The Use of Smart Textiles in the Healthcare Space: Towards an Improvement of the User-Patient Experience

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Abstract

This article explores the role of smart textiles in transforming healthcare environments into spaces that prioritize patient well-being. We will examine the advantages of smart textiles in healthcare settings, such as the real-time monitoring of vital signs through connected clothing. Additionally, we will introduce metadesign as a design approach that considers the interactions between users, healthcare environments, and technologies to create fulfilling experiences. By combining the advanced features of smart textiles with a patient-centered metadesign approach, it becomes possible to create care spaces that cater to patient needs. The objective of this article is to present the integration of metadesign in the design of smart textiles as a process aimed at enhancing the quality of the patient user experience. In this process, we will emphasize the collaborative approach and embrace technological innovation to harness the potential for ongoing improvement and provide users with high-quality experiences. Lastly, we will underscore the significance of adopting a multidimensional approach to evaluate the impact of smart textiles on the patient user experience.

Keywords

Smart Textiles, Healthcare Space, User-Patient Experience, Metadesign

1. Introduction

Technological advancements and the development of new design methods have facilitated the transformation of care spaces into environments that prioritize the well-being and comfort of patients. In this context, the integration of metadesign in intelligent textile design emerges as a promising solution to enhance the pa-

tient user experience. Patient user experience design is founded upon a comprehensive understanding of their needs, enabling the creation of tailored solutions that meet their expectations and provide a positive experience. According to Christine Michel and Guillemette Trognot, various methods are employed in the design of user experiences "are characterized by an explicit comprehension of the users, their emotions, their tasks, and their activity environment, by actively involving them in the design process"[1] [1].

Simultaneously, in the rapidly evolving realm of healthcare, smart textiles represent a groundbreaking innovation poised to revolutionize our approach to health management. Equipped with advanced functionalities, these textiles provide innovative opportunities for enhancing various facets of the patient experience. Furthermore, metadesign, encompassing a holistic design approach, enables the integration of functional, aesthetic, and emotional aspects into the design of care spaces.

This article will explore three key facets of this transformative journey: the role of smart textiles within the healthcare space, the application of metadesign principles in healthcare, and the seamless integration of metadesign into the development of smart textiles tailored for healthcare purposes. These interrelated concepts not only influence the prospective healthcare framework but also promise innovative, personalized solutions that transcend conventional medical boundaries.

Moreover, we will illuminate the pivotal significance of user experience, specifically the patient's perspective, in augmenting the delivery of healthcare services. Therefore, in this article, we will explore the significant improvements that the utilization of smart textiles, incorporating elements of metadesign in its design process, can bring to healthcare environments. Our objective is to investigate how this approach can foster a patient-centered care environment aimed at enhancing the experience of patient users.

2. Smart Textiles in the Healthcare Space

In recent times, the textile industry has experienced significant growth in developing countries [2]. In addition, smart textiles are materials that incorporate advanced technologies to provide specific functionalities. In this regard, Van Lange hove and Hertleer state that: "Smart clothing will find applications in those fields where the need for monitoring and actuation can be of vital importance, such as a medical environment, and with vulnerable population groups, in space travel and the military" [3]. Moreover, the textile industry is essential in everyday life because it meets basic needs of human beings [4]. For example, in the healthcare sector, smart textiles are specifically designed to enhance the patient experience by offering a range of features including thermal regulation, humidity management, vital signs detection, remote monitor-
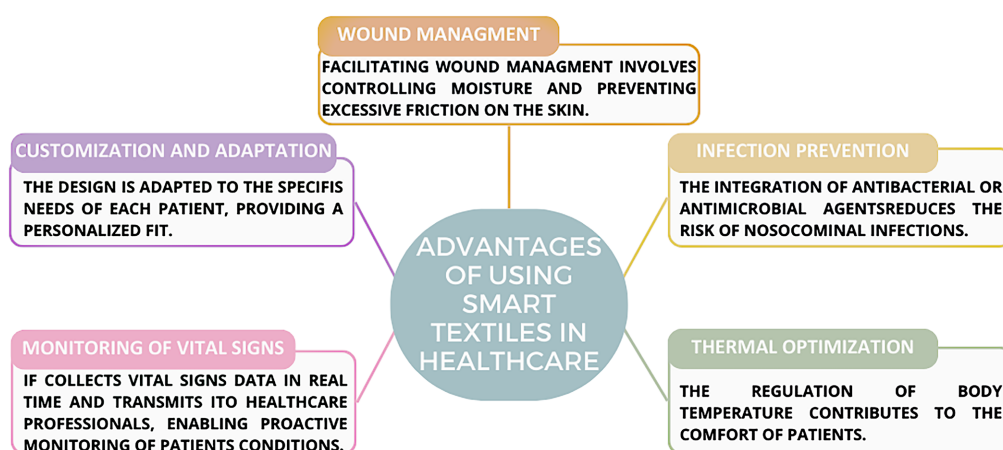
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[1]In the original language (French) «sont caractérisées par une compréhension explicite des utilisateurs, de leur ressenti, de leurs tâches et de leur environnement d'activité, en les faisant participer à la conception».

