk near the ICU."
   "The staff is unfriendly and uninformative."
   "I waited for hours, only to find out the doctor was late due to irrelevant reasons."

"The bed is difficult to adjust, and there's no guidance on how to use its features."
"Communication is poor, and the staff does not listen to patient concerns."
"The pharmacy is slow in processing prescriptions."
"I had to manage tasks like fetching a wheelchair on my own."

2. Thinks:
"Do they care about the comfort and well-being of visitors and patients?"
"Why is communication lacking here? I feel ignored and unimportant."
"Why isn't there better support and guidance for using the bed?"
"Is this level of service available because I'm using BPJS (Social Security Agency on Health)?"
"Why can't they be more professional and attentive to our needs?"
"I'm worried about the quality of care my family member is receiving."

3. Feels:
Frustrated: Due to long wait times, lack of clear communication, and having to manage on their own.
Neglected: The patient's perception that the hospital staff is not responding to their concerns.
Anxious: People are concerned about their family members' well-being because they perceive poor care.
Disappointed: Patients are disappointed because of the overall service and care received at the hospital.
Overwhelmed: The burden of managing tasks has overwhelmed the hospital staff.

4. Does:
Complaints to staff about the lack of air conditioning and poor service.
Waits for hours to see the doctor, only to be disappointed by delays and excuses.
Struggles with the hospital bed and feels dependent on nurses for basic adjustments.
Expresses frustration about the service quality and communication in the review.
Handles tasks independently, such as fetching a wheelchair, due to lack of assistance.

The key findings were as follows:
Comfort and communication are key. The patient values comfort and clear communication, which were both lacking in their experience.
Attention to the details matters. The patient noticed and was frustrated by the lack of attention to both small (air conditioning) and large (timely care) details, as well as the mechanism of bed adjustment and use.
Professionalism is required. The patient expects a higher level of professionalism and responsiveness from the hospital staff.

Regarding the previous identification of visualization of patients (in terms of what they think, feel, say, and do), there are some actions to be considered:
To enhance staff communication and responsiveness to keep patients and their families informed and feeling heard.
To maintain basic amenities like air conditioning in visitor areas to create a better environment.
To address delays and ensure that doctors and nurses are punctual and available as scheduled.
To provide clear guidance and user-friendly adjustments for hospital beds to reduce patient dependence on staff for basic needs.
To offer additional training for staff to enhance professionalism and empathy towards patients and their families.

All of these discussed above are wrapped in an illustrative empathy map, shown in Figure 2. It is to show the situation of patient concerns visually.

Based on the key findings, we conducted a short survey (i.e., by counting the numbers) with those previous 20 patients to identify which areas should be prioritized for improvement. The survey results are as follows:
1. Clear and comfortable communication between patients and nurses (6 respondents)
2. Bed adjustment and usage mechanism (10 respondents)
3. Responsive and responsible hospital staff (4 respondents)

As a result, the hospital has identified the bed adjustment and usage mechanism as the top priority for improving service quality. Thus, it was related to the opportunity to redesign the patient's bed.

Figure 2. Empathy map of hospital services (*AI-based generated object, using DALL-E*)

Kansei Words

As Kansei is a function of perceived service quality [5], we explored the Kansei words due to healthcare service perception, including the quality of healthcare physical facilities. This study used Kansei words to determine the emotional needs of the patients. Those Kansei words were collected through observations, semi-structured interviews, and empathy maps. They reflect the patient's emotional response and impression during their experience with healthcare services. Through the technique of semi-structured interviews, the subjective insights of patients were gathered. These interviews addressed specific incidents of frustration and discomfort, allowing designers to explore and extract detailed emotional feedback. To complement the interview results, observations took place. Through unobtrusive observations, researchers capture how patients experience healthcare equipment. For instance, we observed the frequency of patients requiring assistance in adjusting beds. It reflects the patient's emotional need for autonomy. We finalized the Kansei words "uncomfortable," "frustrated," or "neglected" were deemed to be critical when patients interact with their beds. All the finalized selected Kansei words were considered as "What" and then linked to design elements or features set as "How." For example, "frustrated" can be translated into a metric "simpler control system or clearer instructions," on the patient's bed. In addition, by adding intuitive visual indicators for bed adjustment is expected to fulfill the need for "uncomfortable".

There were 3 types of Kansei words collected (i.e., positive Kansei words, negative Kansei words, and neutral Kansei words). As mentioned above, the data collection was conducted through observation and semi-structured interviews and provided in scripts with no videotaping or recording. It was done due to privacy and sensitive reasons. Due to limited data, the sentiment analysis for Kansei words taken from patient's feedback was conducted manually (as seen in Table 2 and Table 3) which might have similar results with qualitative data analysis using sentiment trends through a statistical tool. However, it is highly taken note of for future study. For future research/study, it is highly advised to conduct more sophisticated and complex analysis using statistical analysis and incorporate quantitative data.

These Kansei words reflect the patient's emotional experience to enhance service design, communication, and hospital operations. The strong prevalence of negative Kansei words indicates key areas where the hospital can improve its emotional impact on patients, such as better communication, quicker response times, more

professional staff behavior, and more comfortable use of bed and its features. In other words, the Kansei words "well-informed," "responsive," "professional" when referring to interactive-based staff, and "comfortable" when referring to physical beds hold significant importance. This synthesis highlights the emotional responses of patients, ranging from satisfaction in areas like cleanliness and helpfulness to significant frustrations regarding service inefficiencies, unprofessional behavior, and feelings of neglect.

