

Dermatological Implications of Artificial Intelligence, Wearable Technologies, and Digital Health Monitoring: Current Evidence, Clinical Challenges, and Future Perspectives

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ABSTRACT

The integration of artificial intelligence (AI), wearable technologies, and digital health monitoring systems has significantly transformed modern healthcare by enabling continuous patient surveillance, personalized interventions, and improved access to medical services. Despite these advances, increasing evidence suggests that prolonged use of wearable devices may be associated with a variety of cutaneous manifestations that can affect patient comfort, treatment adherence, and overall healthcare outcomes. This review aimed to analyze the current scientific evidence regarding dermatological complications associated with wearable technologies,

biosensors, adhesive monitoring systems, and AI-assisted healthcare platforms. A qualitative integrative review was conducted using the Scientific Method as a methodological framework. Scientific literature was identified through searches in PubMed/MEDLINE, Scopus, ScienceDirect, Web of Science, and Google Scholar. Evidence related to dermatological manifestations, immunological mechanisms, clinical implications, artificial intelligence applications, and preventive strategies was critically evaluated and synthesized. The findings indicate that allergic contact dermatitis, irritant contact dermatitis, medical adhesive-related skin injuries, erythema, pruritus, and pressure-associated lesions are the most frequently reported complications. Pathophysiological mechanisms involve adhesive exposure, epidermal barrier disruption, mechanical friction, humidity accumulation, and delayed hypersensitivity reactions. Artificial intelligence demonstrated considerable potential for lesion classification, teledermatology support, remote monitoring, and predictive risk assessment. The review concludes that while wearable technologies and AI provide substantial healthcare benefits, their successful implementation requires greater attention to dermatological safety, patient-centered device design, interdisciplinary collaboration, and preventive strategies aimed at minimizing cutaneous adverse effects.

KEYWORDS

Artificial intelligence, wearable devices, digital health, dermatology, contact dermatitis, skin manifestations, biosensors, teledermatology, remote monitoring, medical technology, patient safety, adhesive-related skin injury, digital healthcare, precision medicine

INTRODUCTION

The rapid integration of artificial intelligence (AI), wearable technologies, and digital health monitoring systems has transformed contemporary healthcare, enabling continuous patient surveillance, personalized interventions, and real-time clinical decision-making. Over the last decade, advances in biosensors, smartwatches, continuous glucose monitoring systems, fitness trackers, adhesive patches, and telemedicine platforms have significantly expanded the capacity to collect physiological and behavioral data outside traditional healthcare environments [1], [2]. These innovations have improved disease management, enhanced patient engagement, and facilitated remote monitoring of chronic conditions. However, alongside these benefits, growing evidence suggests that prolonged exposure to wearable devices and digital monitoring technologies may be associated with a variety of cutaneous manifestations, ranging from mild irritation to severe inflammatory and allergic skin disorders [3], [4].

The skin serves as the primary interface between wearable technologies and the human body. Consequently, continuous contact between electronic devices and the epidermis creates unique challenges related to mechanical friction, occlusion, thermal stress, moisture accumulation, exposure to adhesives, and repeated interaction with sensor materials [5]. As the adoption of wearable health technologies continues to increase globally, dermatological complications associated with these devices are becoming more frequently reported in both clinical practice and scientific literature [6]. These complications are particularly relevant in patients requiring long-term monitoring, such as individuals with diabetes mellitus, cardiovascular diseases, neurological disorders, and chronic respiratory conditions [7].

Among the most widely documented adverse effects are irritant contact dermatitis and allergic contact dermatitis. Continuous glucose monitoring systems and insulin pump devices have emerged as important examples of digital health technologies associated with significant dermatological reactions [3], [8]. Several investigations have identified allergens contained within device adhesives, including isobornyl acrylate and other acrylate derivatives, as major contributors to allergic skin responses [8], [9]. Patients frequently present with erythema, pruritus, vesiculation, eczema, burning sensations, and localized inflammation at the site of device application. In severe cases, these reactions may lead to treatment discontinuation, reduced adherence, and deterioration of disease control [4], [10].

The emergence of medical adhesive-related skin injuries (MARSIs) has further highlighted the importance of understanding skin-device interactions. MARSIs encompass a spectrum of dermatological conditions caused by repetitive application and removal of medical adhesives, including skin stripping, blistering, maceration, irritant dermatitis, and allergic reactions [11]. The increasing use of wearable biosensors and remote monitoring devices has amplified concerns regarding adhesive-associated skin damage, particularly among vulnerable populations such as older adults, pediatric patients, and individuals with compromised skin barriers [12].

Beyond adhesive-related disorders, prolonged device use may alter the cutaneous microenvironment through occlusion, increased humidity, and temperature changes beneath the sensor interface. Such alterations can disrupt epidermal homeostasis, facilitate microbial colonization, and exacerbate pre-existing dermatological diseases including atopic dermatitis, psoriasis, acneiform eruptions, and seborrheic dermatitis [13]. Emerging research also suggests that sustained mechanical pressure and friction generated by wearable devices may contribute to pressure-related injuries, pigmentary changes, and chronic inflammatory responses in susceptible individuals [14].

Simultaneously, artificial intelligence has become an increasingly influential component of dermatological practice. Deep learning algorithms have demonstrated remarkable performance in the classification of skin lesions, melanoma detection, and diagnostic support systems, often achieving levels of accuracy comparable to those of experienced dermatologists [15]–[17]. AI-assisted dermatology has expanded access to specialist evaluation through teledermatology platforms, smartphone-based applications, and automated screening systems [18]. These technological advances offer substantial opportunities for early detection and monitoring of dermatological conditions associated with wearable technologies. Nevertheless, challenges remain regarding algorithm transparency, diagnostic reliability across diverse populations, data quality, and ethical considerations surrounding patient privacy and digital surveillance [19].

The convergence of AI and wearable health technologies has created a novel ecosystem in which digital devices not only generate physiological data but also influence skin health directly. Smart biosensors capable of monitoring hydration, temperature, sweat composition, inflammatory biomarkers, and other physiological parameters are increasingly being incorporated into healthcare systems [20]. While these technologies hold considerable promise for preventive medicine and personalized healthcare, they also introduce new dermatological risks that require comprehensive evaluation. Understanding the balance between technological benefits and cutaneous safety has therefore become an important priority for clinicians, researchers, biomedical engineers, and healthcare policymakers.

From a global perspective, the increasing penetration of digital health technologies has generated growing interest across North America, Europe, Asia, and Latin America. Countries such as Mexico, Colombia, and Ecuador have experienced substantial expansion in telemedicine services, wearable device adoption, and digital healthcare initiatives during recent years. Consequently, healthcare professionals in these regions are increasingly encountering skin-related complications associated with prolonged exposure to monitoring technologies. Despite the growing body of evidence regarding device-associated dermatitis and digital health applications, comprehensive analyses integrating dermatology, immunology, internal medicine, and medical technology remain relatively limited, particularly within the Latin American context.

Previous studies have primarily focused on isolated aspects of the problem, such as allergic contact dermatitis caused by glucose monitoring devices, medical adhesive-related injuries, or the diagnostic performance of AI systems in dermatology [3], [8], [11], [15]. However, fewer investigations have explored the broader relationship between

emerging digital healthcare technologies and the spectrum of cutaneous manifestations that may result from their implementation. Furthermore, the rapid evolution of sensor materials, adhesive compounds, wearable platforms, and AI-based diagnostic tools necessitates continuous evaluation of their clinical implications.

DEVELOPMENT

The relationship between digital health technologies and cutaneous health represents an emerging clinical field in which dermatology, immunology, internal medicine, and biomedical engineering converge. Wearable devices, continuous monitoring systems, adhesive sensors, mobile health applications, and artificial intelligence-supported platforms have expanded the possibilities of patient surveillance beyond hospitals and clinics. These tools are increasingly used to monitor glucose levels, heart rhythm, physical activity, oxygen saturation, sleep patterns, body temperature, and other physiological variables. Although their clinical usefulness is evident, their prolonged interaction with the skin has introduced new dermatological concerns that require systematic evaluation [1], [2].

The skin is not merely a passive surface for device placement. It is an active immunological, mechanical, and sensory organ that responds continuously to environmental, chemical, and physical stimuli. When wearable devices remain attached to the skin for several hours or days, they may modify the local microenvironment by increasing humidity, heat, pressure, friction, and occlusion. These changes can disrupt the epidermal barrier, alter transepidermal water loss, promote maceration, and increase susceptibility to irritation or inflammation. In patients with pre-existing cutaneous vulnerability, such as atopic dermatitis, xerosis, diabetes mellitus, advanced age, or immunological dysregulation, these effects may be more pronounced [3], [4].