ing, and more.

Consequently, intelligent clothing has found utility across various sectors including sports, healthcare, military, security, lifestyle, and entertainment. Its trajectory is aimed at enhancing functionality, comfort, technology diversity, and incorporating more intelligent materials for a more comprehensive user experience [5].

According to Manuel Cardona: "Textiles with sensors can be used to monitor body movements; breathing for bedridden humans as well as for babies' along with the help in regulating body temperature as well" [6]. Corresponding to Barbel Selm *et al.*: "The field of medical textiles is vast. Clothing for hospital staff, surgery blankets, textiles for hygienic and orthopedic purposes, dressings, implants and much more are included in the wider sense" [7]. These textiles incorporate components of artificial intelligence (such as "machine learning"[2] and "optimization algorithms"[3]) to offer an optimal patient experience. In this sense, Katherine Le *et al.*: "There are many opportunities for integration of e-textiles into consumer grade products and applications, for improving lifestyle and health of the general population" [8]. In this regard, Barbel Selm *et al.* stated: "For many years, textile structures have been successfully used for wound treatment, operations, and implants. [...]. Today, the use of textile structures in medicine is a growing market. There are constantly new discoveries concerning cellular components, and the reactions of the human body to new and existing substances" [9].

In agreement with Silvana Zhezhova *et al.*: "Medical textile is an extremely important subcategory of technical textile because it is covering a wide range of products. The term medical textile itself covers all types of textile materials that are used in the healthcare system for various purposes. Medical textile is also known as health textile and is one of the fastest growing sectors in the technical

WOUND MANAGMENT
FACILITATING WOUND MANAGMENT INVOLVES CONTROLLING MOISTURE AND PREVENTING EXCESSIVE FRICTION ON THE SKIN.

CUSTOMIZATION AND ADAPTATION
THE DESIGN IS ADAPTED TO THE SPECIFIS NEEDS OF EACH PATIENT, PROVIDING A PERSONALIZED FIT.

INFECTION PREVENTION
THE INTEGRATION OF ANTIBACTERIAL OR ANTIMICROBIAL AGENTSREDUCES THE RISK OF NOSOCOMINAL INFECTIONS.

ADVANTAGES OF USING SMART TEXTILES IN HEALTHCARE

MONITORING OF VITAL SIGNS
IF COLLECTS VITAL SIGNS DATA IN REAL TIME AND TRANSMITS ITO HEALTHCARE PROFESSIONALS, ENABLING PROACTIVE MONITORING OF PATIENTS CONDITIONS.

THERMAL OPTIMIZATION
THE REGULATION OF BODY TEMPERATURE CONTRIBUTES TO THE COMFORT OF PATIENTS.

Figure 1. Advantages of using smart textiles in healthcare.

[2]Machine learning enables smart textiles to gather and analyze data from embedded sensors. This data can be utilized to identify patterns, anomalies, or relevant health-related information.
[3]Optimization algorithms can be employed to dynamically adjust and control the properties of textiles based on the collected data and specific health objectives.

textile market" [9]. "Although textiles are widely accepted for medical and surgical applications, new areas of application are constantly emerging" [9]. **Figure 1** illustrates several advantages of smart textiles aimed at enhancing the experience of patient users.

Consequently, smart textiles provide substantial benefits to patients within healthcare environments, enhancing their comfort, facilitating medical monitoring, and reducing the risk of infections. The implementation of these textiles in the healthcare field presents new possibilities for improving the patient experience and achieving improved clinical outcomes. As Suleiman, T. and Adinoyi, A. said: "Healthcare delivery is experiencing a paradigm shift due mainly to revolutions engineered by technological advancements, especially those related to mobile connectivity and its accompanying myriad of platforms, applications, sensors, devices, and equipment" [10].