Table 3. Collection of Kansei words

Positive Kansei Words	Negative Kansei Words	Neutral Kansei Words
Clean. The patient expressed gratitude for the cleanliness of certain areas or aspects of the hospital. Helpful, friendly. It refers to the security staff who were helpful and friendly.	Uncomfortable. This refers to physical discomfort caused by factors such as room temperature (the absence of air conditioning in the ICU), bed adjustments, and mechanisms. Frustrated. The patient feels frustrated due to long wait times and misinformation, including an understanding of how to use the bed and its overall features. Slow. It refers to slow responses, particularly in relation to pharmacy services and doctor availability. Unfriendly. People describe the hospital staff's attitude as unfriendly. Unprofessional. It is accusations of unprofessionalism or a lack of proper service behavior and lack of clear instructions for using the physical facility. Neglected. It is a feeling of neglect by the hospital staff in terms of patient care and inadequate attention to the comfort of physical facilities. Misinformed. It reflects dissatisfaction with unclear or misleading communication from hospital staff. Inefficient. It refers to slow or inefficient service, especially when it comes to managing prescriptions and patient requests. Overwhelmed. It reflects the feelings of both the patient and perhaps overworked staff. Incompetent. It is a complaint about the lack of skills and professionalism in handling tasks, particularly nurses.	Available. It refers to the availability of specific services, but the context frequently conveys dissatisfaction with the timing.

Stage 2

Nudge-based Design with Kansei

Thaler & Sunstein [22] popularized the concept of nudging, which involves subtly guiding users toward desirable outcomes by making small adjustments to how choices are presented. In product and interaction design, nudge-based design leverages insights from human behavior to create environments or products that naturally steer users toward making better decisions. Lee and Chu [41] expanded the application of nudge theory to the design field, specifically in retail space branding, by identifying and categorizing nudge design strategies. Their study demonstrated how sensory, cognitive, physical, and social experiences can be strategically designed to influence customer behavior in retail environments. Importantly, their work highlights that nudge-based design is not only about influencing immediate decisions but also about enhancing the overall user experience in a way that aligns with both user needs and organizational goals. This means that design can shape how people interact with products [42].

While both nudge-based design and KE aim to influence human behavior and experience through thoughtful design, they operate on slightly different levels. Nudge-based design is rooted in behavioral economics and

psychology, focusing on influencing decision-making, whereas KE is a customer-centric design methodology that integrates consumers' emotional responses into product design [4; 22]. Combining these two approaches, through a nudge-based Kansei redesign framework, can translate users' emotional needs into design elements while also encouraging positive behavior, making the product more intuitive and user-friendly.

In the previous subchapter, we identified several Kansei words that directly relate to patients' experiences with hospital beds, which is the bed adjustment and its usage mechanism as the top priority for service quality improvement. Negative Kansei words such as "uncomfortable," "frustrated," and "neglected" reflect the physical and emotional challenges patients face when interacting with the bed. Using these words as a basis, we proposed and mapped out several nudge-based design ideas to address these challenges using a concept of need and metric in the House of Quality [43]:

Table 4. Need and metric for nudge-based design features

Selected Negative Kansei Words (Need)	Description	Proposed Nudge-Based Design Features (Metric)
Uncomfortable	Physical discomfort because of the bed adjustment mechanism.	The controls are designed to be easily accessible and ergonomic. Visual indicators for desired configurations, such as slight elevation, can further enhance usability and ensure proper adjustments.
Frustrated	The complexity of the bed controls and the lack of clear instructions are causing frustration.	Universally recognized symbols should be used for better understanding and ease of use. Additionally, incorporating feedback mechanisms like vibration or light signals can improve usability by confirming adjustments. It is also important for the nurse to provide a tutorial when the patient first uses the bed, ensuring proper understanding of its features.
Neglected	Feeling neglected because of inadequate attention to comfort and ease of use.	Visual cues for usage. It is to incorporate subtle nudging by adding clear visual cues on the bed controls or instructions in patient rooms that encourage patients to adjust their beds independently. Ease of use reminder. It is to use reminder messages (e.g., you can use simple voice control to adjust your bed when you feel uncomfortable) to nudge patients towards utilizing the comfort features.

Key concerns such as "uncomfortable," "frustrated," and "neglected" indicate that the current hospital bed design fails to meet patients' needs. To inform the redesign process, the next section will explore how patients interact with hospital beds and outline their expectations for improved functionality and comfort.

Bed Redesign

Figure 3. Illustration of bed experiment and semi-structured interview

We did a deep exploration of how the subjects experienced with the existing bed during their stay in a hospital in the last year (between years 2023 and 2024). There were 2 subjects involved. They were 2 out of 20 subjects involved in Stage 1. An experiment of using bed accompanied by a semi-structured interview and observation was conducted (see Figure 3 as an illustration). It includes the interaction process on the existing hospital bed, form and function, and ideation.

Interaction Process on the Existing Hospital Bed

It includes interviews with patients and explores the interaction process between patients and the existing bed design. Table 5 presents the systematically organized findings from the interviews.

Table 5. The interaction process between patients and the existing bed

Participant	Existing Bed Interaction Process	The Expected Interaction Process
A	It is difficult to be independent and require assistance.	Bed controls need to have clear labels.
	The side rails are difficult to reach.	Without assistance, the patient should be able to easily reach and adjust the side rails.
	It feels empty, uncomfortable, and unsafe.	Bed should provide a sense of security and comfort.
	Raising the backrest and footrest together causes fear of falling, particularly when returning to a flat position.	The bed should provide a smooth and controlled adjustment of the backrest and footrest.
B	It refers to adjustability issues. The subject is having difficulty adjusting the bed position so that it can cause discomfort.	Better bed design, with more intuitive controls and easier adjustability, can empower patients to reposition themselves.
	Mechanical failures can sometimes lead to uneasiness.	Reduce the risk of falls or injuries, especially for vulnerable or elderly patients.
	The difficulty in reaching is caused by the restriction of movement due to the intravenous line in the hand.	The bedside equipment features more intuitive and easily reachable controls.

