International Journal of Engineering Trends and Technology
ISSN: 2231-5381/ https://doi.org/10.14445/22315381/IJETT-V74I8P131
Volume 74 Issue 8, 463-482, August 2026

Review Article

Impact of Telemedicine on Non-Contact Monitoring Systems: A Systematic Review

Brigitte Torres-Pinedo[1], Sebastián Ramos-Cosi[2], Ana Huamani-Huaracca[3]

[1,2,3]*Image Processing Research Laboratory (INTI-Lab), University of Sciences and Humanities, Lima, Peru.*

[3]*Corresponding Author : ahuamani@uch.edu.pe*

Received: 20 March 2026 Revised: 25 July 2026 Accepted: 06 August 2026 Published: 29 August 2026

Abstract - *In recent years, the integration of telemedicine has been transforming different environments. In the context of health, the incorporation of contactless monitoring systems supported by telemedicine has become a relevant option in the way of monitoring patients remotely and facilitating access to health services, however, its literature is dispersed. Therefore, this study aimed to conduct a systematic review that encompasses the current evidence of telemedicine as a tool to accurately monitor patients remotely in real time. Applying the PRISMA methodology, 55 relevant documents were extracted from the Scopus, WoS, Pubmed and IEEE Xplore databases, among them 24 keywords were identified, of which "telemedicine" and "patient monitoring" stand out. In addition, it was identified that the United States stands out in co-authorship between countries, and since 2016, scientific production has been gradually increasing. Content-specific results indicated that 49 papers directly related to the impact of telemedicine technologies, 3 focused on opportunities for optimizing the quality of remote care and predictive analytics, and the remaining 3 explored the limitations and challenges of contactless monitoring systems. The review concludes by stating that this type of technology has great potential to support health professionals, however, it is necessary to improve and address the limitations.*

Keywords - *Contactless sensors, Telemedicine, Monitoring systems, Telehealth, Review.*

1. Introduction

Currently, telemedicine has seen significant scientific and technological advances in specialized remote healthcare applications [1]. It has also been under increasing pressure due to the rising number of cases of chronic diseases, an aging population, and the need for physicians to identify clinical abnormalities in patients in a timely manner. According to a report by the World Health Organization (WHO), in 2021, noncommunicable diseases caused approximately 43 million deaths, representing 75% of deaths not linked to the pandemic that occurred that year [2].

In most cases, these premature deaths occurred among families with low and middle incomes. It is worth noting that, in many health centers, it is sometimes difficult for patients to secure a medical appointment, which prevents them from receiving ongoing monitoring of their respiratory rate, heart rate, body temperature, mobility, and other physiological signs. Although some health care specialists believe that in-person care is the most effective way to provide high-quality care, they fail to take into account that, in some cases, the need for physical resources, travel times, and the availability of clinical staff lead to significant gaps in care, especially for patients with chronic conditions such as heart disease, cancer, diabetes, arthritis, Alzheimer's, and kidney disease [3]. However, with the onset of the COVID-19 pandemic in 2020, consultations shifted to a virtual format due to restrictions on physical contact, so doctors had to adapt to the situation and learn to provide medical guidance through mobile apps and remote monitoring platforms to help reduce the spread of the virus. Despite this, digitalization progressed unevenly, as in some cases-such as poor signal or internet connectivity-these factors posed obstacles to receiving or providing medical care [4].

Despite the challenges many healthcare professionals faced in learning new digital modernization techniques-and having to provide medical care in a different format-contactless monitoring systems on telemedicine platforms have significantly contributed to the accuracy and continuity of clinical follow-up to this day.

Furthermore, some studies highlight technologies such as Doppler radar [5, 6], optical sensors, and computer vision, as they enable accurate estimates of parameters such as respiratory and heart rates, even in uncontrolled environments. Similarly, a study focused on the development of Doppler radar sensors and the verification of their effectiveness demonstrated an accuracy of over 95% compared to conventional ECG devices for measuring heart rate [7].