3. The Metadesign in the Healthcare Space

Before delving into the intricacies of our discussion, it is imperative to establish clear definitions of both metadesign and its application within the healthcare space.

Healthcare organizations can be viewed as intricate sociotechnical systems comprising individuals, technologies, and tasks that interact within an environment to execute processes (physical, cognitive, social/behavioral, and organizational) shaping outcome(s) [11]. Moreover, concentrating on healthcare environments offers a foundation for comprehending essential components and establishing criteria for assessing a wide variety of spaces that facilitate the healing journey [12]. These ideas emphasize the importance of considering healthcare organizations as a whole, acknowledging both the complexity of their components and the impact of their environment on healthcare outcomes.

The definition of metadesign implies a design approach that integrates a global vision. According to Elisa Giaccard: "Designers therefore consider Metadesign as the 'design of a design process'" [13]. To comprehend the overall concept of metadesign, we refer to the definition provided by Andrea Fesce: "The word metadesign highlights the fact that the attention is not focused on devising tools for practical solutions, but rather on setting up an integrated conceptual framework that may stimulate further research" [14]. It considers the interactions among users, environments, and technologies to generate fulfilling experiences. According to Gerhard Fischer and Eric Scharff: "Metadesign characterizes the activities, processes and objectives to create new media and new environments that allow users to act as designers and be creative"[4] [15].

Vincent Beaubois [16] points out that it is important to note the evolution of metadesign since its inception in the 1960s by the metadesign movement, which

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[4]In the original language (French) «Le métadesign caractérise les activités, les processus et les objectifs pour créer de nouveaux médias et de nouveaux environnements permettant aux usagers d'agir en tant que concepteurs et d'être créatifs».

emphasized the seamless connection between design and production. This evolution eventually gave rise to the concept of metadesign (2000), which places emphasis on the continuity between design and usage. Consequently, Gerhard Fischer and Elisa Giaccardi assert that: "Metadesign differs fundamentally from the creation of complete systems: rather than developing complete solutions, it means developing sociotechnical environments allowing users to create the solutions themselves"[5] [17]. Within the domain of architecture, Lars Spuybroek [18] promotes the techniques of metadesign "as tools for constructing dynamic spaces where people can unpredictably and creatively interact with their environment" [19]. In addition, architecture and design guidelines should involve all stakeholders in the design process, ensuring an inclusive and collaborative approach that considers the needs and experiences of patients, staff, and visitors [20]. By incorporating dynamic spaces that allow for unpredictable and creative interactions, healthcare facilities can foster a healing environment that promotes well-being and positive outcomes for all users [20].

In the context of the patient user experience, metadesign encompasses an integrative design approach that considers various aspects of a product, space, or service, including user interactions. As a result, metadesign plays a crucial role in enhancing the healthcare environment by contributing to the creation of healthcare spaces. Figure 2 illustrates the role of metadesign in improving the care environment.
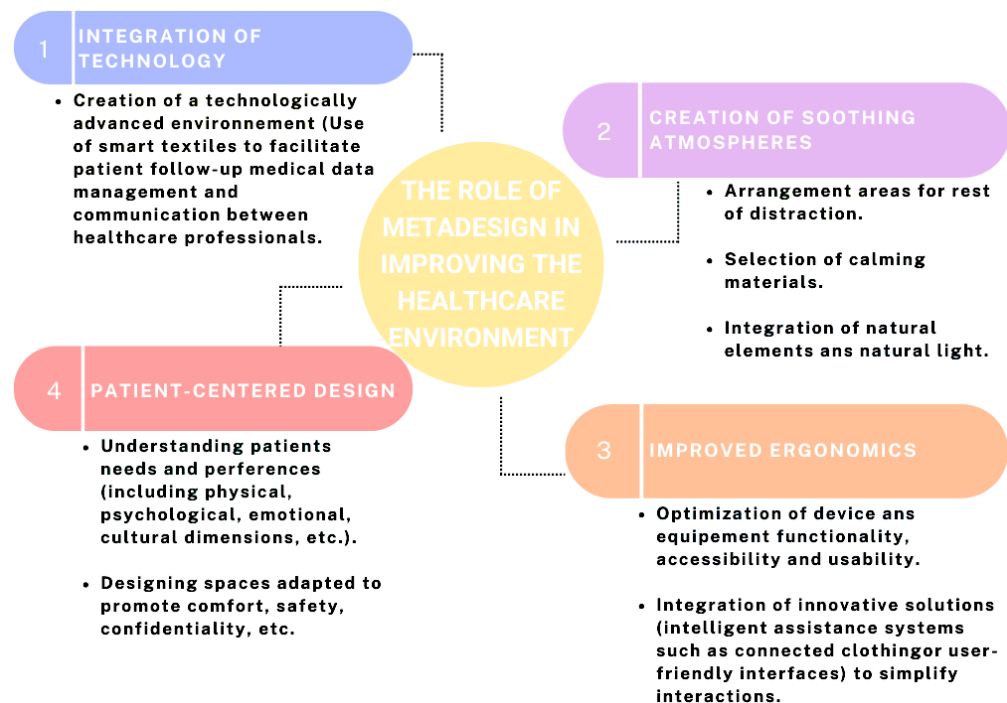
Figure 2. The role of metadesign in improving the healthcare environment.