Table 5 shows the interaction between patients and existing hospital beds, highlights the challenges patients face, and suggests improvements. The problems that participants A and B had are typical of ergonomic hospital beds. For example, using the bed on your own can be difficult, and it can be uncomfortable when the controls do not work correctly or are in the wrong place. These issues suggest a need for improved ergonomics through better labelling, intuitive control placements, and safer bed designs. The feelings of insecurity and discomfort reported by Participant A also indicate a gap in meeting emotional needs, which could be addressed by refining the bed's design. These issues can be resolved by subtly influencing users' behavior through design. By making desirable actions like adjusting the bed easier and safer, the design can also "nudge" patients toward increased self-sufficiency and comfort. The subchapter 'Form and Function' is the implementation of the expected interaction process.

Form and Function

The redesigned bed should adhere to several aspects of form and function to balance its visual and physical design. The design should incorporate key aspects and features based on previous interactions with patients.

Table 6. Proposed function and form of bed redesign

Key Aspect	Function	Form (Gestalt & Product Semantics)
Movement and Adjustability	Incorporate features that allow smooth and intuitive adjustment of the bed's height, backrest, and footrest. This will allow patients to quickly reposition themselves and enhance their comfort and independence.	Proximity. It is to place controls close to each other and in relation to each other. Product semantics. The visual cues should be clear (arrow icons for up and down, reclining figures for backrest adjustments). Colour coding can be used to differentiate functions.
Ergonomics (less physical strain and stress)	Ensuring that controls, side rails, and adjustments are positioned for convenient access, reducing physical strain on both patients, caregivers, and healthcare staff.	Figure-ground relationship. It is to ensure that controls, grips, and adjustment handles are visually distinct from the surrounding areas, utilizing contrast in colour, material, or texture to guide the patient's interaction with the bed.

Key Aspect	Function	Form (Gestalt & Product Semantics)
		Product Semantics. It is to use clear, easily understandable symbols (such as icons or arrows) to denote the functions of different controls. For instance, reclining figures for backrest adjustments and leg icons for footrest controls make the purpose of each element self-evident.
Safety features	Integrate safety elements such as secure side rails, anti-slip surfaces, and reliable locking mechanisms. These features should minimize the risk of falls and injuries, ensuring patient safety during various bed functions.	Figure-ground relationship. It is to propose the grip area stands out against the background of the bed (colour and material). Proximity. It is to provide an adjustment control for side rails located close to where the patient naturally places their hands. Product semantics. The side rails are designed with handles or grips with contrasting textures or materials or with different colours.
Accessibility and support	Ensure the bed provides adequate support for patients with varying mobility levels. This includes easy-to-reach controls and supports that assist with getting in and out of bed, as well as enhancing in-bed mobility.	Proximity. It is to keep handrails and support handles within close reach to ensure that patients with varying mobility levels can safely transition in and out of the bed. Adjustment controls should be placed near natural hand positions for ease of access. Figure-ground relationship. It is to ensure that areas intended for gripping, such as side rails, are distinct from the rest of the bed by using contrasting colours or textures. This differentiation helps patients locate supportive features quickly. Product semantics. It is to employ contrasting materials and intuitive designs for handles and grips, ensuring they are easy to identify. Colour coding can help differentiate between safety features (like locking mechanisms) and adjustable components.
Patient comfort	Focus on providing a comfortable experience by incorporating supportive cushioning, adjustable components that meet individual needs, and features that enhance overall patient comfort. This includes addressing issues such as pressure relief and comfort during prolonged periods in bed.	Proximity. It is to ensure adjustable components, like controls for cushioning firmness or angle, are close to where the patient lies to allow easy, immediate adjustments without requiring help. Figure-ground relationship. It is to use contrasting colours and materials to make the adjustable areas of the bed, such as cushioning zones or pressure relief areas, easily distinguishable from non-adjustable components, guiding the patient's experience. Product semantics. It is to provide visual cues, like reclining figures or cushion icons that clearly indicate areas for comfort adjustments, ensuring that the patient intuitively understands how to enhance their comfort.

Ideation and Paper Prototyping

Regarding the ergonomic considerations for healthcare bed redesigns, there are several design standards and research that can justify the recommendations. For instance, according to [19], there is a set of foundational guidelines for furniture designs that promotes comfort and could be applied to healthcare beds. In addition, KE addresses the integration of emotional needs (Kansei) and related ergonomic aspects into the design

process to obtain user usability and emotional satisfaction. Hignett *et al.* [2] also highlight the importance of human factors engineering in improving safety for both healthcare staff and patients, especially in bed adjustment settings. In addition, Kim *et al.* [44] urge the concept of proximity and figure-ground relationships taken from product semantics that create bed controls more visual and physically intuitive for patients.

In the design process, the ideation phase plays a crucial role in addressing both functional needs and the overall patient journey. By understanding how patients interact with their environment, particularly their hospital beds, we can develop solutions that enhance comfort, usability, and safety. The patient journey, from admission to discharge, involves multiple touchpoints with the bed, from lying down for rest, adjusting positions for comfort, to using controls for mobility support. With these insights in mind, the ideation process focuses on improving these interactions. The illustration of the existing patient bed and its ideation process in preparing a prototype paper are available in Figure 4, Figure 5, and Table 7 consecutively.