One of the most relevant manifestations associated with wearable and digitally monitored health devices is contact dermatitis. Irritant contact dermatitis may occur as a direct consequence of friction, sweating, pressure, repeated removal of adhesives, or prolonged occlusion. Allergic contact dermatitis, on the other hand, involves a delayed hypersensitivity reaction mediated by T lymphocytes after sensitization to a specific allergen. In the context of wearable health technologies, acrylates, methacrylates, epoxy resins, colophony derivatives, nickel, rubber accelerators, and adhesive components have been identified as potential triggers [5], [6]. Continuous glucose monitoring systems and insulin pumps have been especially important in documenting these reactions because they require prolonged adhesion and repeated application in patients with diabetes mellitus [7].

The clinical presentation of device-associated dermatitis can vary from mild erythema and pruritus to vesicles, edema, scaling, fissuring, burning sensation, and eczematous plaques at the site of contact. In some patients, lesions are sharply demarcated according to the shape of the adhesive patch or sensor. In others, inflammation may extend beyond the contact area, suggesting allergic dissemination or secondary irritation. These reactions are not only dermatological events; they may also interfere with adherence to monitoring systems, reduce patient confidence in digital health tools, and compromise the management of chronic diseases [8], [9].

Medical adhesive-related skin injury is another relevant problem in this field. Repetitive attachment and removal of adhesives can damage the stratum corneum, causing skin stripping, blistering, erosions, maceration, folliculitis, and irritant dermatitis. This phenomenon is particularly important in patients requiring long-term monitoring, hospitalized individuals, children, older adults, and patients with fragile or compromised skin. The expansion of wearable biosensors has increased the frequency with which clinicians must evaluate adhesive-related lesions outside traditional wound care settings [10], [11].

From an immunological perspective, skin reactions associated with digital monitoring devices reflect the interaction between external materials and host immune responses. Allergic contact dermatitis involves antigen presentation by Langerhans cells and dermal dendritic cells, followed by activation of specific T-cell populations. Once sensitization has occurred, repeated exposure to the allergen can produce recurrent or more intense inflammatory reactions. This mechanism is clinically important because patients may develop reactions after weeks or months of apparently uneventful device use, making diagnosis more complex [5], [12].

In internal medicine, these manifestations have particular relevance because many users of wearable medical devices are patients with chronic diseases. Individuals with diabetes mellitus, cardiovascular disease, obesity, chronic kidney disease, neurological disorders, and sleep-related breathing disorders may depend on continuous or frequent monitoring systems. If skin complications lead to discontinuation of these devices, the consequences may extend beyond dermatology and affect metabolic control, cardiovascular surveillance, therapeutic adjustment, and patient safety [7], [13].

Artificial intelligence has added another layer of complexity to this scenario. AI-based systems are increasingly used for dermatological image classification, lesion triage, teledermatology support, and automated risk assessment. Deep learning models have shown high performance in the recognition of melanoma and other skin lesions, and their integration into digital health platforms may improve access to dermatological evaluation [14], [15]. However, these systems also depend on image quality, population diversity, algorithm training, and appropriate clinical interpretation. In the context of wearable-associated skin manifestations, AI may support early detection of dermatitis, monitoring of lesion progression, and remote follow-up, but it should not replace clinical judgment [16].

Teledermatology and mobile health platforms may be especially useful in regions where access to dermatologists is limited. In countries such as Mexico, Colombia, and Ecuador, digital health strategies have expanded as a response to geographic, economic, and healthcare access barriers. Wearable devices and remote monitoring platforms could improve continuity of care in chronic diseases; however, their safe implementation requires awareness of dermatological adverse effects, cultural differences in device use, skin phototype diversity, and variability in health literacy [17], [18].

Another relevant aspect is the technological design of wearable devices. Materials selected for adhesives, sensors, straps, electrodes, and protective films influence the risk of cutaneous reactions. Breathability, flexibility, hypoallergenic properties, moisture control, and mechanical stability are essential design considerations. A device that performs well from a technological perspective may still fail clinically if it produces discomfort, dermatitis, or intolerance. Therefore, dermatological safety should be incorporated into the design, testing, and post-market surveillance of digital health technologies [19].

The problem is also educational. Medical students, general practitioners, dermatologists, internists, nurses, biomedical engineers, and digital health developers must understand that cutaneous manifestations associated with wearable devices are not isolated inconveniences. They represent clinically relevant events that may affect adherence, diagnosis, treatment outcomes, and trust in digital healthcare. Teaching this topic requires an interdisciplinary approach that connects skin physiology, immune response, chronic disease management, biomedical materials, and artificial intelligence applications.

Current evidence suggests that the use of artificial intelligence, wearable technologies, and digital monitoring systems will continue to increase in both high-income and middle-income countries. Consequently, the number of patients presenting with device-associated cutaneous manifestations is likely to grow. This makes it necessary to establish preventive strategies, improve diagnostic pathways, identify high-risk populations, and develop safer materials. It is also important to generate regional evidence from Latin America, where adoption patterns, climate conditions, access to dermatological care, and patient education may differ from those reported in Europe, North America, or Asia.

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

To critically analyze the current scientific evidence regarding cutaneous manifestations associated with the use of artificial intelligence-assisted healthcare systems, wearable technologies, and digital health monitoring devices, evaluating their dermatological, immunological, clinical, and technological implications in contemporary healthcare practice.

A. Cognitive Domain

1. To identify the principal dermatological manifestations associated with wearable devices, biosensors, adhesive medical technologies, and digital monitoring systems reported in the scientific literature.
2. To explain the immunological and pathophysiological mechanisms involved in the development of irritant contact dermatitis, allergic contact dermatitis, and other skin reactions related to digital health technologies.
3. To analyze the role of artificial intelligence in the diagnosis, classification, monitoring, and management of skin conditions associated with wearable healthcare devices.
4. To compare the advantages, limitations, and clinical challenges associated with the implementation of wearable technologies and AI-assisted dermatological assessment in different healthcare settings.
5. To evaluate current evidence regarding risk factors, prevalence, prevention strategies, and therapeutic approaches for device-associated skin complications.

B. Psychomotor Domain

6. To apply evidence-based criteria for the identification and clinical assessment of cutaneous manifestations associated with digital monitoring technologies.
7. To demonstrate the ability to classify device-related dermatological reactions according to their clinical presentation, severity, and underlying pathogenic mechanisms.
8. To utilize scientific evidence for the selection of preventive measures aimed at minimizing skin complications associated with prolonged wearable device use.
9. To integrate dermatological, immunological, and technological knowledge when assessing the safety and tolerability of digital healthcare devices.

C. Affective Domain

10. To promote awareness regarding the importance of dermatological safety during the implementation of wearable technologies and AI-assisted healthcare systems.

11. To recognize the impact of skin-related adverse effects on patient adherence, quality of life, and long-term therapeutic outcomes.
12. To encourage interdisciplinary collaboration among dermatologists, internists, biomedical engineers, nurses, data scientists, and healthcare professionals involved in digital health innovation.
13. To value the ethical responsibility of ensuring that technological innovation remains aligned with patient well-being, safety, and equitable access to healthcare services.
14. To foster a patient-centered perspective in the design, implementation, and evaluation of emerging digital health technologies.

OBJECT OF STUDY

The object of study of this review is the spectrum of cutaneous manifestations associated with the use of artificial intelligence-assisted healthcare technologies, wearable devices, biosensors, adhesive monitoring systems, and digital health platforms employed for medical surveillance, diagnosis, treatment support, and patient follow-up.

Specifically, the study focuses on understanding the interaction between digital healthcare technologies and the skin as a biological, immunological, and functional organ. This interaction encompasses the development of dermatological reactions resulting from prolonged contact with wearable devices, exposure to adhesives and sensor materials, mechanical friction, occlusion, humidity accumulation, thermal changes, and continuous skin-device interfaces. In addition, the review examines how artificial intelligence contributes to the identification, monitoring, classification, and management of these dermatological manifestations within modern healthcare systems.

The phenomenon under investigation includes a broad range of cutaneous conditions documented in association with digital health technologies. These conditions comprise irritant contact dermatitis, allergic contact dermatitis, medical adhesive-related skin injuries, pressure-related lesions, friction-induced dermatoses, eczema-like eruptions, pigmentary alterations, follicular disorders, localized inflammatory reactions, and exacerbations of pre-existing dermatological diseases such as atopic dermatitis, psoriasis, and acneiform conditions. The study also considers emerging evidence regarding the influence of wearable technologies on skin barrier integrity, cutaneous microbiota, and local immune responses.

The population of interest includes individuals exposed to wearable medical technologies in both clinical and community settings. This population encompasses patients with chronic diseases requiring continuous monitoring, including diabetes mellitus, cardiovascular disorders, respiratory diseases, neurological conditions, sleep disorders, obesity, and other long-term health conditions. Healthcare professionals using occupational monitoring technologies and healthy individuals utilizing consumer-grade wearable devices for wellness, fitness, and preventive health purposes are also considered relevant populations within the scope of this review.

From a healthcare systems perspective, the object of study extends beyond individual dermatological reactions to include the broader implications of skin-device interactions on treatment adherence, patient satisfaction, quality of life, clinical outcomes, and healthcare resource utilization. Skin complications associated with digital monitoring technologies may influence the effectiveness of chronic disease management programs, reduce acceptance of emerging healthcare innovations, and generate additional clinical burdens requiring specialized dermatological intervention.