[5]In the original language (French) «Le métadesign diffère fondamentalement de la création de systèmes complets: plutôt que de développer des solutions complètes, cela signifie développer des environnements sociotechniques permettant aux usagers de créer eux-mêmes les solutions».
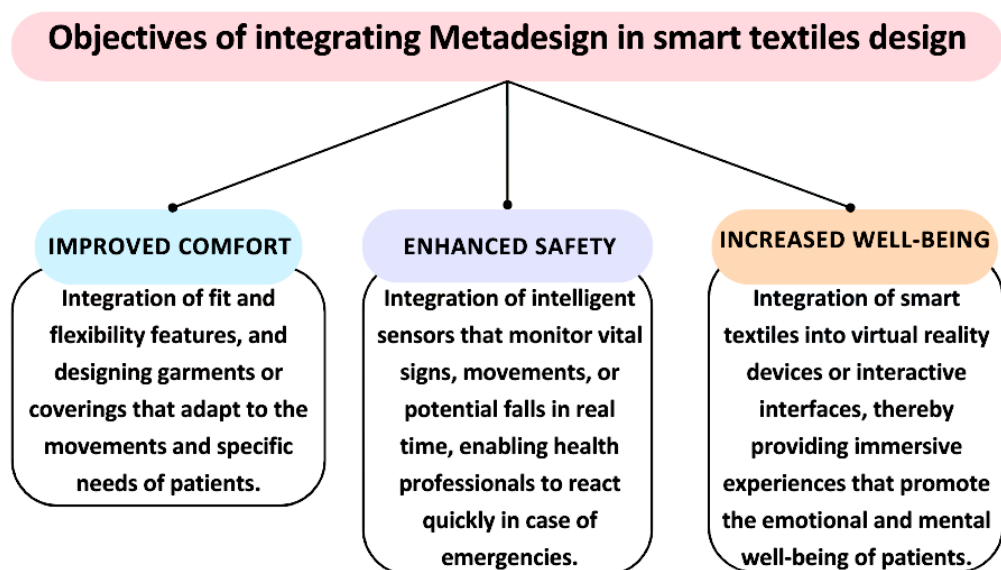
Based on the findings depicted in Figure 2, it can be understood that metadesign enables the reevaluation and transformation of care environments, fostering the creation of spaces that cater to the requirements of patients and facilitate a positive and gratifying experience. Consequently, it contributes to enhancing the quality of care, reinforcing the effectiveness of medical interventions, and promoting the recovery of patients.