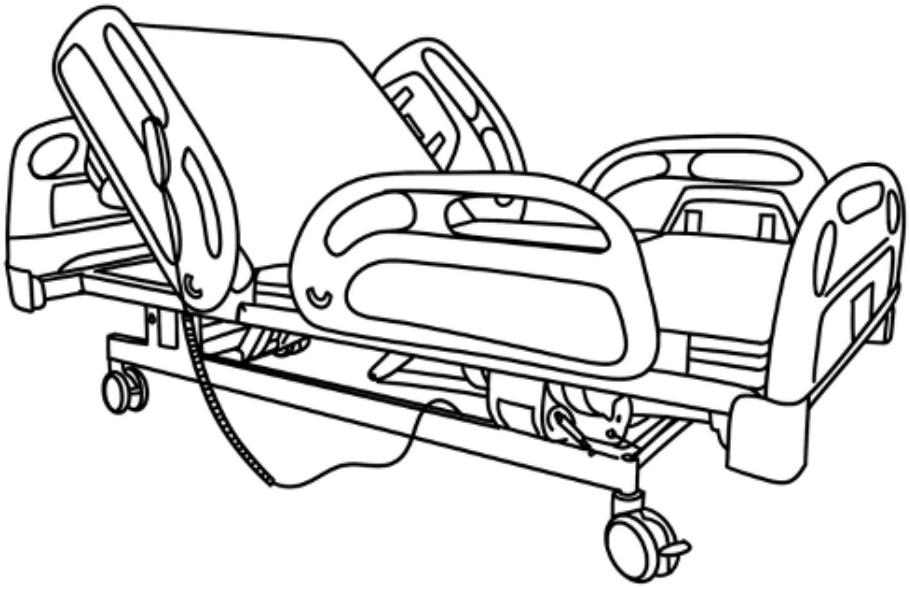

Figure 4. The rough 3D-based existing patient bed

Figure 5. The rough sketch of the ideation process

Based on the proposed function and form of bed redesign discussed in Table 6 and the ideation process, these are some proposed prioritized ideas provided in a paper prototype.

Table 7. Proposed prioritized ideas for patient bed redesign

Item	Description
Handrails grip	The use of contrasting colors and materials helps patients easily distinguish between adjustable and non-adjustable areas of the bed. In the provided images, the upper section represents the initial design where the handrail grip blends with the rest of the bed, making it harder for patients to intuitively identify where to place their hands for adjustments. In contrast, the lower section shows an improved design where the handrail grip is highlighted with a different color and material. This change creates a clear visual cue, guiding the patient to the correct areas for interaction, enhancing usability, and improving the overall experience of adjusting the bed. This approach reduces confusion and helps patients, especially those with limited mobility or vision, operate the bed more independently.
Color-coded bed sheet	Color-coded bed sheets can enhance the usability of adjustable beds by making the adjustable sections easily identifiable for patients. By using distinct colors, such as blue for the upper part (backrest) and orange for the lower part (leg elevation), patients can intuitively understand where adjustments can be made. This design connects seamlessly with the bed's remote, where the corresponding buttons are also color-coded in blue and orange. This reduces cognitive load and enhances comfort, allowing patients to quickly recognize and adjust their position, supporting a more user-friendly and efficient experience.
Clearly labeled bed controls	This new bed control can be placed on the handrails of the hospital bed. The front panel shows six buttons around a silhouette of a person lying on a bed. The buttons represent controls for adjusting different parts of the bed: the upper three buttons (upward arrows) are used to elevate the backrest, knees, and body, while the lower three (downward arrows) lower them. On the right, there is a circular nurse button to ask for assistance, and below it (a grid of dots) is speakers for auditory feedback or communication. Based on the previous feedback (negative Kansei words), the new bed control design addresses several concerns highlighted with the old controls. The new design simplifies the interface with clearly labeled and universally understood icons for bed adjustments. The ergonomic placement of the controls and buttons makes it easy to use and prevents accidental presses. The feedback mechanism is also added, like vibrations when a button is pressed.

Feedback and Refinement

The feedback collected for the redesigned items, which are shown in Table 7. The feedback comes from 2 subjects (namely, X and Y) who have been hospitalized within the last 2 years and involved in Stage 1. Their insights reflect their personal experiences with the redesigned hospital beds and remote controls, focusing on aspects such as movements, ergonomics, accessibility, safety, and comfort (see Tables 8 and 9).

Apart from the patients' points of view, a doctor and a nurse in hospital X have been asked for their feedback regarding the proposed redesigned bed. The interview yielded the following feedback.

According to the findings, it can be summarized as follows. The redesigned bed controls are intuitive, reducing time spent on patient adjustments and improving workflow efficiency for healthcare staff. Patients are more independent, reducing non-urgent requests and reducing physical strain on staff. The height adjustment

feature reduces strain on mobility assistance, promoting ease and efficiency. The smooth adjustment of backrests and footrests also promotes patient comfort and satisfaction. The inclusion of clearly labelled bed controls and secure side rails ensures patient safety.

Table 8. Feedback and iterative refinement of bed redesign from patients

No	Participant	Movement	Ergonomics	Accessibility and Support	Safety	Comfort
1	X	Satisfied with the bed's ability to support mobility (raising and lowering back and footrest)	The bed is sturdy, comfortable, and clean.	The remote-control feature makes it easy for the user to raise and lower the back parts of the bed.	Safe to use, side rails protect the body.	Comfortable to use, and it supports positive feelings during the stay.
2	Y	It is simple to adjust bed height and backrest using a remote control.	The design of the bed contributes to the feeling of being well cared for.	Allows easy movement, helping patients change positions and adjust comfort.	Safe and comfortable with side rails.	Bed redesign helps reduce frustration with its aesthetics.