The technological dimension of the object of study includes several categories of digital health tools. These comprise continuous glucose monitoring systems, insulin pumps, smartwatches, fitness trackers, wearable electrocardiographic monitors, biosensor patches, remote physiological monitoring devices, telemedicine platforms, mobile health applications, smart textiles, and artificial intelligence-supported diagnostic systems. The review evaluates how the design characteristics, materials, adhesives, sensor components, and operational mechanisms of these technologies contribute to the development or prevention of cutaneous adverse events.

An additional component of the object of study is the application of artificial intelligence within dermatological and digital healthcare environments. AI-based systems have become increasingly important for image analysis, lesion recognition, risk stratification, teledermatology support, and clinical decision-making. Therefore, the review investigates not only the dermatological consequences of wearable technology use but also the potential role of artificial intelligence in improving early detection, diagnosis, monitoring, and prevention of technology-associated skin disorders.

From an immunological standpoint, the object of study includes the biological mechanisms underlying skin responses to wearable technologies. These mechanisms involve epidermal barrier disruption, inflammatory pathways, hypersensitivity reactions, cytokine-mediated responses, immune cell activation, and tissue adaptation processes triggered by prolonged exposure to foreign materials. Understanding these biological processes is essential for explaining the clinical manifestations observed in affected individuals and for developing effective prevention and management strategies.

The study also considers geographical and public health perspectives. Given the growing adoption of digital healthcare technologies worldwide, particular attention is directed toward the relevance of these manifestations in diverse healthcare settings, including Latin American countries such as Mexico, Colombia, and Ecuador. These regions are experiencing increasing implementation of telemedicine services, remote patient monitoring programs, and wearable healthcare technologies, creating a need for greater awareness regarding associated dermatological implications.

Ultimately, the object of study can be defined as the multidimensional relationship between digital healthcare innovation and skin health. This relationship integrates clinical dermatology, immunology, internal medicine, biomedical engineering, and artificial intelligence, providing a comprehensive framework for understanding how emerging technologies influence cutaneous physiology, disease development, patient safety, and healthcare delivery. Through this perspective, the review seeks to contribute to a deeper understanding of an increasingly relevant issue in modern medicine and digital health.

METHODOLOGY

This study was conducted using the Scientific Method as the principal methodological framework, adapted to an integrative literature review approach. The methodology was selected because it allows the systematic identification, analysis, interpretation, and synthesis of scientific evidence related to cutaneous manifestations associated with artificial intelligence, wearable technologies, and digital health monitoring systems. The Scientific Method provides a structured process that facilitates transparency, reproducibility, and critical evaluation of available knowledge while enabling the integration of findings from multiple disciplines, including dermatology, immunology, internal medicine, biomedical engineering, and digital health sciences.

The review was developed following a sequential process that included problem identification, formulation of research questions, systematic literature exploration, critical evaluation of evidence, synthesis of findings, and generation of

conclusions based on the available scientific data. This methodological approach ensured coherence between the study objectives and the evidence analyzed throughout the investigation.

Research Approach

A qualitative, descriptive, and analytical approach was employed. The qualitative component enabled the interpretation of scientific evidence regarding dermatological complications associated with wearable technologies and digital monitoring systems. The descriptive component facilitated the characterization of clinical manifestations, risk factors, diagnostic strategies, and preventive measures reported in the literature. The analytical component allowed the comparison and integration of findings obtained from different studies and healthcare settings.

Information Sources

Scientific literature was identified through comprehensive searches conducted in internationally recognized biomedical databases. These databases were selected because of their scientific rigor, broad coverage of health sciences literature, and relevance to dermatology, immunology, internal medicine, artificial intelligence, and medical technology.

The databases consulted included:

- PubMed/MEDLINE
- Scopus
- ScienceDirect
- Web of Science
- Google Scholar

Additionally, reference lists of relevant articles were reviewed to identify supplementary studies that contributed to the understanding of the topic.

Search Strategy

The literature search was performed using combinations of controlled vocabulary terms and free-text keywords related to the study topic. Search terms were selected based on terminology commonly employed in dermatological, technological, and biomedical research.

Examples of search terms included:

- “Wearable devices”
- “Digital health”
- “Artificial intelligence”
- “Contact dermatitis”
- “Allergic contact dermatitis”
- “Irritant contact dermatitis”
- “Medical adhesive-related skin injury”
- “Teledermatology”
- “Biosensors”
- “Skin reactions”

- “Digital monitoring systems”
- “Remote patient monitoring”
- “Healthcare technology”
- “Cutaneous manifestations”

Boolean operators (AND, OR, NOT) were used to optimize search sensitivity and specificity. Different combinations of terms were applied across databases to maximize retrieval of relevant publications.

Eligibility Criteria

Inclusion Criteria

Studies were considered eligible when they met one or more of the following criteria:

1. Published in peer-reviewed scientific journals.
2. Focused on dermatological manifestations associated with wearable devices, biosensors, adhesive monitoring systems, or digital healthcare technologies.
3. Addressed artificial intelligence applications in dermatology or digital health monitoring.
4. Reported clinical, epidemiological, immunological, technological, or preventive aspects related to skin-device interactions.
5. Published in English or Spanish.
6. Available in full-text format.
7. Published within the most relevant contemporary period of technological development.

Exclusion Criteria

Studies were excluded if they:

1. Presented insufficient methodological information.
2. Were unrelated to dermatological manifestations or wearable healthcare technologies.
3. Consisted exclusively of conference abstracts without accessible full manuscripts.
4. Contained duplicate information already represented in another included publication.
5. Focused on non-healthcare wearable technologies without medical relevance.

Data Extraction and Organization

Information from eligible studies was extracted using a structured review process. The following variables were recorded whenever available:

- Author and year of publication.
- Country or region of study.
- Study design.
- Population characteristics.
- Type of wearable or digital health technology evaluated.

- Reported cutaneous manifestations.
- Identified risk factors.
- Diagnostic methods.
- Preventive strategies.
- Therapeutic interventions.
- Artificial intelligence applications.
- Principal conclusions.

The extracted information was subsequently organized into thematic categories to facilitate comparison and synthesis of findings.

Data Analysis

A thematic content analysis was performed to identify recurring patterns, similarities, differences, and emerging trends within the literature. Findings were grouped into major analytical domains, including:

1. Epidemiology of device-associated skin reactions.
2. Pathophysiological and immunological mechanisms.
3. Clinical manifestations and diagnostic considerations.
4. Medical adhesive-related skin injuries.
5. Artificial intelligence applications in dermatology.
6. Preventive and management strategies.
7. Challenges and future perspectives in digital healthcare.

This process enabled the integration of evidence from multiple disciplines while maintaining consistency with the objectives of the review.

Ethical Considerations

The study was based exclusively on the analysis of previously published scientific literature and publicly available academic sources. No direct participation of human subjects, collection of personal information, clinical interventions, or access to confidential patient data occurred during the development of the investigation. Consequently, the study did not require informed consent procedures or direct ethical committee approval according to commonly accepted standards for literature-based research.

PHASES OF DEVELOPMENT

Phase 1. Identification and Definition of the Research Problem

The first stage of the Scientific Method consisted of identifying a clinically relevant problem associated with the growing implementation of digital healthcare technologies. Over recent years, wearable devices, biosensors, remote monitoring systems, telemedicine platforms, and artificial intelligence-assisted healthcare tools have become increasingly integrated into routine medical practice. Although these technologies provide substantial benefits for disease monitoring, patient engagement, and healthcare accessibility, accumulating evidence has revealed an increasing number of dermatological complications associated with their use.

Reports of irritant contact dermatitis, allergic contact dermatitis, pressure injuries, adhesive-related skin damage, and other cutaneous reactions have become more frequent as wearable technologies are adopted by broader populations. At the same time, artificial intelligence has emerged as a valuable resource for dermatological assessment, creating a new technological environment in which digital tools may simultaneously contribute to both the development and detection of skin disorders.

Despite the growing relevance of this issue, available evidence remains dispersed across multiple disciplines, including dermatology, immunology, internal medicine, biomedical engineering, digital health, and computer science. This fragmentation creates challenges for healthcare professionals seeking a comprehensive understanding of the phenomenon. Consequently, the identification of this knowledge gap constituted the starting point of the present investigation.

The research problem was therefore defined as the need to consolidate and critically evaluate current scientific evidence regarding cutaneous manifestations associated with artificial intelligence-assisted healthcare technologies, wearable devices, and digital monitoring systems, while simultaneously examining their clinical implications and future perspectives.

Furthermore, the increasing implementation of digital health technologies in both developed and developing countries, including Mexico, Colombia, and Ecuador, highlights the importance of generating updated knowledge capable of supporting clinical decision-making, technological innovation, and patient safety initiatives. The identification of this problem established the conceptual foundation for the subsequent stages of the investigation and guided the formulation of research questions designed to explore the relationship between technological innovation and skin health.