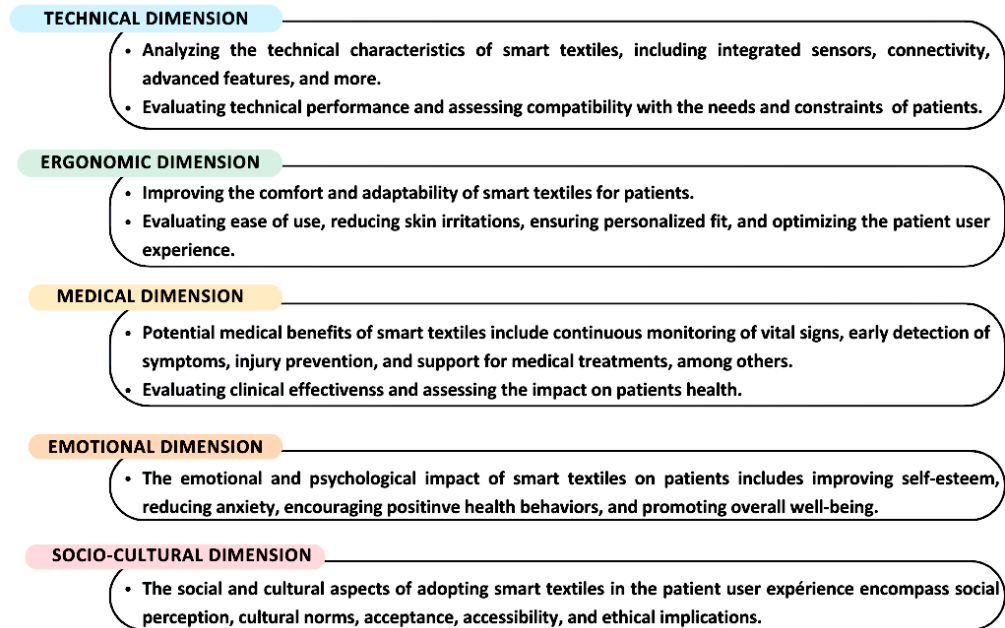## 4. The Integration of Metadesign in the Design of Smart Textiles for Healthcare.

The integration of metadesign in the design of smart textiles entails a thorough examination of the interactions among patients, care environments, and textiles with the aim of creating fulfilling experiences. Peter Scher highlighted that the "users have to be involved from the design stage on, and that positive, patient-centred spaces could promote healing processes, enhance staff performance" [21]. To provide quality care, Bélanger, Marquis and Mercier mention who it is essential to take into account: "courtesy and respect, the involvement of the patient and his relatives, information and communication, emotional support, access, coordination, transition and continuity of care, as well as physical comfort and the environment" [22]. Based on this, we can highlight some objectives of integrating the metadesign approach into the design of smart textiles (refer to Figure 3).

Incorporating the metadesign approach into the design of smart textiles necessitates a close collaboration among designers, healthcare professionals, and patients to ensure the effective fulfillment of these requirements. Taking into consideration the perspectives of both health professionals and designers involved in implementing these approaches is of utmost importance.

Their observations and evaluations can complement the data collected from

Objectives of integrating Metadesign in smart textiles design

IMPROVED COMFORT

Integration of fit and flexibility features, and designing garments or coverings that adapt to the movements and specific needs of patients.

ENHANCED SAFETY

Integration of intelligent sensors that monitor vital signs, movements, or potential falls in real time, enabling health professionals to react quickly in case of emergencies.

INCREASED WELL-BEING

Integration of smart textiles into virtual reality devices or interactive interfaces, thereby providing immersive experiences that promote the emotional and mental well-being of patients.

Figure 3. Role of metadesign in the design of smart textiles.

TECHNICAL DIMENSION
- Analyzing the technical characteristics of smart textiles, including integrated sensors, connectivity, advanced features, and more.
- Evaluating technical performance and assessing compatibility with the needs and constraints of patients.

ERGONOMIC DIMENSION
- Improving the comfort and adaptability of smart textiles for patients.
- Evaluating ease of use, reducing skin irritations, ensuring personalized fit, and optimizing the patient user experience.

MEDICAL DIMENSION
- Potential medical benefits of smart textiles include continuous monitoring of vital signs, early detection of symptoms, injury prevention, and support for medical treatments, among others.
- Evaluating clinical effectivenss and assessing the impact on patients health.

EMOTIONAL DIMENSION
- The emotional and psychological impact of smart textiles on patients includes improving self-esteem, reducing anxiety, encouraging positinve health behaviors, and promoting overall well-being.

SOCIO-CULTURAL DIMENSION
- The social and cultural aspects of adopting smart textiles in the patient user expérience encompass social perception, cultural norms, acceptance, accessibility, and ethical implications.