Table 9. Feedback and iterative refinement of bed remote control from patients

No	Participant	Movement	Ergonomics	Accessibility and Support	Safety	Comfort
1	X	Bed movements are easy to adjust using the remote, but the symbols on the remote are not.	The remote buttons are clear and easy to access due to their raised design, but the symbols could be better aligned.	The remote is easy to access, with a hanger on the side rail for convenience and a nurse call feature built into the remote.	The remote is safe to use, with effective tactile cues and buttons that are easy to identify.	The remote helps reduce user frustration, with colors that support positive feelings during the treatment.
2	Y	Easy to adjust the bed using the remote but adding text to the symbols could improve user-friendliness.	Visually intuitive but could benefit from added text for clarity and contrast improvement in panel colors.	Easy to access with side attachment and features like speaker, mic, and nurse-call button.	The remote is safe but could be improved by adding texture differences for users with special needs.	The remote design helps reduce frustration by being easy to access and enhancing patient comfort.

The study proposes an innovative approach to hospital bed design, integrating Kansei Engineering (KE) and Nudge Theory (NT) inside the Design Thinking (DT) framework (abbreviated as KENT-DT). Inherently, this approach combines both emotional/affective and cognitive human processes. More specifically, KENT-DT addresses patient comfort and autonomy by tackling negative emotional responses (such as feeling frustrated, neglected, and uncomfortable). Afterwards, this study proposes ergonomic design cues and visual-based design, which smoothly guide intended patient behavior. It is hoped that patients will be independent since there is a reduction of reliance on healthcare staff, for instance, in the case of basic bed adjustments.

In the current study, the KENT-DT method proposes a structured and multi-stage design thinking process to assess the existing patient beds, how the beds are currently operated, and what patients need and feel comfortable with. It will cater to the patients' needs. Afterwards, it then creates, and tests patient bed redesign prototypes based on KE and NT principles. Hence, the study bridges emotional (Kansei or affect) and functional design (cognition) in healthcare. It fills the research gap where most KE applications lack contextual and cultural background considerations.

Therefore, this approach is deemed to be standing out from conventional hospital bed redesigns since it introduces an integrated behavioral and emotional dimension to usability and addresses both service quality and patient autonomy. This is done through a multidisciplinary model, which is rarely explored in a healthcare context.

Table 10. Feedback from doctor and nurse

Statement	Implication
Doctor	
"The redesigned bed controls are intuitive and reduce the time spent assisting patients with bed adjustments. Patients potentially may require less help, which allows us to focus on more critical tasks."	It seems that it may improve workflow efficiency for healthcare staff
"I believe that the patients are more independent with the new bed design. They can adjust their position more easily without calling for assistance, which has significantly reduced the frequency of non-urgent requests."	It will boost patient independence
"The bed's new height adjustment feature may reduce the physical strain on staff when assisting patients with mobility. It's now easier for us to help them without compromising our own safety."	It promotes ease and efficiency for healthcare staff
Nurse	
"With the smooth adjustment of the backrest and footrest, it will make patients stay more pleasant, and potentially it will decrease in discomfort-related complaints."	It promotes patient comfort and satisfaction
"The inclusion of clearly labelled bed controls and secure side rails will lead to patient safety. We feel more confident that patients are less likely to experience falls or accidents while adjusting their beds."	It leads to increased safety for patients

Conclusions

This study discusses the integration of Kansei Engineering and Nudge Theory within the Design Thinking framework (known as KENT-DT) applied in healthcare services. This integrative approach collectively addresses both physical and emotional aspects of patient and proposes a more holistic method to product and service designs in healthcare services. It has demonstrated significant potential in enhancing healthcare bed redesign to improve patient autonomy, comfort, and overall service quality experience. In other words, the redesigned bed emphasizes both functional and emotional patient needs that contributes positively to patient satisfaction and comfort. The results and discussion sub-sections highlight critical insights gained from patient feedback and experiences. They include several key pain points such as frustration, discomfort, and no autonomy in bed utilization. According to these concerns, this study has proposed and tested a healthcare bed redesign equipped with more intuitive, better adjustability, and more visual cues for patient use. The feedback gathered from the iterative refinement process confirmed that the redesigned bed has been deemed to be more effective in mitigating those challenges. It might be enforcing patient autonomy and overall well-being. This improvement has confirmed and aligned with the objective of the study. It leads to more human-centric approach for healthcare beds. More specifically, it promotes patient convenience and a positive behavior (known as nudges) for better healthcare environments. The findings serve as a practical guide for practitioners in healthcare services (e.g., administration staff, hospital managers, doctors, and nurses) to provide more well-being physical facilities and service quality. Moreover, the implementation of the redesigned beds is highly expected to mitigate any potential hazards or problems for patients, and eventually to boost patient comfort.

There are some potential limitations from this study including:
Sample size and diversity. The study was conducted with a limited number of participants, which may not fully represent the diverse demographics of hospital patients, and it was constrained by a case study in hospital X's services. The limited sample size combined with the lack of diversity of participant's backgrounds in this study will bring significant impact on the generalizability of the findings. This study only involved 20 participants in interviews. Since there was insufficient broad representation of demographic factors (e.g., age, gender, medical conditions), the findings may not fully represent the spectrum of patient populations with various healthcare settings. That limited participant may lead to partial emotional (Kansei) and physical needs so that they are not adequately captured, as Kansei is a contextual basis as well [10]. Hence, to address this potential limitation, the recruitment of a more diverse set of participants is highly proposed. More specifically, the demographic backgrounds, including diverse age groups, social and economic factors, and medical conditions, are potentially explored. It would be expected that design strategies and solutions developed through a KE-based approach integrated with other relevant methods account for the wider range of patient needs and experiences.