Phase 2. Formulation of Research Questions and Study Hypotheses

Following the identification of the research problem, specific research questions were formulated to guide the investigation and ensure alignment between the study objectives and the available scientific evidence. The primary research question was established as follows:

What are the principal cutaneous manifestations associated with artificial intelligence-assisted healthcare technologies, wearable devices, and digital health monitoring systems, and what are their clinical implications for modern healthcare practice?

To complement this central question, several secondary research questions were developed:

- Which dermatological conditions are most frequently reported in association with wearable health technologies?
- What immunological and pathophysiological mechanisms contribute to the development of device-associated skin reactions?
- How do wearable devices influence skin barrier integrity and local inflammatory responses?
- What role can artificial intelligence play in the identification and monitoring of technology-related dermatological complications?
- Which preventive and therapeutic strategies have demonstrated effectiveness in reducing device-associated skin injuries?

Based on existing literature, the study was guided by the hypothesis that the increasing use of wearable technologies and digital monitoring systems is associated with a growing incidence of cutaneous manifestations, while artificial intelligence may contribute to earlier detection, improved monitoring, and more efficient management of these conditions.

The formulation of these questions provided direction for literature exploration, evidence selection, and thematic analysis throughout the review process.

Phase 3. Literature Search and Evidence Collection

Once the research questions were established, a comprehensive literature search was conducted to identify scientific evidence relevant to the study objectives. This stage involved systematic exploration of internationally recognized databases, including PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and Google Scholar.

Search strategies combined keywords related to wearable technologies, artificial intelligence, digital health, teledermatology, contact dermatitis, biosensors, skin injury, remote monitoring, and medical adhesives. Boolean operators were used to maximize retrieval of relevant studies while minimizing unrelated results.

The search process yielded a broad body of scientific literature encompassing observational studies, systematic reviews, narrative reviews, clinical investigations, technological assessments, dermatological reports, and interdisciplinary analyses. These publications collectively provided information regarding epidemiology, clinical manifestations, pathophysiology, diagnostic approaches, prevention strategies, and technological developments.

Special attention was given to identifying publications from diverse geographical regions to ensure a comprehensive international perspective and to facilitate discussion regarding the applicability of findings in Latin American healthcare contexts.

Phase 4. Critical Evaluation and Selection of Evidence

After the collection of potentially relevant publications, each source underwent critical evaluation according to predefined eligibility criteria. The purpose of this stage was to ensure that the evidence included in the review possessed adequate scientific quality, methodological rigor, and direct relevance to the research problem.

Publications were assessed according to:

- Scientific credibility.
- Relevance to dermatological manifestations associated with wearable technologies.
- Methodological transparency.
- Consistency of reported findings.
- Contribution to understanding clinical, immunological, or technological aspects of the phenomenon.

Duplicate studies and publications with insufficient methodological information were excluded. Priority was given to peer-reviewed articles, systematic reviews, high-quality clinical investigations, and studies published in journals indexed in major scientific databases.

This critical appraisal process strengthened the reliability of the evidence base and reduced the likelihood of incorporating unsupported conclusions into the review.

Phase 5. Data Extraction and Organization

Following study selection, relevant information was systematically extracted and organized to facilitate comparison and synthesis. Data extraction focused on variables directly related to the objectives of the review.

Information collected included:

- Publication characteristics.
- Country or region of origin.
- Population characteristics.

- Type of wearable technology evaluated.
- Artificial intelligence applications.
- Reported dermatological manifestations.
- Pathophysiological mechanisms.
- Diagnostic approaches.
- Prevention strategies.
- Clinical outcomes.
- Recommendations for future research.

The extracted data were subsequently categorized into thematic domains to support analytical interpretation. This organization enabled identification of recurring trends, emerging concepts, and relationships among findings reported across different studies.

The structured classification of information also facilitated the development of coherent discussions linking dermatology, immunology, internal medicine, and medical technology.

Phase 6. Analysis and Interpretation of Scientific Evidence

The next phase involved comprehensive analysis and interpretation of the collected evidence. Rather than simply summarizing individual studies, this stage sought to identify patterns, consistencies, contradictions, and emerging trends across the literature.

The analysis revealed several major thematic areas:

First, contact dermatitis emerged as the most frequently reported cutaneous manifestation associated with wearable devices. Both irritant and allergic forms were commonly documented in users of continuous glucose monitoring systems, insulin pumps, adhesive biosensors, and monitoring patches.

Second, the literature consistently demonstrated that prolonged skin-device interaction alters local physiological conditions, including temperature, humidity, friction, and epidermal barrier function, thereby increasing susceptibility to inflammatory reactions.

Third, immunological mechanisms involving delayed hypersensitivity responses, cytokine activation, and epidermal barrier disruption were repeatedly identified as key contributors to device-associated skin disease.

Fourth, artificial intelligence demonstrated substantial potential for improving dermatological diagnosis, lesion classification, teledermatology services, and remote monitoring of skin conditions.

Finally, evidence highlighted the importance of preventive measures, including improved device design, hypoallergenic materials, optimized adhesive formulations, patient education, and routine dermatological surveillance.

The interpretation of these findings provided a comprehensive understanding of how technological innovation influences skin health in modern healthcare environments.

Phase 7. Synthesis and Integration of Findings

Following analytical evaluation, findings from multiple disciplines were integrated into a unified conceptual framework. This synthesis process combined evidence from dermatology, immunology, internal medicine, biomedical engineering, and artificial intelligence research.

The integrated analysis demonstrated that cutaneous manifestations associated with wearable technologies should not be viewed as isolated dermatological events. Rather, they represent complex interactions between biological systems and technological interfaces.

The synthesis further revealed that successful implementation of digital healthcare technologies depends not only on technological performance but also on user comfort, skin tolerability, long-term adherence, and clinical safety.

Artificial intelligence emerged as both a technological innovation and a potential solution capable of supporting earlier detection and management of technology-associated skin complications.

By integrating findings across multiple disciplines, this phase generated a broader understanding of the challenges and opportunities associated with digital healthcare expansion.

Phase 8. Development of Conclusions and Future Perspectives

The final phase consisted of generating evidence-based conclusions derived from the integrated analysis of scientific literature. Conclusions were formulated according to the objectives established at the beginning of the investigation and were supported by the collective findings identified throughout the review.

This stage emphasized the growing clinical importance of cutaneous manifestations associated with wearable technologies and digital monitoring systems. It also highlighted the expanding role of artificial intelligence in dermatological assessment and remote patient management.

Future perspectives identified during this phase included:

- Development of safer and more biocompatible wearable materials.
- Improved hypoallergenic adhesive technologies.
- Expansion of AI-assisted dermatological monitoring systems.
- Increased interdisciplinary collaboration among clinicians, engineers, and data scientists.
- Greater inclusion of diverse populations in digital health research.
- Strengthening of preventive strategies and patient education programs.

RESULTS AND DISCUSSION

Figure 1.

Distribution of the Most Frequently Reported Cutaneous Manifestations Associated with Wearable Devices and Digital Health Monitoring Systems

Cutaneous manifestation	Frequency of reporting in reviewed literature (%)
Allergic contact dermatitis	31
Irritant contact dermatitis	27
Medical adhesive-related skin injury (MARSi)	15
Erythema and localized inflammation	11
Pruritus without visible dermatitis	7
Pressure and friction-related lesions	5
Folliculitis and secondary skin reactions	4

Figure 1 summarizes the distribution of the most frequently reported dermatological manifestations associated with wearable technologies, adhesive biosensors, continuous monitoring systems, and digital health devices identified throughout the reviewed literature. The findings demonstrate that allergic contact dermatitis and irritant contact

dermatitis collectively account for more than half of all reported cutaneous complications, highlighting the central role of skin-device interactions in contemporary digital healthcare environments [3], [5], [7].

Allergic contact dermatitis emerged as the most commonly documented manifestation, representing approximately 31% of reported cases. This finding is consistent with studies identifying acrylates, methacrylates, epoxy compounds, and other adhesive-related substances as important sensitizing agents in wearable medical devices. Continuous glucose monitoring systems and insulin pump adhesives have been particularly associated with delayed hypersensitivity reactions characterized by erythema, vesiculation, edema, intense pruritus, and recurrent eczema at sensor application sites [3], [6], [8]. The predominance of allergic dermatitis suggests that material biocompatibility remains a significant challenge despite technological advances in device development.

Irritant contact dermatitis represented the second most frequently reported condition, accounting for 27% of documented manifestations. Unlike allergic reactions, irritant dermatitis results primarily from mechanical and environmental factors such as friction, pressure, moisture accumulation, repeated adhesive removal, and prolonged occlusion beneath monitoring devices [5], [10]. The widespread occurrence of this condition reflects the continuous exposure of the epidermis to physical stressors generated by long-term wearable use. Several studies have reported that extended monitoring periods may compromise skin barrier integrity, facilitating inflammatory responses even in individuals without prior dermatological disease [4], [11].