Similarly, it has been demonstrated that the use of sensors based on the Doppler radar principle not only represents a technological advancement but also offers a safe and effective option for remote patient monitoring, especially in situations where direct contact may be restricted or dangerous. Crucially, the 95% accuracy achieved in this study provides reliable real-time data, enabling healthcare professionals to make faster and more effective decisions when providing remote care to their patients. Although progress has been made in developing an accepted standard for evaluating noncontact monitoring systems, standardized methods for evaluating them do not yet exist [8]; consequently, discrepancies arise between studies due to the different approaches, metrics, and parameters applied (i.e., study sample size) [9]. On the one hand, numerous studies have analyzed individual types of sensors or methods; however, none indicate which is most suitable for telemedicine due to their isolated nature. On the other hand, most studies have been conducted under controlled conditions [10, 11], which limits the availability of data on the performance of these systems in real-world conditions.

Therefore, the objective of this study is to conduct a systematic analysis of current non-contact monitoring systems used in telemedicine platforms for the remote monitoring of patients. It seeks to address the following questions: What are the effects of telemedicine in providing high-quality contactless monitoring? What are the potential limitations and challenges of contactless monitoring systems? What opportunities will arise to improve the quality of remote care through predictive analysis of contactless monitoring devices? Based on these questions, the objective of this study is to conduct a systematic review of the current literature on telemedicine as a method for accurate, real-time monitoring of patients at home, thereby enabling earlier intervention and improving patient outcomes. While other reviews have focused primarily on a specific area, this review will simultaneously consider the benefits, challenges, and opportunities for improving the quality of remote monitoring devices, thereby contributing to a deeper understanding of the topic.

Finally, the article is organized into four sections that provide a comprehensive overview of non-contact patient monitoring systems. First, the workflow methodology is presented. Next, the results regarding the evolution of telemedicine in recent years and its contributions to the field of healthcare are presented. Subsequently, a discussion will be held to analyze the results obtained and their implications. Furthermore, the conclusions of this study are presented as recommendations for future specialists who wish to explore the topic in greater depth.

2. Materials and Methods

In the present research, a systematic review approach was employed, thus ensuring the accuracy and clarity of the information collected in relation to non-contact monitoring systems based mainly on telemedicine. A systematic review is a research method that helps to identify, evaluate, and compile all relevant scientific studies related to a single research topic, using an unbiased method. Systematic reviews differ from other types of reviews because they are more modern (from a narrative perspective) and less focused (from a methodological perspective). Unlike other types of reviews, systematic reviews use greater methodological precision (with inclusion criteria) and subjectively critical assessments, which leads to the development of more objective conclusions 005B12]. This section will describe the general process of locating and critically analyzing potential studies, along with the unique characteristics of each.

Second, due to the diversity of academic disciplines used to study telehealth, the PRISMA method (Preferred Report Items for Systematic Reviews and Meta-analyses) was employed. PRISMA provides a systematic method for evaluating and selecting literature with clear and defined selection criteria, and allows for a systematic and replicable evaluation of selected literature [13].

2.1. Study Design

This study was designed as a systematic literature review with bibliometric and narrative synthesis. This type of approach is commonly used to compile and analyze existing research in order to assess progress in a specific field of study [14]. The purpose of this study was to analyze trends, compare clinical and technological perspectives on remote monitoring systems, and identify areas with limited research, specifically regarding continuous monitoring.

This review reviewed the various studies conducted in various healthcare settings where the use of non-contact remote monitoring alternatives using various computational methods (e.g., advanced optical technologies or remote sensing) was suggested or analyzed. Due to the wide variety of study designs, evaluation methods, and applications of these remote monitoring alternatives, a quantitative approach was not used to analyze the data; instead, a qualitative approach, together with bibliometric analysis, was employed to identify publishing trends and emerging research areas, which is suggested as a valuable resource for conducting comprehensive assessments of the progress of a scientific discipline [15]. Using this approach, the present study provides an overview of the current state of the scientific discipline and identifies opportunities for future research.

2.2. Data Sources

An exhaustive literature review on this topic was carried out using four independent and consolidated academic sources: PubMed, Scopus, IEEE Xplore and Web of Science (WoS). These sources were selected for their ability to address this research topic holistically, including the large number of interdisciplinary fields referenced in both Scopus and WoS (two of the most widely used databases to identify and cite high-impact scientific literature). In addition, PubMed provides full access to clinical and healthcare research, while IEEE Xplore offers studies focused on advanced contactless technologies, such as systems, sensors, and digital technologies, for remote monitoring of people. Overall, the combined use of these four databases has allowed the authors to gain a broad and diverse perspective of the area of study, while minimizing the risk of overlooking important contributions.