Context specificity. The study's findings are contextually specific to the chosen hospital setting (i.e., hospital X), which may limit generalizability to other healthcare environments with different operational challenges or patient demographics.

Resource constraints. Implementation of the redesigned bed may require significant investment in training and maintenance, potentially limiting its applicability across healthcare facilities with restricted budgets or resources. This study has been constrained by paper prototyping. A physical prototype with real touch and experience may produce different results and feedback from patients. Inherently, the constraint occurred in physical prototype may affect the validity of the research results. Since this study utilized a paper prototype, it was concerned that it may not totally capture the functional, tactile, and ergonomic aspects embedded in the entire healthcare services and equipment especially when patients experience with real healthcare beds. A paper prototype may only provide a visual feature of the proposed design, without allowing the patients or participants to fully touch, try, and interact with the redesigned bed. There are no specific interactions like adjusting bed's reclining, touching its materials, and controlling its height. As consequences, it will impact on less accuracy in terms of usability and comfort. Surely, the critical aspects such as ease of movement and feel of controls can be assessed through physical prototypes. Hence, a consolidation process of potential differences between patient feedback from physical and paper prototypes may generate valuable inputs for deeper understanding of user needs and fulfilments. Paper prototypes will lead to more aesthetical visual-focused feedback, whereas physical prototypes will complete it incorporating physical comfort, usability, and physical interactions. For future research, it is highly recommended to involve physical prototypes for more valid and grounded real-world applicability of proposed designs.

For further research, there are some formulized recommendations:
Essentially, the findings and insights from Stage 1 are potentially applied to other hospital equipment (e.g., wheelchairs or intravenous (IV) stands). Related to wheelchairs, patients may feel uncomfortable, stressed, and confused due to poorly designed features of wheelchairs. Afterwards, the Kansei words comfort, and autonomy may be connected to more ergonomic handles by considering relevant anthropometric data and easy intuitive controls for the ease of movement, including the provision of adjustable seating and easy-to-handle brake levers. In addition, the provision of better cushioning on wheelchairs will promote stress reduction. Apart from that, wheelchairs, patients may be concerned about the use of IV stands. Patients may be potentially feeling frustrated due to mobility constraints. Based on some collected emotional cues from Stage 1 (i.e., Kansei words), IV stands will be redesigned by considering the anthropometric data of users in terms of their adjustable heights, movement mechanisms, and easy-to-grip handles. Hence, it is critical to enhance the overall healthcare experience by improving both functional and Kansei aspects.

Broader testing across diverse settings. The future research could expand testing to include a broader range of hospitals and healthcare settings to determine the design's adaptability and effectiveness in different environments. Some levels of hospital services may produce significant differences in terms of research findings.

Longitudinal studies on patient outcomes. We may potentially conduct longitudinal studies to assess the long-term impact of the KE and Nudge Theory-based designs on patient recovery, satisfaction, and comfort.

Patients' voices are considered the main or central emotional needs (Kansei) in this study. Nevertheless, there is an opportunity to include healthcare staff perspectives, which are potentially contributing to patient care and healthcare service quality. Apart from patient's perspectives, semi-structured interviews involving doctors, nurses, and supporting healthcare staff may provide valuable insights related to the usability of patient beds and hospital service quality. The observation process that includes the interaction between healthcare staff and patients will provide insights into how to improve bed adjustability mechanisms and patient movement. In this study, healthcare staff and doctors were involved in the evaluation of the proposed redesigned bed. These opportunities of combining both patient and healthcare staff perspectives can be considered for future research.

Evaluation of staff training and support needs. It is advised to investigate the training requirements and support structures for healthcare staff in using and maintaining the redesigned beds to ensure sustained usability and impact. Not only patient's perspectives but also nurses and doctors' perceptions on hospital services may bring various impacts on customer and patient perceptions.

Refining the proposed framework and focusing more on the specific research objectives. For instance, this study aims to improve patient beds by addressing both emotional and functional needs.

Acknowledgments

This research is funded and supported by the research grant with a scheme of fundamental research of the Ministry of Research, Technology, and Higher Education Indonesia, and the authors express their gratitude for any feedback advised by the anonymous reviewers.

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] V. M. Patel *et al.*, "How has healthcare research performance been assessed? A systematic review," *Journal of the Royal Society of Medicine*, vol. 104, no. 6, pp. 251–261, 2011. https://doi.org/10.1258/jrsm.2011.110005

[2] S. Hignett, P. Carayon, P. Buckle, and K. Catchpole, "State of science: Human factors and ergonomics in healthcare," *Ergonomics*, vol. 56, no. 10, pp. 1491–1503, 2013. https://doi.org/10.1080/00140139.2013.822932

[3] H. Vinagre and J. Neves, "Emotional predictors of consumer's satisfaction with healthcare public services," *International Journal of Health Care Quality Assurance*, vol. 23, no. 2, pp. 209–227, 2010. https://doi.org/10.1108/09526861011017111

[4] M. Nagamachi, "Kansei engineering: A new ergonomic consumer-oriented technology for product development," *International Journal of Industrial Ergonomics*, vol. 15, no. 1, pp. 3–11, 1995. https://doi.org/10.1016/0169-8141(94)00052-5

[5] M. Hartono and K. C. Tan "How the Kano model contributes to Kansei engineering in services," *Ergonomics*, vol. 54, no. 11, pp. 987–1004, 2011. https://doi.org/10.1080/00140139.2011.616229