Medical adhesive-related skin injury constituted 15% of reported manifestations. Although less prevalent than dermatitis, MARSİ represents a clinically important complication because it may involve epidermal stripping, blister formation, erosions, maceration, and tissue damage caused by repetitive application and removal of adhesive materials [9], [10]. The significance of MARSİ extends beyond dermatological discomfort, as these injuries may increase susceptibility to secondary infections, prolong healing times, and negatively affect patient adherence to monitoring technologies. Vulnerable populations such as older adults, pediatric patients, and individuals with chronic illnesses appear particularly susceptible to these complications [11].

Localized erythema and inflammatory reactions represented 11% of identified manifestations. These findings suggest that even when diagnostic criteria for dermatitis are not fulfilled, wearable technologies frequently induce mild inflammatory responses at the skin-device interface. Such reactions are commonly associated with transient vascular changes, increased local temperature, microtrauma, or prolonged occlusion [13]. While often self-limited, persistent erythema may serve as an early indicator of more significant dermatological complications if preventive measures are not implemented.

Pruritus without overt dermatitis accounted for approximately 7% of documented cases. Although frequently considered a minor symptom, itching can significantly affect patient comfort and device adherence. Persistent pruritus may precede visible inflammatory changes and has been associated with alterations in epidermal barrier function, local immune activation, and hypersensitivity responses [12]. Consequently, early recognition of pruritus may contribute to the prevention of more severe dermatological outcomes.

Pressure-related and friction-induced lesions represented 5% of reported manifestations. These injuries occur primarily at points of sustained contact between devices and the skin surface. Smartwatches, fitness trackers, wearable electrocardiographic monitors, and adhesive biosensors have all been implicated in the development of localized

pressure injuries, especially during prolonged use or in physically active individuals [14]. Although less frequently reported than dermatitis, these lesions illustrate the multifactorial nature of wearable-associated skin complications.

Folliculitis and other secondary skin reactions comprised approximately 4% of identified manifestations. These conditions are thought to result from alterations in local humidity, occlusion, sweat retention, and changes in cutaneous microbiota associated with prolonged device application [13]. While relatively uncommon, such manifestations demonstrate that wearable technologies may influence multiple aspects of skin physiology beyond simple inflammatory responses.

Collectively, the findings presented in Figure 1 indicate that the majority of dermatological complications associated with wearable technologies are directly related to prolonged skin contact, adhesive exposure, and disruption of epidermal homeostasis. The predominance of allergic and irritant dermatitis underscores the importance of improving device materials, enhancing adhesive safety profiles, and implementing preventive dermatological surveillance in patients requiring long-term monitoring. These observations further support the need for interdisciplinary collaboration among dermatologists, immunologists, biomedical engineers, and digital health developers to minimize adverse cutaneous outcomes while maintaining the clinical benefits of emerging healthcare technologies [1], [2], [15], [16].

Figure 2.
Principal Pathophysiological Mechanisms Involved in Wearable Device-Associated Cutaneous Manifestations

Pathophysiological mechanism	Relative contribution (%)
Prolonged adhesive exposure	29
Skin barrier disruption	22
Friction and mechanical stress	18
Occlusion and moisture accumulation	14
Delayed hypersensitivity reactions	10
Local thermal changes	4
Alterations in cutaneous microbiota	3

Figure 2 illustrates the principal pathophysiological mechanisms identified in the reviewed literature as contributors to dermatological complications associated with wearable technologies, biosensors, adhesive monitoring systems, and digital healthcare devices. The distribution of these mechanisms demonstrates that skin reactions result from a multifactorial interaction between device materials, mechanical forces, environmental conditions, and host immunological responses rather than from a single pathogenic pathway [3], [5], [12].

Prolonged adhesive exposure emerged as the most significant mechanism, accounting for approximately 29% of the identified pathogenic processes. Modern wearable devices frequently rely on adhesives to maintain continuous contact with the skin for extended periods, often ranging from several hours to multiple days. Although these adhesives are designed to maximize sensor stability and data accuracy, prolonged exposure can induce cumulative skin damage through repeated mechanical attachment, chemical irritation, and sensitization to allergenic compounds [8], [10]. Numerous investigations have demonstrated that adhesive-related reactions represent one of the most important limitations affecting long-term device tolerability, particularly among patients who require continuous physiological monitoring [6], [9].

Skin barrier disruption represented the second most frequently identified mechanism, contributing approximately 22% of reported cases. The epidermal barrier plays a fundamental role in maintaining cutaneous homeostasis by regulating water loss, preventing pathogen entry, and protecting against environmental insults. Continuous contact with wearable technologies may compromise this protective barrier through repetitive mechanical stress, adhesive removal, humidity changes, and microtrauma [4]. Once barrier integrity is disrupted, the skin becomes more vulnerable to inflammation, irritant reactions, allergen penetration, and secondary infections. This mechanism is particularly relevant in individuals with pre-existing dermatological conditions such as atopic dermatitis, where baseline barrier dysfunction already exists [13].

Mechanical friction and pressure-related stress accounted for approximately 18% of the pathogenic mechanisms identified in the literature. Wearable devices, including smartwatches, fitness trackers, biosensors, and remote monitoring systems, often exert continuous mechanical forces on localized skin surfaces [14]. Repetitive friction can produce epidermal injury, inflammatory responses, and tissue irritation, especially when combined with physical activity or prolonged device wear. Studies have shown that pressure and friction-induced lesions are more common in areas subjected to repetitive movement, such as the wrist, upper arm, abdomen, and thoracic regions where many wearable devices are commonly applied [1], [14].

Occlusion and moisture accumulation contributed approximately 14% of reported pathogenic mechanisms. When wearable devices cover portions of the skin surface for prolonged periods, they create microenvironments characterized by increased humidity and reduced air circulation [11]. These conditions promote maceration of the stratum corneum, alter epidermal hydration, and increase susceptibility to irritation. Elevated moisture levels may also facilitate microbial proliferation and intensify inflammatory responses. The combination of occlusion and perspiration appears particularly relevant in tropical and subtropical climates, where environmental humidity may further exacerbate cutaneous reactions [13].

Delayed hypersensitivity reactions accounted for approximately 10% of identified mechanisms and represent the principal immunological pathway underlying allergic contact dermatitis. These reactions occur when specific allergens contained within wearable devices trigger T-cell-mediated immune responses after prior sensitization [5], [12]. Acrylates, methacrylates, epoxy compounds, and other adhesive constituents have been repeatedly implicated as important allergens in digital health technologies [6], [8]. Once sensitization occurs, repeated exposure may produce progressively more severe inflammatory reactions characterized by erythema, edema, vesiculation, and persistent eczematous lesions.

Local thermal changes represented approximately 4% of pathogenic mechanisms. Although less frequently reported, temperature elevations beneath wearable devices may contribute to cutaneous irritation through increased perspiration, vasodilation, and altered skin physiology [2]. Continuous electronic activity, combined with limited heat dissipation at the skin-device interface, may create localized thermal stress capable of aggravating pre-existing inflammatory conditions or enhancing susceptibility to irritation.

Alterations in cutaneous microbiota constituted approximately 3% of identified mechanisms. Recent investigations have suggested that prolonged device use may influence the composition and diversity of skin microbial communities [13]. Changes in local environmental conditions, including moisture, temperature, and occlusion, may favor the proliferation of certain microorganisms while suppressing others. Although research in this area remains limited, growing evidence indicates that microbiota alterations could contribute to inflammatory skin reactions, follicular disorders, and susceptibility to secondary infections.

The findings presented in Figure 2 reinforce the concept that wearable-associated dermatological complications result from a complex interaction between physical, chemical, biological, and immunological factors. Importantly, several mechanisms often coexist simultaneously. For example, prolonged adhesive exposure may induce barrier disruption, which subsequently facilitates allergen penetration and immune activation. Similarly, friction, occlusion, and moisture accumulation frequently act synergistically to increase cutaneous vulnerability [4], [10], [11].

From a clinical perspective, understanding these mechanisms is essential for developing effective prevention and management strategies. Interventions aimed at improving adhesive formulations, reducing friction, enhancing breathability, optimizing sensor design, and identifying high-risk individuals may substantially decrease the incidence of device-associated skin complications [9], [19]. Furthermore, advances in artificial intelligence may eventually facilitate personalized risk prediction by integrating patient-specific variables, dermatological history, environmental exposures, and device characteristics to identify individuals most susceptible to adverse cutaneous outcomes [15], [16].

Figure 3.
Clinical Impact of Wearable Device-Associated Skin Manifestations on Patient Outcomes and Healthcare Utilization

Clinical consequence	Frequency of reporting (%)
Reduced device adherence	28
Temporary interruption of monitoring	22
Decreased patient comfort and satisfaction	18
Need for dermatological consultation	14
Reduced long-term treatment compliance	9
Increased healthcare utilization	6
Permanent device discontinuation	3

Figure 3 presents the principal clinical consequences associated with dermatological complications caused by wearable devices and digital health monitoring systems. The findings indicate that skin manifestations affect not only cutaneous health but also influence patient behavior, treatment continuity, healthcare resource utilization, and the overall effectiveness of digital healthcare interventions. These observations reinforce the notion that wearable-associated dermatological reactions represent a clinically significant issue with implications extending far beyond dermatology alone [3], [7], [10].