2.3. Search Strategy

Boolean operators were used to implement the different search methods according to the syntax and characteristics of each database. Each formula consisted of a combination of keywords related to telemedicine and contactless sensors. The keywords, along with linguistic variations and abbreviations, allowed the scope of the search to be broadened to include other concepts related to sensors, physiological parameters, and diagnostic methods. The use of these keywords was carried out through the specifications offered by each database and in fields such as title, abstract and keywords, highlighting the search for studies strictly related to telemedicine and non-contact sensor technology. For each database, the keywords used in the search process are shown below:

- Scopus: TITLE-ABS-KEY ((telemedic* OR telehealth OR ehealth OR mhealth OR "digital health" OR "remote healthcare") AND (monitor* OR "remote monitoring" OR "patient monitoring" OR "vital signs" OR "physiological monitoring" OR "heart rate" OR "respiratory rate") AND (contactless OR "non-contact" OR noncontact OR "remote sensor*" OR radar OR "Doppler radar" OR "radio frequency" OR RF OR ultrasonic OR ultrasound OR "computer vision" OR "thermal imaging" OR infrared OR hybrid))
- Web of Science (WoS): TI=(Telemedic* OR telehealth OR ehealth OR mhealth) AND TI=(contactless OR "non contact" OR "non-contact")
- Pubmed: (telemedicine[Title] OR telehealth[Title] OR ehealth[Title] OR mhealth[Title]) AND (contactless[Title] OR "non contact"[Title] OR "non-contact"[Title])
- IEEE Xplore: ("Document Title": Telemedic* OR "Document Title": telehealth OR "Document Title":ehealth OR "Document Title":mhealth) AND ("Document Title": contactless OR "Document Title": "non contact" OR "Document Title": "non-contact" OR "Document Title": sensor)

It should be noted that, as a complementary and targeted effort, a review was conducted to analyze emerging contactless monitoring methods, including radio-frequency sensors, ultrasonic sensors, thermography, infrared sensors, computer vision, and hybrid systems. This was used to expand the information from the systematic review and provide support for the comparative analysis, without altering the bibliometric corpus obtained from the search strategy.

2.4. Study Selection Process

Figure 1 graphically illustrates the study selection process, which followed the PRISMA phases: identification, filtering, screening, eligibility, and inclusion. The first stage of identification consists of an initial search in each database, culminating in the selection of relevant articles. In this first phase, a total of 24,797 publications were retrieved from the four databases: 875 from Scopus, 4,362 from Web of Science, 15,206 from PubMed, and 2,354 from IEEE Xplore.

Subsequently, during the filtering phase, general rules were applied-such as document type and subject areas-specifically ensuring that the topics were directly related to the study and that the articles were open access, in order to refine the filtered records.

Furthermore, documents were considered eligible based on criteria such as thematic relevance, access to the full text, document type, the 2021–2025 time period, and relevance to contactless monitoring systems in telemedicine, resulting in a total of 456 articles: 241 from Scopus, 18 from Web of Science, 25 from PubMed, and 72 from IEEE Xplore.

During the screening phase, a thorough analysis of the titles and abstracts was conducted, resulting in the exclusion of 398 articles that were not relevant to the study because they did not address the main topic, were irrelevant applications, or did not contain sufficient technical and clinical information. Consequently, only 58 articles were selected for further analysis.

Furthermore, during the eligibility phase, it was found that among the 58 articles that had been retained from a previous analysis, 3 were duplicates; consequently, in the final inclusion phase, only 55 articles remained, which formed the basis for the qualitative, comparative, and bibliometric analyses.

All articles in this study were managed and organized using Mendeley, a bibliographic management tool useful for organizing collected articles for further analysis. This made it easier to analyze and simplified the review of these research articles. In addition, for each article, relevant bibliographic data such as authors, date of publication, journal and numerical data were obtained, which allowed the analysis to focus on open data. Subsequently, the VOSviewer and Bibliometrix applications were used, bibliometric tools [16, 17] widely used in various researches, since they allow the generation of visual graphs that facilitate the interpretation and detailed analysis of scientific production.