[6] S. F. Liu, Y. C. Hsu, and H. C. Tsai, "Development of a new cultural design process using Kansei engineering and fuzzy techniques: A case study in Mazu crown design," *International Journal of Clothing Science and Technology*, vol. 31, no. 5, pp. 663-684, 2019. https://doi.org/10.1108/IJCST-12-2017-0183

[7] A. Hakim, B. Suhardi, P. W. Laksono, and M. Ushada, "Systematic review of Kansei engineering method developments in the design field," *Jurnal Optimasi Sistem Industri*, vol. 23, no. 1, pp. 92–108, 2024. https://doi.org/10.25077/josi.v23.n1.p92-108.2024

[8] M. Hartono, "The extended integrated model of Kansei Engineering, Kano, and TRIZ incorporating cultural differences into services," *International Journal of Technology*, vol. 7, no. 1, pp. 97–104, 2016. https://doi.org/10.14716/ijtech.v7i1.1789

[9] F. I. Stuart, "The influence of organizational culture and internal politics on new service design and introduction", *International Journal of Service Industry Management*, 9(5), pp.469-485, 1998. https://doi.org/10.1108/09564239810238866

[10] M. Hartono, A. Santoso, and D. N. Prayogo, "How Kansei Engineering, Kano and QFD can improve logistics services," *International Journal of Technology*, vol. 8, no. 6, pp. 1070–1081, 2017. https://doi.org/10.14716/ijtech.v8i6.689

[11] C. H. Douglas and M. R. Douglas, "Patient-friendly hospital environments: Exploring the patients' perspective," *Health Expectations*, vol. 7, no. 1, pp. 61–73, 2004. https://doi.org/10.1046/j.1369-6513.2003.00251.x

[12] F. Y. A. Drayi, "The impact of hospital bed and beddings on patients: The Ghanaian healthcare consumer perspectives," *International Journal of Innovative Research and Advanced Studies (IJIRAS)*, vol. 6, no. 1, pp. 138–144, 2019. https://www.ijiras.com/2019/Vol_6-Issue_1/paper_21.pdf

[13] K. I. Pollak, S. C. Alexander, J. A. Tulsky, P. Lyna, C. J. Coffman, R. J. Dolor, P. Gulbrandsen, and T. Østbye, "Physician empathy and listening: Associations with patient satisfaction and autonomy", *The Journal of the American Board of Family Medicine*, vol. 24 no. 6, pp. 665-672, 2011. https://doi.org/10.3122/jabfm.2011.06.110025

[14] E. J. Cooper, "To nudge or not to nudge: Promoting environmentally beneficial behaviors," *Bard Center for Environmental Policy*, vol. 10, 2017. https://digitalcommons.bard.edu/bcep/10/

[15] M. G. Hunnes, "Nudging: How human behavior is affected by design," *Annual Review of Policy Design*, vol. 4, no. 1, 2016. https://ojs.unbc.ca/index.php/design/article/view/1479

[16] O. Tronstad, D. Flaws, S. Patterson, R. Holdsworth, and J. F. Fraser, "Creating the ICU of the future: patient-centred design to optimise recovery", *Critical Care*, vol. 27, no. 1, pp. 402, 2023. https://doi.org/10.1186/s13054-023-04685-2

[17] W. Lian, K. C. Wang, Y. Li, H. Y. Chen, and C. H. Yang, "Affective-Blue design methodology for product design based on integral Kansei engineering," *Mathematical Problems in Engineering*, 2022, doi: 10.1155/2022/5019588. https://doi.org/10.1155/2022/5019588

[18] Q. Fu, J. Lv, S. Tang, and Q. Xie, "Optimal design of virtual reality visualization interface based on Kansei engineering image space research," *Symmetry*, vol. 12, no. 10, pp. 1–22, 2020. https://doi.org/10.3390/sym12101722

[19] K. H. E., Kroemer, *Fitting the Human: Introduction to Ergonomics / Human Factors Engineering*, Seventh Edition (7th ed.). CRC Press. 2017. https://doi.org/10.1201/9781315398389.

[20] M. I. Adelino, H. R. Zadry, and L. Susanti, "Contemporary trends in human factors and ergonomics within engineering research," *Jurnal Teknik Industri: Jurnal Keilmuan dan Aplikasi Teknik Industri*, vol. 26, no. 1, pp. 61-76, 2024. https://doi.org/10.9744/jti.26.1.61-76

[21] V. A. Entwistle and I. S. Watt, "Treating Patients as Persons: A Capabilities Approach to Support Delivery of Person-Centered Care,". *The American Journal of Bioethics*, vol. 13, no. 8, pp. 29–39, 2013. https://doi.org/10.1080/15265161.2013.802060

[22] B. Fisher, "Richard H. Thaler and Cass R. Sunstein: Nudge: Improving Decisions About Health, Wealth, and Happiness," *Environmental and Resource Economics*, vol. 47, no. 1, p.149, 2010. https://doi.org/10.1007/s10640-010-9363-8

[23] A. Sant'Anna, A. Vilhelmsson, and A. Wolf, "Nudging healthcare professionals in clinical settings: A scoping review of the literature," *BMC Health Services Research*, vol. 21, no. 543, 2021. https://doi.org/10.1186/s12913-021-06496-z

[24] O. Nwafor *et al.*, "Effectiveness of nudges as a tool to promote adherence to guidelines in healthcare and their organizational implications: A systematic review," *Social Science & Medicine*, vol. 317, p. 115424, 2022. https://doi.org/10.1016/j.socscimed.2022.115424

[25] R. Buchanan, "Declaration by design: Rhetoric, argument, and demonstration in design practice," *Design Issues*, vol. 2, no. 1, p. 4, 1985. https://ojs.unbc.ca/index.php/design/article/view/1659

[26] O. Demirbilek and B. Sener, "Product design, semantics and emotional response," *Ergonomics*, vol. 46, no. 13–14, pp. 1346–1360, 2003. https://doi.org/10.1080/00140130310001610874.