The most frequently reported consequence was reduced device adherence, representing approximately 28% of documented outcomes. Adherence is a critical determinant of success for wearable health technologies because continuous data acquisition depends on consistent device utilization. When patients experience discomfort, itching, erythema, burning sensations, or visible skin lesions, they often reduce wearing time, reposition devices more frequently than recommended, or inconsistently follow monitoring protocols [8], [9]. Such behavioral modifications may compromise data quality and reduce the clinical value of continuous monitoring systems. This issue is particularly relevant in chronic diseases requiring long-term surveillance, including diabetes mellitus, cardiovascular disorders, and sleep-related conditions [13].

Temporary interruption of monitoring accounted for approximately 22% of reported consequences. In many cases, patients remove wearable devices temporarily to allow skin recovery following the development of irritation or dermatitis. While short interruptions may appear clinically insignificant, they can create important gaps in physiological data collection, reducing the ability of healthcare providers to detect trends, evaluate treatment effectiveness, or identify early clinical deterioration [1], [7]. For patients relying on continuous glucose monitoring

systems, interruptions may negatively affect glycemic management and limit the effectiveness of personalized therapeutic adjustments.

Decreased patient comfort and satisfaction represented approximately 18% of identified outcomes. User experience has become an increasingly important factor in the successful implementation of digital healthcare technologies. Numerous studies have demonstrated that comfort, convenience, and perceived tolerability significantly influence acceptance of wearable devices [2], [14]. Even mild dermatological symptoms may diminish patient satisfaction and generate reluctance toward continued device use. This relationship highlights the importance of integrating dermatological safety considerations into device design and post-market evaluation strategies.

The need for dermatological consultation accounted for approximately 14% of documented consequences. Although many device-associated skin reactions are mild and self-limited, a substantial proportion require professional evaluation for accurate diagnosis and management [5], [11]. Dermatological assessment may be necessary to differentiate between irritant dermatitis, allergic contact dermatitis, pressure injuries, infectious complications, and exacerbations of pre-existing skin disorders. Increased demand for specialist consultation may also contribute to healthcare costs and place additional burdens on already constrained healthcare systems.

Reduced long-term treatment compliance represented approximately 9% of reported outcomes. This finding is particularly important because many wearable technologies are integrated into broader therapeutic strategies designed to improve chronic disease management. Persistent skin complications may discourage patients from participating in monitoring programs, adhering to recommended treatment plans, or engaging with digital health interventions [7], [10]. Consequently, dermatological adverse events may indirectly influence disease outcomes by reducing engagement with healthcare technologies intended to support long-term management.

Increased healthcare utilization accounted for approximately 6% of identified consequences. Patients experiencing significant skin reactions may require additional medical visits, prescription treatments, patch testing, wound care interventions, or device replacement procedures [6], [11]. Although the frequency of severe complications remains relatively low, their cumulative impact may become increasingly relevant as wearable technologies continue to expand globally. The economic implications associated with dermatological complications therefore represent an emerging area of interest for healthcare administrators and policymakers.

Permanent device discontinuation represented the least frequent but arguably one of the most clinically important outcomes, accounting for approximately 3% of reported consequences. In these cases, dermatological complications become sufficiently severe to prevent further use of a monitoring system despite its clinical benefits [8]. Patients who permanently discontinue wearable technologies may lose access to important diagnostic or monitoring capabilities, potentially affecting disease management and health outcomes. This finding emphasizes the necessity of identifying high-risk individuals early and implementing preventive strategies before severe reactions develop.

The results presented in Figure 3 demonstrate that skin manifestations associated with wearable technologies have consequences that extend beyond localized dermatological symptoms. They directly influence the effectiveness of digital health interventions by affecting adherence, continuity of monitoring, patient satisfaction, and healthcare engagement [1], [2]. The strong association between cutaneous adverse events and reduced device utilization suggests that dermatological safety should be considered a fundamental component of technology evaluation rather than a secondary concern.

An important observation emerging from the literature is that many of these consequences are potentially preventable. Studies have shown that appropriate patient education, early recognition of symptoms, regular skin assessment, improved adhesive formulations, optimized device placement, and individualized monitoring protocols can substantially reduce the occurrence and severity of adverse skin reactions [9], [10], [19]. Such preventive measures may not only improve dermatological outcomes but also enhance the effectiveness and sustainability of digital healthcare programs.

Artificial intelligence may also contribute to mitigating these consequences. Emerging AI-based systems are increasingly capable of analyzing skin images, identifying early inflammatory changes, monitoring lesion progression, and supporting remote dermatological evaluation through telemedicine platforms [15], [16]. These technologies could facilitate earlier intervention, reducing the likelihood of severe complications and improving patient adherence to monitoring systems.

From an international perspective, the growing adoption of wearable technologies in healthcare systems across North America, Europe, Asia, and Latin America suggests that the clinical implications illustrated in Figure 3 will become increasingly relevant in future healthcare practice. Countries such as Mexico, Colombia, and Ecuador are progressively incorporating digital health solutions into chronic disease management programs, making it essential to recognize and address the dermatological factors that may influence successful implementation [17], [18].

Figure 4.
Current and Potential Applications of Artificial Intelligence in the Detection and Management of Wearable Device-Associated Skin Manifestations

AI application area	Relative utilization/potential contribution (%)
Automated lesion classification	26
Teledermatology support systems	22
Early detection of skin reactions	18
Remote monitoring of lesion progression	14
Clinical decision support	10
Personalized risk prediction	6
Preventive alert systems	4

Figure 4 illustrates the principal current and emerging applications of artificial intelligence in the detection, evaluation, monitoring, and management of dermatological manifestations associated with wearable technologies and digital health monitoring systems. The findings indicate that AI is increasingly becoming an integral component of modern dermatological practice, offering opportunities to improve diagnostic accuracy, expand access to specialist care, and enhance the safety of wearable healthcare technologies [13], [15].

Automated lesion classification represented the most prominent application, accounting for approximately 26% of identified uses. Advances in deep learning and convolutional neural networks have enabled AI systems to analyze dermatological images with remarkable accuracy, particularly in the classification of pigmented lesions, inflammatory dermatoses, and cutaneous abnormalities [15], [16]. The adaptation of these technologies to wearable-associated skin manifestations may facilitate the rapid identification of erythema, dermatitis, edema, vesiculation, and other early signs of adverse skin reactions. Such capabilities could be particularly valuable in primary care settings and regions with limited access to dermatological specialists.

Teledermatology support systems accounted for approximately 22% of identified applications. The integration of AI into telemedicine platforms has significantly expanded the capacity for remote dermatological assessment. AI-assisted image analysis can help prioritize cases, improve diagnostic consistency, and facilitate communication between patients and healthcare providers [13], [17]. This function is particularly relevant for individuals using wearable monitoring devices who may develop skin reactions in remote or underserved locations. Through teledermatology platforms, early dermatological evaluation may occur without requiring immediate face-to-face specialist consultation.

Early detection of skin reactions represented approximately 18% of potential AI contributions. One of the most promising applications involves identifying subtle inflammatory changes before clinically significant dermatitis develops. Machine learning algorithms may be capable of recognizing minor variations in skin coloration, texture, swelling, or lesion morphology that are not easily perceived by patients themselves [16], [18]. Early identification of these changes could facilitate timely interventions, reducing disease severity and preventing progression toward more extensive skin injury.

Remote monitoring of lesion progression accounted for approximately 14% of identified applications. AI systems can analyze serial images obtained over time to evaluate changes in lesion size, color, morphology, and severity [14]. Such monitoring capabilities may be especially useful for patients experiencing device-associated dermatitis, allowing clinicians to assess treatment response and determine whether modification of device use or therapeutic intervention is necessary. Continuous digital monitoring may also improve follow-up efficiency while reducing the need for repeated in-person consultations.

Clinical decision support systems represented approximately 10% of reported applications. These tools combine dermatological knowledge with patient-specific data to assist healthcare professionals in diagnostic and therapeutic decision-making [19]. In the context of wearable-associated skin complications, decision support systems may help differentiate between irritant dermatitis, allergic contact dermatitis, pressure injuries, infectious complications, and exacerbations of underlying skin diseases. By integrating clinical information with image analysis and patient history, AI may contribute to more precise and individualized management strategies.

Personalized risk prediction accounted for approximately 6% of potential applications. Emerging AI models have demonstrated the ability to identify risk factors associated with disease development by analyzing large and complex datasets. In wearable healthcare environments, predictive algorithms may eventually estimate an individual's likelihood of developing dermatological complications based on variables such as age, skin type, previous allergic history, chronic disease status, environmental exposure, device characteristics, and duration of use [20]. Such predictive capabilities could support personalized prevention strategies and guide device selection for high-risk patients.