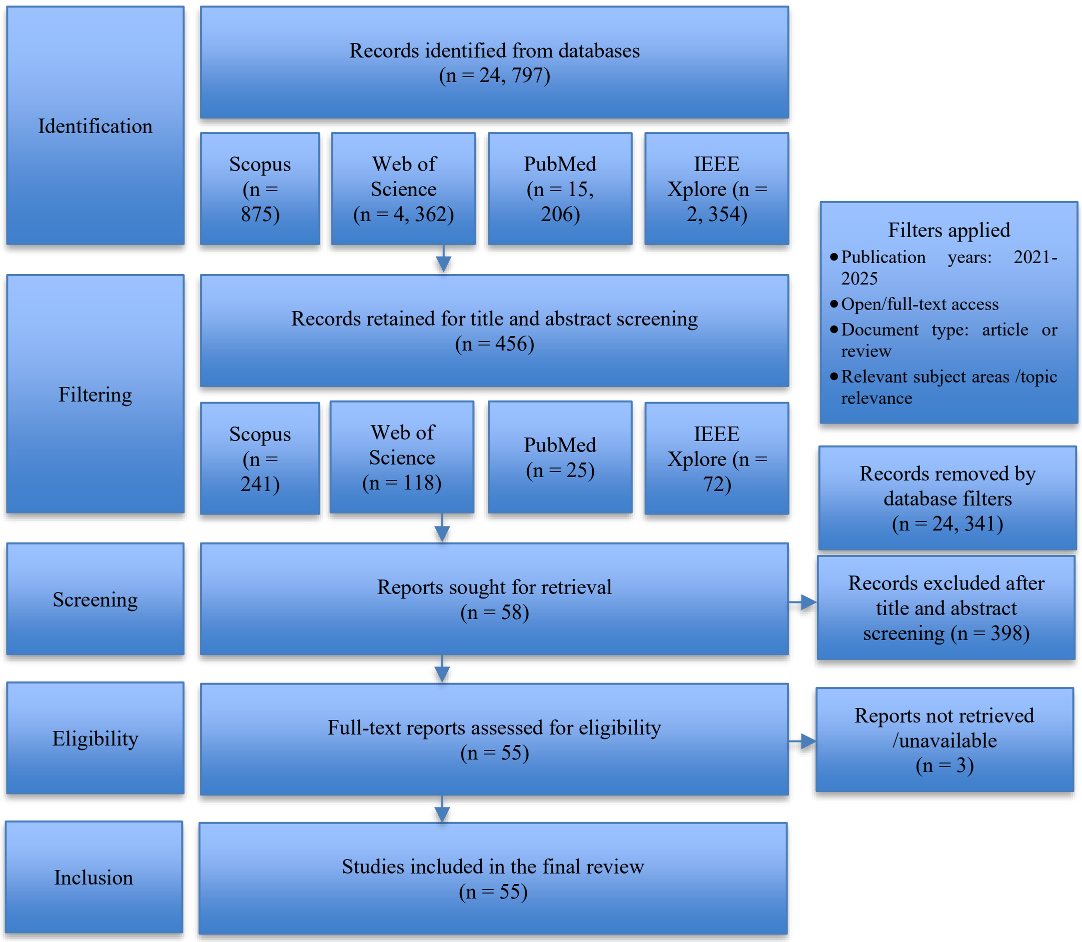

Fig. 1 PRISMA-based flowchart

3. Result

3.1. Study Findings

The results show that research on patient monitoring via telemedicine is not only growing, but also focuses on systems whose clinical effectiveness will depend on the integration of technology, work processes, and communication [18, 19]. For example, in critical emergency situations, telemedicine models have been developed that allow real-time patient monitoring through the integration of commercial technologies and personalized communication programs [20]. Important factors such as signal delay time, transmission reliability in unstable network environments, and practical difficulties reported by clinicians in the experimental stages are then evaluated [21].

