

# Smart Textiles for Health Care in the Era of 6G and the Internet of Things

by Md. Saiful Hoque and Azadeh Yadollahi 

Clothing is often described as a “second skin,” providing comfort and aesthetic expression while maintaining close and continuous contact with the human body [1]. This intimate interface makes textiles an ideal platform for embedding biomedical sensing and therapeutic functions. Since the early 2000s, R&D in smart textiles has shifted toward health-care applications, leading to garments that are capable of monitoring vital signs and supporting clinical interventions. The integration of these medical textiles with digital health technologies is and will be redefining how health care is delivered by allowing continuous, unobtrusive, and patient-centered monitoring in everyday life.

Unlike rigid wearable devices, smart textiles offer distinct advantages for a broad spectrum of users, including children and older adults (see Figure 1). First, the inherent flexibility and conformability of textile fibers and functional polymers enable garments to adapt seamlessly to the body’s natural movements, which eliminate the need for conscious adjustment or external effort. Second, textiles are inherently lightweight yet can exhibit remarkable mechanical strength, surpassing even that of steel on a weight-to-strength ratio, thus minimizing the risk of the discomfort, skin irritation, or mechanical interference often associated with rigid wearables. Third, the extensive surface area of textiles allows a larger sensing interface, which enhances data acquisition, robustness, and reliability across multiple body sites, supporting more comprehensive physiological monitoring. Finally, when designed into everyday clothing, smart textiles integrate unobtrusively into daily life, leading to higher levels of user acceptance, long-term adherence, and clinical applicability.

With the advancement of the Internet of Things (IoT), data generated from smart textiles can be transmitted in real time to smartphones or cloud-based platforms for real-time analysis. This capability has given rise to an emerging ecosystem of textile-integrated wearable IoT health devices that enable remote patient monitoring, facilitate early detection of health issues,



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and support personalized medicine. Industry forecasts highlight the rapid growth of this sector: the global smart textile market was valued at approximately US\$7.8 billion in 2024 and is projected to expand to US\$51 billion by 2029 [2]. Canada is also a significant contributor to this trend, with its smart textile market valued at US\$223.3 million in 2024 and expected to grow at a compound annual growth rate of 25.8%, reaching an estimated US\$912.1 million by 2030 [3]. As we stand on the cusp of 6G wireless networks, this short review examines the state of the art in smart health-care textiles, how 6G and advanced IoT will propel the field forward, and what innovations and challenges lie ahead.

## Smart Textiles in Health Care: State-of-the-Art Technologies and Challenges

The revolution of smart textiles, from fiber development to fully finished garments, has transformed conventional clothing into functional clothing, made possible through close interdisciplinary collaboration among engineers, clinicians, and researchers that has propelled progress in this sector at a geometric pace. Conductive fibers made from metals, nanomaterials, or polymers are now converted into flexible textiles, which allows sensors, actuators, and data transmission throughout garments [4]. At the same time, self-powered textiles that use piezoelectric and triboelectric nanogenerators are harnessing body motion as an energy source [5]. Moving beyond passive sensing, next-generation smart garments have active functions such as therapeutic

delivery, temperature regulation, and fluid monitoring for patients with conditions like heart failure [6], [7], [8], [9].

Data from smart textiles are increasingly integrated with artificial intelligence and analytics to denoise the data and enable advanced health insights. Advanced machine learning algorithms are being used to analyze these large

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sets of data to detect patterns or early warning signs. For example, researchers have developed a flexible sensor patch that measures electrocardiograms, respiration, skin temperature, and sweat humidity on the skin, with smartphone-based edge computing algorithms that detect arrhythmias, coughs, and falls in real time [10].

Despite these rapid advancements, challenges remain in areas like durability (e.g. washability of electronic components), power management, mass production, standardization, and validation across larger patient cohorts [11], [12], as shown in Figure 2. Accordingly, current research is exploring solutions such as robust washable electronic circuits, integrated energy-harvesting storage systems, self-healing materials, and the reliable clinical potential of smart textile technologies.

**6G Networks and the Future of IoT Textile Wearables in Health Care**

Although 5G networks have begun to address needs for high data rates and low latency in the Internet of Medical Things (IoMT), 6G networks are anticipated to further revolutionize this field [13]. The Internet of Wearable Things will markedly benefit from 6G technologies, which are being designed to support long-range, low-power communication; ultra-reliable low-latency connections; and even in-network intelligent computing for data processing at the network edge [14]. In a medical context, this means that smart textiles and wearables will communicate faster and more reliably than ever. Real-time patient monitoring will be enhanced by 6G's ability to transmit

data instantaneously. The ultralow latency and high reliability of 6G are especially important for telemedicine that can accelerate the intervention or instant alerts to first responders and even support remote examinations or guided therapies, such as rehabilitation with haptic feedback suits. 6G's massive device connectivity capability also means that the IoMT can scale up dramatically. Finally, with the capacity of 6G networks and the IoT, the application of smart textiles in health care can be limitless.