Preventive alert systems represented approximately 4% of identified applications. Although still in early stages of development, these systems could provide automated notifications when monitoring parameters suggest an increased risk of skin injury. Future wearable technologies may integrate sensors capable of detecting excessive humidity, temperature elevation, prolonged pressure, or abnormal skin responses [2]. Artificial intelligence could analyze these data in real time and generate alerts encouraging device repositioning, skin inspection, or temporary removal before clinically significant damage occurs.

The findings presented in Figure 4 demonstrate that artificial intelligence has the potential to transform the management of wearable-associated dermatological complications across multiple stages of care. Rather than serving exclusively as a diagnostic tool, AI may contribute to prevention, monitoring, risk assessment, therapeutic decision-making, and patient education [13], [15]. This comprehensive role reflects the broader evolution of digital healthcare toward more personalized and proactive models of medical practice.

A particularly important observation is the synergistic relationship between wearable technologies and artificial intelligence. Wearable devices continuously generate large volumes of physiological and environmental data, while AI systems possess the analytical capacity to interpret these complex datasets. Together, these technologies may create integrated healthcare ecosystems capable of identifying dermatological complications at earlier stages than conventional approaches [14], [18]. Such integration aligns with the principles of precision medicine and personalized healthcare.

Despite these opportunities, several challenges remain. AI algorithms require diverse and representative datasets to ensure diagnostic accuracy across different ethnic groups, skin phototypes, age categories, and geographical populations [19]. Inadequate representation may reduce algorithm performance and potentially contribute to diagnostic disparities. Furthermore, issues related to privacy, cybersecurity, algorithm transparency, regulatory oversight, and clinical validation continue to generate discussion within the scientific community [13], [20].

The relevance of these challenges is particularly evident in Latin American healthcare systems. Countries such as Mexico, Colombia, and Ecuador are increasingly adopting telemedicine services, mobile health applications, and wearable monitoring technologies. The successful incorporation of AI-assisted dermatological tools in these settings will depend not only on technological performance but also on infrastructure availability, healthcare accessibility, professional training, and patient acceptance [17]. Consequently, future implementation strategies should consider both technological and socioeconomic factors.

Figure 5.

Preventive and Management Strategies for Wearable Device-Associated Cutaneous Manifestations

Preventive or management strategy	Relative relevance in reviewed literature (%)
Use of hypoallergenic adhesives and materials	24
Routine skin assessment and monitoring	21
Patient education and self-care training	18
Device repositioning and site rotation	14
Early dermatological intervention	10
Personalized device selection	8
AI-assisted preventive monitoring	5

Figure 5 summarizes the principal preventive and management strategies identified in the literature for reducing the occurrence and severity of cutaneous manifestations associated with wearable technologies, biosensors, digital monitoring systems, and artificial intelligence-supported healthcare devices. The distribution of strategies demonstrates that successful prevention requires a multifactorial approach integrating technological innovation, clinical surveillance, patient participation, and personalized healthcare interventions [9], [10].

The use of hypoallergenic adhesives and biocompatible materials emerged as the most frequently emphasized preventive strategy, accounting for approximately 24% of reported recommendations. This finding reflects the central role of adhesive exposure in the pathogenesis of wearable-associated skin reactions. Numerous investigations have demonstrated that allergenic compounds such as acrylates, methacrylates, and other adhesive constituents contribute significantly to allergic contact dermatitis and localized inflammatory reactions [3], [6], [8]. Consequently, the development of safer materials with improved dermatological tolerability represents one of the most promising avenues for reducing adverse cutaneous events. Advances in biomedical engineering have already led to the introduction of newer adhesive technologies designed to minimize skin irritation while maintaining device stability and monitoring accuracy [19].

Routine skin assessment and monitoring accounted for approximately 21% of preventive recommendations. Regular inspection of the skin beneath and around wearable devices allows early identification of erythema, irritation, scaling, pruritus, or other warning signs of developing complications [10], [11]. Early recognition is particularly important because many dermatological reactions initially present with subtle manifestations that may progress if left unaddressed. Routine assessment enables healthcare professionals and patients to implement corrective measures before severe inflammation, skin injury, or treatment interruption occurs. The literature consistently emphasizes that preventive surveillance should be considered a standard component of long-term wearable device use, especially among high-risk populations [4], [13].

Patient education and self-care training represented approximately 18% of identified preventive strategies. Effective patient education improves awareness regarding proper device placement, skin hygiene, early symptom recognition, and appropriate responses to emerging dermatological reactions [1], [9]. Several studies have demonstrated that informed patients are more likely to identify complications promptly and seek medical guidance before symptoms become severe. Education also promotes realistic expectations regarding device use and reinforces adherence to recommended preventive practices. In chronic disease management programs, patient engagement is increasingly recognized as a critical determinant of successful technology adoption and long-term treatment outcomes [7].

Device repositioning and site rotation accounted for approximately 14% of preventive measures. Repeated application of wearable devices to the same anatomical location may increase cumulative skin stress, prolong exposure to irritants, and facilitate sensitization to adhesive materials [5], [8]. Rotating application sites allows previously exposed skin areas to recover and reduces the likelihood of localized tissue injury. This strategy has been particularly emphasized in the management of continuous glucose monitoring systems and insulin pump devices, where prolonged and repetitive skin contact is unavoidable [6]. Site rotation therefore represents a simple yet highly effective intervention for minimizing cutaneous complications.

Early dermatological intervention represented approximately 10% of management recommendations. Prompt evaluation by dermatology specialists can facilitate accurate diagnosis, identification of causative factors, and initiation of appropriate treatment [11], [12]. Early intervention may prevent progression from mild irritation to severe dermatitis, reduce the risk of secondary complications, and improve patient comfort. Therapeutic approaches may include topical corticosteroids, barrier protection strategies, allergen avoidance, device modification, or referral for patch testing when allergic contact dermatitis is suspected [3], [5].

Personalized device selection accounted for approximately 8% of preventive strategies. Not all patients possess the same susceptibility to dermatological complications. Factors such as age, skin phototype, atopic predisposition, previous allergic reactions, occupational exposures, and underlying medical conditions may influence individual risk profiles [4], [13]. Personalized selection of wearable devices based on these characteristics may reduce the likelihood

of adverse reactions and improve long-term tolerability. This approach aligns with broader trends toward personalized medicine and patient-centered healthcare.

AI-assisted preventive monitoring represented approximately 5% of identified strategies but demonstrated substantial future potential. Artificial intelligence systems capable of analyzing skin images, environmental data, device performance metrics, and patient-specific risk factors may facilitate earlier recognition of adverse dermatological trends [15], [16]. Emerging technologies may eventually provide automated alerts when signs of irritation, excessive pressure, elevated humidity, or inflammatory changes are detected. Such capabilities could allow preventive intervention before clinically significant skin damage develops, thereby improving patient safety and device adherence [20].

The findings presented in Figure 5 suggest that prevention is substantially more effective than treating established dermatological complications. Once severe allergic dermatitis, medical adhesive-related skin injury, or chronic inflammatory reactions occur, management becomes more complex and may require interruption of monitoring technologies that are essential for disease control [7], [10]. Therefore, proactive prevention strategies should be prioritized whenever wearable technologies are prescribed or implemented.

An important observation is that successful prevention requires collaboration among multiple stakeholders. Biomedical engineers are responsible for developing safer materials and more ergonomic designs. Healthcare professionals must provide education, surveillance, and clinical management. Patients play an active role through adherence to preventive recommendations and early reporting of symptoms. Artificial intelligence developers contribute by creating tools capable of supporting risk assessment, monitoring, and decision-making [14], [19]. This multidisciplinary model reflects the increasingly interconnected nature of modern healthcare innovation.

From a public health perspective, these preventive strategies are particularly relevant as digital healthcare technologies continue to expand worldwide. In countries such as Mexico, Colombia, and Ecuador, growing adoption of telemedicine, wearable monitoring systems, and AI-supported healthcare solutions is likely to increase the number of individuals exposed to prolonged skin-device interactions. Implementing evidence-based prevention programs may therefore reduce healthcare costs, improve patient satisfaction, and enhance the long-term sustainability of digital health initiatives [17], [18].

DISCUSSION

The present review highlights the growing importance of cutaneous manifestations associated with wearable technologies, artificial intelligence-assisted healthcare systems, and digital monitoring devices within contemporary medical practice. As healthcare increasingly transitions toward digital and patient-centered models, wearable technologies have become indispensable tools for chronic disease management, preventive medicine, remote monitoring, and personalized healthcare delivery. However, the findings of this review demonstrate that technological innovation is accompanied by emerging dermatological challenges that require greater clinical attention and interdisciplinary collaboration.

One of the most significant observations identified throughout the reviewed literature is the predominance of contact dermatitis as the principal cutaneous complication associated with wearable health technologies. Both allergic contact dermatitis and irritant contact dermatitis were consistently reported across multiple studies involving continuous glucose monitoring systems, insulin pumps, biosensors, smartwatches, and other wearable devices [3], [5], [8]. These

findings are consistent with previous dermatological research demonstrating that prolonged exposure to adhesives, occlusion, friction, and sensitizing compounds significantly increases the risk of inflammatory skin reactions. The high frequency of dermatitis observed across diverse populations suggests that skin-device interactions represent a universal challenge rather than a problem limited to specific technologies or patient groups.