Among the research studies identified, a common technical theme was that there are still significant issues related to interoperability and system integration. Despite standards created to promote interoperability (e.g., IEEE 11073, HL7) [22], many research prototypes/systems continue to use simpler methods of adaptation and simplification (e.g., basic websites, device interface) as a means to accelerate their commercialization and complete technical feasibility testing in real-world situations. At the same time, this research highlights that constant monitoring requires reducing delays and ensuring confidence, especially when physiological data [23] are available for decision-making in critical or emergency circumstances.

From a clinical perspective, evidence reveals that the effectiveness of telemedicine is closely related to the level of familiarity of physicians with the use of the systems in remote consultations. In addition, the literature indicates limitations, such as difficulty in capturing nonverbal cues, since video resolution can directly affect clinical diagnosis [24]. Likewise, evidence indicates that the reliability of non-contact monitoring systems is affected by factors such as the limited knowledge that doctors may have about the use of telemedicine and compatibility with the platform they use for healthcare [25]. All these elements, in turn, have an impact on the effectiveness of these systems in the real environment.

3.1.1. Bibliometric Analysis Processing

This analysis was performed to synthesize the study on remote monitoring. To graphically represent the networks of co-occurrence of keywords, co-authorship and countries, the

VOSviewer tool was used, as it allowed scientific maps to be examined and visually represented. Its main function is to convert complex bibliographic information from the aforementioned databases into interactive graphics that facilitate a better interpretation. In this way, the less studied topics are visualized and allow for further exploration.

Keyword Co-Occurrence Map

A study on the co-occurrence of keywords was carried out using information from Scopus, WoS Pubmed and IEEE Xplore, which was analyzed using VOSviewer, considering all keywords and implementing four concurrents. Figure 2 shows that a total of 24 keywords were generated, distributed in three main groups, with 159 links and a total strength of 287 links. In the visual representation, the size of each node reflects the most commonly used terms for each keyword, the thick connections indicate the intensity of the co-occurrence, and the colors distinguish the different thematic groups. Digital health services and telemedicine are the areas most closely associated with the green group. Within this group, the most frequently linked term is "telemedicine," as it appears to be the most common and is most closely related to "patient monitoring," "eHealth," "remote monitoring," "mobile app," "mHealth," and "healthcare." This set of information reveals that much of the research focuses on remote monitoring systems as a viable alternative for physicians, where patients can be monitored remotely using online platforms, mobile apps, and remote health services [26, 27]. On the other hand, the blue section represents the non-contact detection and physiological signs segment in the area. Relevant terms such as "heart rate", "non-contact", "signal processing" and "heart rate measurement" are closely interconnected. This implies that numerous studies focus on monitoring vital signs, particularly those of the heart, without the need for physical presence to obtain valuable information from their clinical examination [28]. The mention of terms such as "electrocardiography" and "electrocardiogram" suggests that cardiac monitoring is a common practice in remote telemedicine systems.