**Future Directions and Recommendations**

Although smart textiles for health care have advanced rapidly, several challenges remain before their widespread adoption in clinical and everyday settings. Addressing these challenges requires not only technical improvements but also coordinated efforts across research,

policy, and industry. The following key directions highlight priorities that can guide future development and successful integration of smart textile wearables into health-care systems:

- *Interdisciplinary collaboration:* Achieving smart textile health-care breakthroughs requires close collaboration across engineering, materials science, data science, and medicine. Joint research and industry partnerships are needed to ensure that designs satisfy technical constraints and clinical needs simultaneously. Breaking down silos will accelerate innovation and help establish common standards.
- *Policy and ethical frameworks:* Clear regulatory guidelines and standards should be developed for textile-based medical devices to ensure safety, efficacy, and data privacy. Policies must address certification of these wearables and mandate strong data protection for

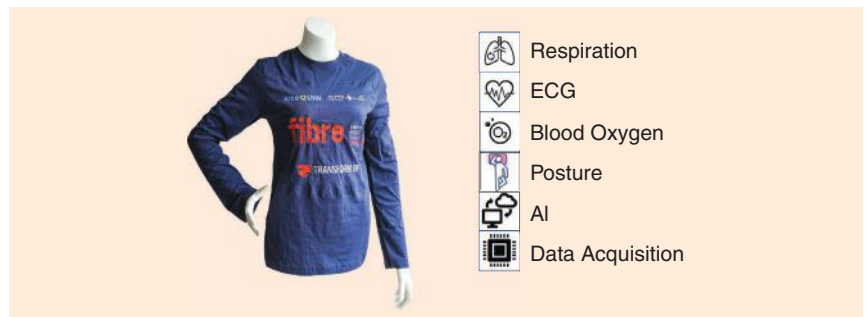


Figure 1: A smart textile prototype designed for continuous monitoring of physiological signals and capable of advancement through 6G network integration.

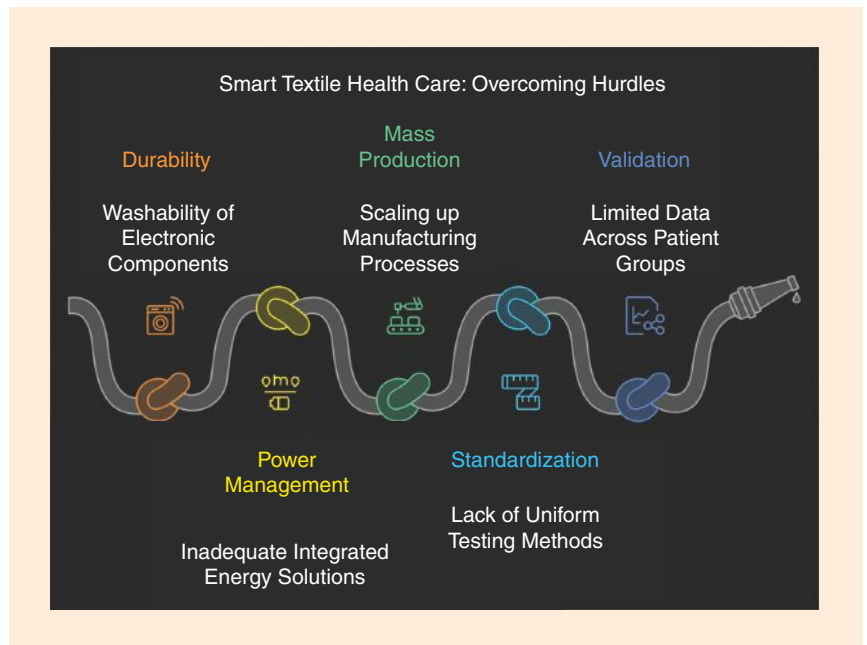


Figure 2: Key challenges of smart textiles, including durability, power management, data privacy, and large-scale deployment.

patient information [15]. Ethical frameworks are also vital.

- **Commercialization challenges:** To move from lab prototypes to real-world use, smart textiles must be robust, user friendly, and cost-effective. Manufacturers should focus on improving durability and wearability and simplifying use. Demonstrating clinical value through robust studies will encourage adoption by health-care providers. Building user trust by proving reliability and protecting privacy is equally important for widespread deployment.

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## Conclusion

Smart textiles integrated with 6G and IoT technologies are poised to redefine health care by enabling continuous personalized monitoring and timely interventions. Fabric-based sensors can seamlessly gather vital health data and transmit them in real time, and upcoming 6G networks will further amplify these capabilities with ultra-fast, ubiquitous connectivity. We also highlighted innovative trends such as self-powered e-textiles, on-device data processing, stronger data security, and new materials that are making smart textile wearables more comfortable and reliable. There are challenges ahead, from ensuring privacy and safety to achieving large-scale production and user adoption. However, interdisciplinary collaboration and supportive policies can help overcome these hurdles. The health-care community, technology developers, and policy makers are called to action to work together in advancing smart textile solutions. ■

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