[27] R. Chitturi, R. Raghunathan, and V. Mahajan, "Form versus function: How the intensities of specific emotions evoked in functional versus hedonic trade-offs mediate product preferences," *Journal of Marketing Research*, vol. 44, no. 4, pp. 702–714, 2007. https://doi.org/10.1509/jmkr.44.4.702

[28] R. Chitturi, R. Raghunathan, and V. Mahajan, "Delight by design: The role of hedonic versus utilitarian benefits," *Journal of Marketing*, vol. 72, no. 3, pp. 48–63, 2008. https://doi.org/10.1509/JMKG.72.3.048

[29] A. Tideholm and O. Ryden, "*Design thinking as facilitator for innovation in Swedish healthcare — A case study at Karolinska University Hospital*," Master of Science Thesis in the Management and Economics of Innovation Programme, Department of Technology Management and Economics Division of Innovation Engineering and Management, Chalmers University of Technology, 2015. https://odr.chalmers.se/server/api/core/bitstreams/d4661f27-6b84-430e-bef4-9c820382c246/content

[30] M. Altman, T. T. K. Huang, and J. Y. Breland, "Design thinking in health care," *Preventing Chronic Disease*, vol. 15, Sep. 2018. https://doi.org/10.5888/pcd15.180128

[31] A. Pakarinen, T. Lemström, E. Rainio, and E. Siirala, Eds., *Design Thinking in Healthcare: From Problem to Innovative Solutions*. Springer Nature, 2023. https://doi.org/10.1007/978-3-031-24510-7

[32] A. A. Caulliraux and M. J. Meiriño, "The design thinking and the health services: The competitive differential through the humanization of patient experience," *Brazilian Journal of Operations & Production Management*, vol. 12, no. 2, p. 322, 2015. https://doi.org/10.1186/s12913-021-06496-z

[33] K. Stola, "User experience and design thinking as a global trend in healthcare," *Journal of Medical Science*, vol. 87, no. 1, pp. 28–33, 2018. https://doi.org/10.20883/jms.2018.281

[34] X. A. Levander *et al.*, "The role of human-centered design in healthcare innovation: A digital health equity case study," *Journal of General Internal Medicine*, vol. 39, no. 4, pp. 690–695, 2024. https://doi.org/10.1007/s11606-023-08500-0

[35] Y. Liang, "Application of Gestalt psychology in product human-machine interface design," *IOP Conference Series: Materials Science and Engineering*, vol. 392, p. 062054, 2018. https://doi.org/10.1088/1757-899x/392/6/062054

[36] J. E. Lugo, J. P. Schmiedeler, S. M. Batill, and L. Carlson, "Quantification of classical gestalt principles in two-dimensional product representations," *Journal of Mechanical Design*, vol. 137, no. 9, 2015. https://doi.org/10.1115/1.4030988

[37] L. B. Ncube and A. W. Crispo, "Toward meaningful learning in a global age: How Gestalt principles can facilitate organization of student learning of product lifecycle management concepts," in *2007 37th Annual Frontiers in Education Conference - Global Engineering: Knowledge without Borders, Opportunities without Passports*, 2007. https://doi.org/10.1109/fie.2007.4418012

[38] J.H. Lee, S. J. Fenves, C. Bock, H.W. Suh, S. Rachuri, X. Fiorentini, and R.D. Sriram, "A semantic product modeling framework and its application to behavior evaluation," *IEEE Transactions on Automation Science and Engineering*, vol. 9, no. 1, pp. 110-123, 2011. https://doi.org/10.1109/TASE.2011.2165210

[39] C.-H. Lin, "Research in the use of product semantics to communicate product design information," *Lecture Notes in Computer Science*, pp. 556–565, 2011. https://doi.org/10.1007/978-3-642-21753-1_62

[40] J. F. Petiot and B. Yannou, "How to comprehend and assess product semantics—A proposal for an integrated methodology," in *DS 31: Proceedings of ICED 03, the 14th International Conference on Engineering Design*, Stockholm, 2003. https://www.designsociety.org/publication/24002/HOW+TO+COMPREHEND+AND+ASSESS+PRODUCT+SEMANTICS+-+A+PROPOSAL+FOR+AN+INTEGRATED+METHODOLOGY

[41] J. Lee and W. Chu, "Nudge design strategies for experiential marketing and retail space branding," *Journal of Interior Design*, vol. 48, no. 3, pp. 174–190, 2023. https://doi.org/10.1177/10717641231177463

[42] D. Lockton, D. Harrison, and N. A. Stanton, "The design with intent method: A design tool for influencing user behaviour," *Applied Ergonomics*, vol. 41, no. 3, pp. 382–392, 2010. https://doi.org/10.1016/j.apergo.2009.09.001

[43] Y. Akao, "Quality Function Deployment: Integrating Customer Requirements into Product Design "(1st ed.). Productivity Press. 2004. https://doi.org/10.4324/9781003578833

[44] S. Kim, K. J. Yoon, & I. S. Kweon, I. S., "Object recognition using a generalized robust invariant feature and Gestalt's law of proximity and similarity", *Pattern Recognition*, vol. 41, no. 2, pp.726-741, 2008. https://doi.org/10.1016/j.patcog.2007.05.014