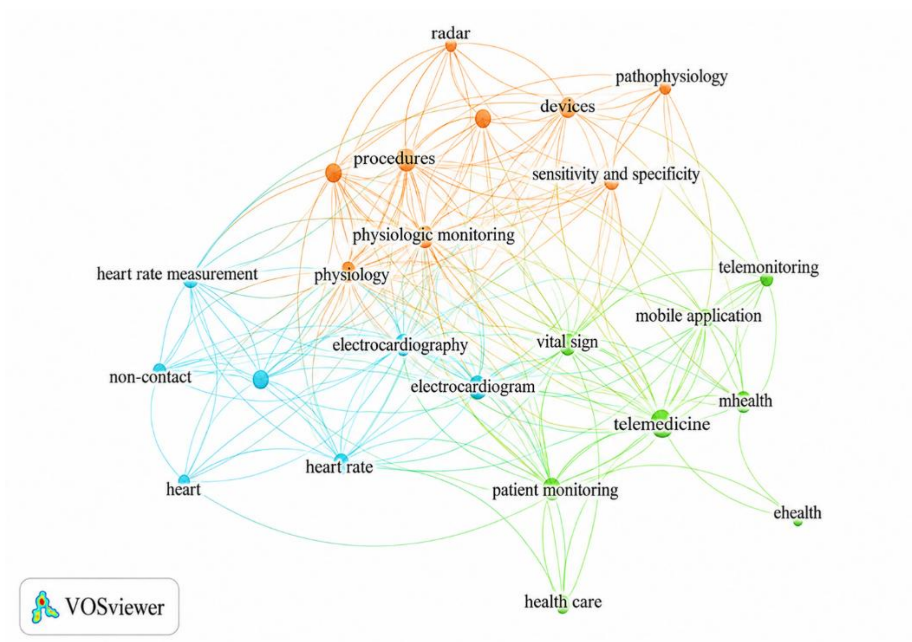

Fig. 2 Keyword Co-occurrence Map

In addition, diagnostic and clinical evaluation aspects, such as technology, procedures, devices, imaging, and physiological assessment, are included in the orange category. This category covers research related to the verification of monitoring technologies, as well as the analysis of accuracy and clinical utility. The presence of "radar" illustrates that the use of radar sensors for non-contact monitoring is part of the group's research activities [29, 30]. Recent reviews have validated the accuracy of using IR-UWB radar sensors to assess respiratory movements, even in challenging circumstances, such as in a neonatal intensive care unit, reducing both the number of invasive devices and the risk of physical interference. As new forms of remote monitoring are developed, there is a clear trend towards the use of safe, effective and appropriate remote monitoring for today's healthcare environment [31].

Co-Authorship Map

Through co-author analysis, researchers' collaborative tendencies in conducting research in telemedicine were revealed. As shown in Figure 3, a single group of four authors who met the minimum number of publications required for inclusion also formed six links with a total weight of 18 links.

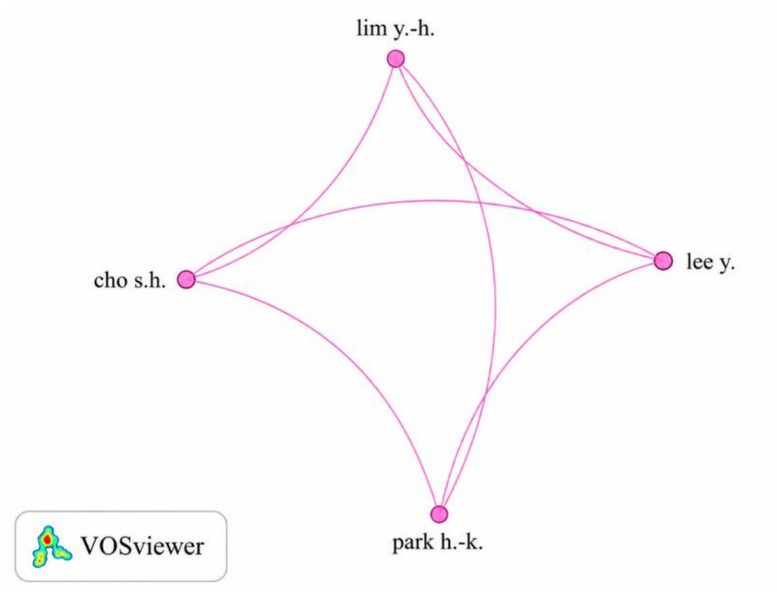

Fig. 3 Co-authorship map

Using the "at least two papers per author" method to identify important co-authorship relationships and avoid potential links, a small number of authors were identified who reached the established number of publications. Studying this provides a foundation for understanding how knowledge and collaborative efforts are created in research, integrating multiple viewpoints and diverse talents to produce more innovative, relevant, and effective results. It also promotes the distribution of workload among researchers, thus accelerating the advancement of science.

The graphic network created produces a very well-organized network, demonstrating that the authors have established more collaborative relationships with each other than either of the other two authors (Park H.-K.) or the authors (Lim Y.-H., Lee Y. khác) have the same pattern of close collaboration as the authors, therefore exhibiting close and ongoing collaborative relationships is common among these authors and is beneficial for sharing knowledge and coherence of research. The absence of a large number of scientific collaboration groups suggests that this area of scientific collaboration is still highly concentrated in small clusters rather than expanding into larger networks. This indicates how the telemedicine studies that were analyzed were more compact collaborations than large collaborative teams. As such, the connectivity density of team members was more prominent in these teams than the size of their co-authoring networks [32]. In addition, it suggests that this area of research is still in its scientific infancy, where scientists collaborate on very narrowly defined areas of research without large-scale global collaboration. Promoting interdisciplinary collaboration and the formation of specific research groups should lead to a better generation of knowledge in this field. Greater collaboration between multiple organizations, nations, and fields of knowledge will lead to an improvement in the quality and impact of research in this field, as well as aid in the innovation of telemedicine and its effective implementation in health care systems.