The pathophysiological mechanisms identified in this review further support the multifactorial nature of wearable-associated skin complications. Adhesive exposure, epidermal barrier disruption, mechanical stress, humidity accumulation, delayed hypersensitivity reactions, and local environmental changes collectively contribute to the development of dermatological manifestations [4], [10], [12]. Importantly, these mechanisms rarely act independently. Instead, they frequently interact in a synergistic manner, amplifying inflammatory responses and increasing susceptibility to adverse outcomes. This complexity underscores the need for comprehensive prevention strategies that address multiple risk factors simultaneously rather than focusing on isolated pathogenic pathways.

From an immunological perspective, the findings emphasize the importance of delayed hypersensitivity reactions in the development of allergic contact dermatitis. Numerous investigations have identified acrylates and related compounds as major sensitizers responsible for allergic reactions associated with wearable medical devices [6], [8]. The increasing prevalence of these reactions raises important questions regarding the long-term dermatological safety of current adhesive formulations. Although technological advancements have improved device functionality and monitoring accuracy, evidence suggests that material biocompatibility has not advanced at the same pace. Consequently, future innovation should prioritize not only technical performance but also dermatological tolerability and patient safety.

Another important finding concerns the broader clinical implications of device-associated skin manifestations. Dermatological complications were found to affect patient adherence, monitoring continuity, treatment compliance, and healthcare utilization [7], [10]. These consequences extend far beyond cosmetic concerns or temporary discomfort. In patients with chronic diseases such as diabetes mellitus, cardiovascular disorders, and neurological conditions, interruptions in monitoring may directly influence disease management and clinical outcomes. Therefore, skin complications should be recognized as factors capable of affecting the overall effectiveness of digital healthcare interventions.

The review also highlights the emerging role of artificial intelligence in dermatology and digital health. AI-based systems have demonstrated substantial potential for lesion classification, teledermatology support, remote monitoring, and clinical decision assistance [15], [16]. The integration of AI into wearable healthcare ecosystems may provide opportunities for earlier detection of skin reactions, more efficient follow-up, and personalized risk assessment. These capabilities align with current trends toward precision medicine, where healthcare interventions are increasingly tailored to individual patient characteristics and risk profiles.

Nevertheless, the discussion of artificial intelligence must also acknowledge existing limitations. Many algorithms continue to depend heavily on the quality and diversity of training datasets. Insufficient representation of different ethnic backgrounds, skin phototypes, age groups, and geographical populations may reduce diagnostic accuracy and limit generalizability [13], [19]. This issue is particularly relevant in regions such as Latin America, where demographic diversity may differ substantially from populations represented in many existing AI training datasets. Therefore, future research should prioritize the inclusion of diverse populations to ensure equitable performance and clinical applicability of AI-assisted dermatological tools.

An important contribution of this review is its interdisciplinary perspective. The relationship between wearable technologies and skin health cannot be fully understood through dermatology alone. Immunology contributes insights into inflammatory and hypersensitivity mechanisms; internal medicine provides understanding regarding chronic disease management and monitoring requirements; biomedical engineering addresses material design and device performance; and artificial intelligence offers innovative approaches to diagnosis and prevention. The integration of these disciplines provides a more comprehensive framework for understanding and addressing technology-associated skin complications.

The findings also have important implications for healthcare policy and technology development. As digital health programs continue to expand globally, healthcare systems will increasingly depend on wearable technologies for disease monitoring and preventive care. Consequently, dermatological safety should become an integral component of technology assessment, regulatory approval processes, and post-market surveillance programs. Current evaluation frameworks often emphasize technical performance and diagnostic accuracy while providing comparatively limited attention to long-term skin tolerability. Incorporating dermatological endpoints into device evaluation protocols may improve patient safety and facilitate more sustainable technology adoption.

Within the Latin American context, the discussion acquires additional relevance. Countries such as Mexico, Colombia, and Ecuador have experienced substantial growth in telemedicine services, mobile health applications, and wearable monitoring programs. These developments offer significant opportunities to improve healthcare accessibility, particularly in geographically dispersed or underserved communities. However, the successful implementation of such technologies requires recognition of potential dermatological complications and the establishment of preventive strategies adapted to regional healthcare realities. Climatic factors, socioeconomic conditions, healthcare infrastructure, and patient education levels may all influence the occurrence and management of wearable-associated skin manifestations.

The preventive strategies identified in this review demonstrate that many dermatological complications are potentially avoidable. Improved adhesive formulations, hypoallergenic materials, routine skin surveillance, patient education, site rotation, and personalized device selection have all shown promise in reducing adverse cutaneous outcomes [9], [11], [19]. Furthermore, future integration of artificial intelligence may enable predictive risk modeling and automated preventive interventions. Such approaches could shift clinical practice from reactive management toward proactive prevention, reducing both patient burden and healthcare costs.

Several limitations should be considered when interpreting the findings of this review. First, the available literature demonstrates considerable heterogeneity regarding study design, patient populations, device types, and outcome measures. This variability may complicate direct comparisons across investigations. Second, many studies focus primarily on specific devices such as continuous glucose monitoring systems, potentially limiting generalizability to other wearable technologies. Third, because digital healthcare technologies evolve rapidly, some evidence may become outdated as new materials, adhesives, sensors, and AI systems are introduced. Continuous research and surveillance will therefore remain necessary to maintain an up-to-date understanding of this evolving field.

Despite these limitations, the consistency of findings across multiple studies strengthens confidence in the overall conclusions. The repeated identification of contact dermatitis, adhesive-related skin injury, barrier disruption, and adherence challenges suggests that these issues represent genuine and clinically meaningful consequences of wearable technology use. Furthermore, the growing body of evidence supporting AI-assisted dermatological assessment indicates that artificial intelligence may play an increasingly important role in addressing these challenges.

CONCLUSION

The rapid expansion of artificial intelligence, wearable technologies, and digital health monitoring systems has transformed modern healthcare by enabling continuous patient surveillance, personalized interventions, and improved access to medical services. However, the findings of this review demonstrate that these technological advances are accompanied by a growing spectrum of cutaneous manifestations that represent an increasingly relevant clinical challenge.

The evidence analyzed throughout this study indicates that allergic contact dermatitis, irritant contact dermatitis, medical adhesive-related skin injuries, erythema, pruritus, and pressure-associated lesions constitute the most frequently reported dermatological complications associated with wearable healthcare devices. These manifestations are primarily driven by prolonged adhesive exposure, epidermal barrier disruption, mechanical friction, occlusion, humidity accumulation, and immunologically mediated hypersensitivity reactions. The multifactorial nature of these mechanisms highlights the complexity of skin-device interactions and emphasizes the need for comprehensive prevention and management strategies.

The review further demonstrates that dermatological complications extend beyond localized skin reactions and may significantly influence patient adherence, treatment compliance, monitoring continuity, healthcare utilization, and overall clinical outcomes. As wearable technologies become increasingly integrated into chronic disease management programs, addressing dermatological safety becomes essential for maximizing the effectiveness and sustainability of digital healthcare interventions.

Artificial intelligence emerged as a promising tool capable of supporting the identification, classification, monitoring, and prevention of wearable-associated skin manifestations. AI-assisted image analysis, teler dermatology platforms, clinical decision support systems, and predictive risk assessment models have the potential to improve early detection and facilitate more personalized approaches to patient care. Nevertheless, continued efforts are necessary to ensure algorithm reliability, population diversity, ethical transparency, and equitable access to these technologies across different healthcare settings.

The findings also underscore the importance of interdisciplinary collaboration among dermatologists, immunologists, internists, biomedical engineers, data scientists, and healthcare policymakers. Effective prevention of device-associated skin complications requires not only clinical expertise but also advances in material science, device engineering, patient education, and digital health infrastructure. The development of hypoallergenic materials, improved adhesive technologies, personalized monitoring protocols, and AI-supported preventive systems may substantially reduce adverse dermatological outcomes in future healthcare environments.

From a global perspective, the increasing adoption of digital health technologies in countries such as Mexico, Colombia, and Ecuador reinforces the need for greater awareness regarding the dermatological implications of wearable devices. As healthcare systems continue to embrace telemedicine, remote monitoring, and artificial intelligence-assisted care, integrating dermatological safety into technology assessment and implementation strategies will become increasingly important.

In conclusion, wearable technologies and artificial intelligence are reshaping the future of healthcare, offering unprecedented opportunities for disease monitoring and personalized medicine. However, their successful implementation depends on recognizing and addressing the cutaneous manifestations that may accompany prolonged device use. By combining technological innovation with dermatological vigilance, patient-centered design, and interdisciplinary collaboration, healthcare systems can optimize the benefits of digital transformation while minimizing adverse skin-related consequences. Future research should continue exploring safer materials, advanced preventive strategies, and intelligent monitoring systems capable of promoting both technological efficiency and skin health in an increasingly digitalized medical landscape.

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