Figure 4. Assessing the impact of smart textiles and metadesign on the patient user experience.

patients, offering additional insights into the effectiveness and challenges associated with the utilization of smart textiles in healthcare settings. Hence, a multidimensional approach is essential for assessing the impact of smart textiles on the patient's user experience. This approach entails examining multiple dimensions (refer to **Figure 4**) to gain a comprehensive understanding of the influence of these technologies and concepts.

This multidimensional approach enables us to gain a comprehensive understanding of the impact of these technologies and concepts on the patient user experience. It facilitates the evaluation of the advantages, limitations, challenges, and opportunities of these technologies for optimal design and implementation in the healthcare and well-being domain while considering various relevant dimensions. This evaluation allows for the measurement of both tangible and subjective benefits associated with the use of smart textiles, thereby providing valuable information for the ongoing enhancement of the patient experience in healthcare spaces. By integrating the advanced features of smart textiles with a patient-centered metadesign approach, it becomes feasible to develop care environments that are better tailored, more comfortable, and focused on meeting the needs and expectations of patients. Furthermore, a collaborative approach and a receptiveness to technological innovation are vital for fully harnessing the potential for ongoing enhancements and providing high-quality patient user experiences. In **Figure 5**, we outline the key aspects of the collaborative approach within the context of patient user experiences in healthcare spaces.

The collaborative approach fosters cooperation, participation, and ongoing engagement among healthcare professionals, designers, patients, researchers, and other relevant stakeholders in the design, development, and evaluation
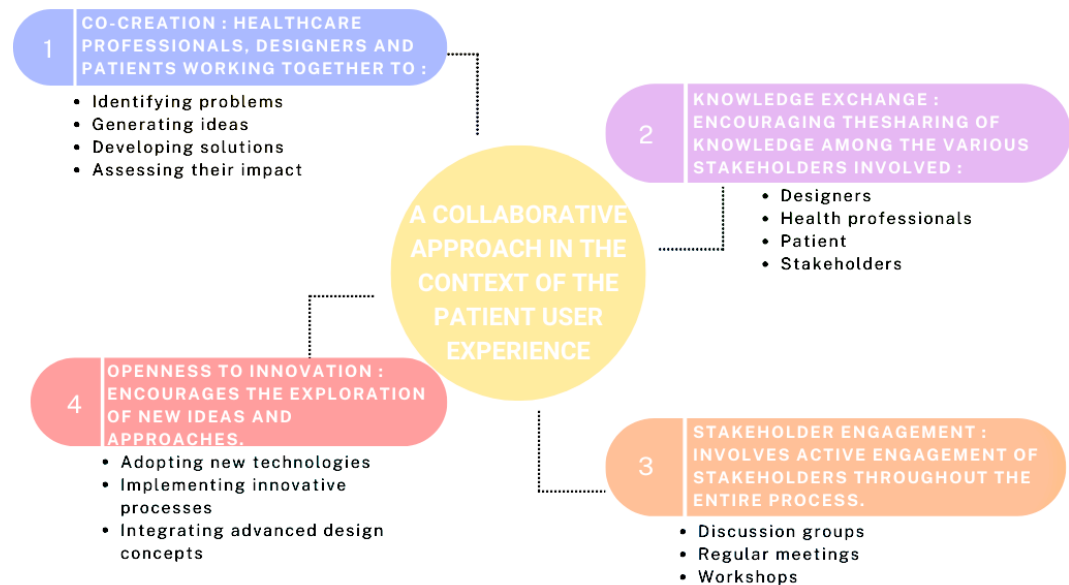
Figure 5. Key aspects of the collaborative approach in the context of patient user experiences.

process of solutions for healthcare spaces. This entails open communication, attentive listening, and considering the needs, expectations, and aspirations of all parties involved.

5. Conclusion

The integration of metadesign in the design of smart textiles within healthcare environments is of utmost significance. It enhances the comfort, safety, and satisfaction of patients while optimizing clinical practices and facilitating communication between patients and healthcare professionals. Moreover, these approaches provide opportunities for personalized care based on individual patient needs, thus promoting a patient-centered approach. The widespread adoption of these approaches, supported by continuous interdisciplinary collaboration and increased awareness, is essential to fully harness their potential and deliver high-quality, patient-centered, and wellness-oriented healthcare that improves the patient experience. In conclusion, the design of the user-patient experience, coupled with the integration of metadesign in the design of intelligent textiles, opens new horizons for transforming care spaces into welcoming environments centered around the well-being of patients.

Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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