This collaborative model demonstrates that non-contact monitoring is still being developed through specific study groups, whose main focus is science production and science-related technical exchange. In addition, collaboration between diverse countries involved in non-contact monitoring has the potential to develop uniform protocols, as well as to generate more diverse samples for evaluation and generate more robust evidence, thus facilitating the safe and effective implementation of these technologies.

Co-Authorship Map by Country

The international collaboration provides a framework that allows researchers to look at international relationships in various areas to establish telemedicine knowledge creation, including the production and transfer of telemedicine information across diverse geographic regions. This analysis is useful in determining how different nations conduct this type of research and the degree of international collaboration in telemedicine. To conduct this analysis, countries associated with selected articles from the four databases were considered, and a minimum of two articles per country was set as the lower limit for inclusion in this study. As a result, at least ten countries met the criteria, and the resulting country-to-country linkages developed into a network of international collaboration, as illustrated in Figure 4. Consequently, the collaborative networks resulting from VOSviewer had a total of three groups with fourteen links between nations, indicating the existence of different collaboration networks between countries for telemedicine research.

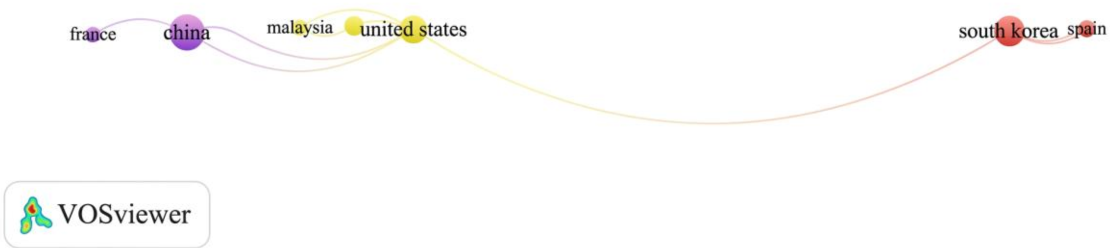

Fig. 4 Co-authorship map by country

The diagram shows that the United States is considered the most important hub and hub of the "network" that connects different groups of nations. As such, it serves to connect different groups of nations, while also playing a crucial role as a mediator in the exchange of knowledge, creating opportunities for countries with scientific data to exchange it with other regions of the countries involved. In addition, this positioning not only represents a substantial commitment to research and technological advancement but also demonstrates that the United States has managed to establish global partnerships for cooperation and collaboration in joint initiatives in the field of digital health. It also represents the geographical similarities between regions that can and should be leveraged to develop collaborative scientific research initiatives that benefit globally. There are also cooperation groups, such as those formed by France and China, as well as those of Spain and South Korea, which demonstrate more concrete and specialized alliances. This demonstrates the presence of regional interactions in scientific collaboration based on both geographical similarities and shared technological objectives. However, it also highlights that countries that are underrepresented in the area of science must continue to increase their efforts to get involved; The more inclusive or present they are at the international level, the more variety of research mechanisms they will be able to produce and use to develop technological solutions that are more applicable to the health care challenges of developing countries. In summary, the findings illustrate that international collaborative research in telemedicine is still somewhat limited, with a concentration of activity in a few countries [33, 34]. Therefore, it is necessary to strengthen and expand cooperation networks between nations to generate a broader and more equitable exchange of knowledge in this area at the international level. Similarly, broader international collaboration could help connect diverse experiences and implementation scenarios, which in turn would drive the development of more innovative and flexible solutions.

3.1.2. Annual Evolution of Scientific Production

Annual research reports help identify trends in scientific research in the specific subject area over time, as well as identify trends when research activity increases, remains stable, or decreases. Figure 5 shows the results obtained from Bibliometrix and provides an overview of the number of annual research articles published for this research and their evolution over time. In the first part of this assessment, as indicated in the graph, the total number of research publications on the topic was very limited and published infrequently, indicating that research on this topic is at a very early stage. At the time, research on the use of telemedicine was not published regularly, which could be attributed to the lack of use of the technology and the absence of a regulatory framework in the provision of healthcare services.

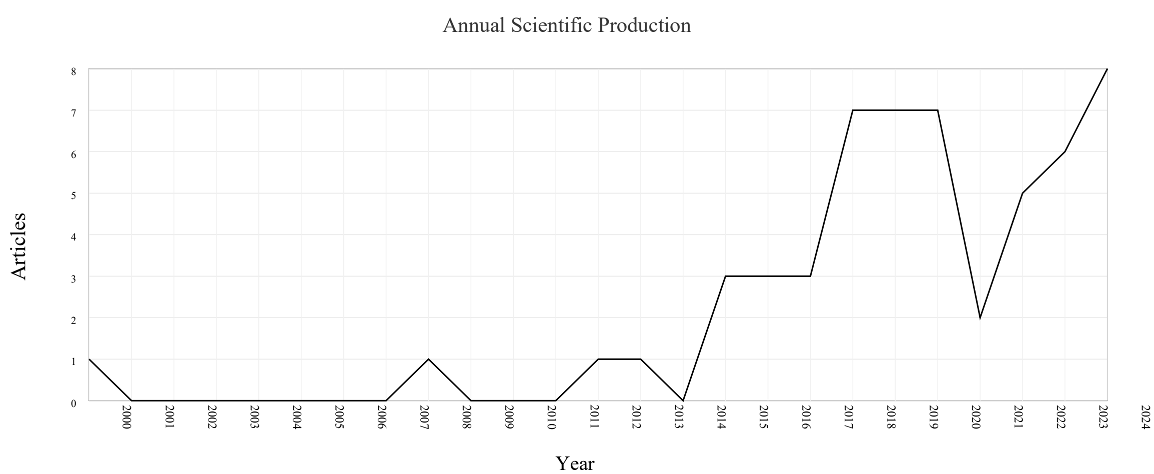

Fig. 5 Evolution by year of scientific journals

Since 2016, the number of articles published has shown a steady increase, indicating a higher level of focus and advancement in the field. This also suggests that, at that time, the research community had come to recognize the potential of digital technologies to transform traditional health care delivery systems. In addition, telemedicine research increased significantly during the following years, particularly between 2019 and 2020, coinciding with a rapidly evolving global technological landscape and an urgent demand for remote healthcare alternatives due to the COVID-19 pandemic [35]. As a result of the pandemic, health systems accelerated their telehealth initiatives, prompting researchers to develop new testing modalities and analyze new technologies and methodologies for care delivery. Therefore, this trend suggests that telemedicine has moved from being an emerging area of research to a critical component of health systems around the world. While declines were observed in some years, the long-term trend shows that telemedicine research has recovered and is growing steadily to the present day. Telemedicine research data strongly supports this premise, as it has progressed significantly as a research area over the period studied, with continued advancements attributable to the technology. In addition, the continued growth of scientific knowledge in telemedicine suggests that the area will continue to grow and develop due to the current state of eHealth and the crucial role of telemedicine in transforming health systems. In summary, the findings show that research in this field has increased over the past ten years, highlighting its relevance for innovation in health systems and the development of new methods of remote care.

3.1.3. Distribution of Publications by Journals

Important information can be obtained to find the right scientific resources to disseminate studies related to telemedicine by examining the amount of research published in all sciences through the different journals. In addition, this analysis will provide information on the journals most closely related to telemedicine and indicate, in general, the most common types of research used to create their registries.

Figure 6 provides a visual representation of the number of articles published and will allow you to identify the most important journals according to the volume of literature published. IEEE Access published the most articles, making it the most important digital technology and health journal, thus facilitating the dissemination of telemedicine-based studies.

There are other journals with a high presence in the field of telemedicine, such as Scientific Reports, PLOS ONE, Sensors and Reviews in Cardiovascular Medicine. The wide variety of journals in the field of telemedicine covers various areas of study, integrating innovative technology and its application in healthcare. This diverse collection of scientific literature on telemedicine illustrates the global growth of telemedicine research from various perspectives, contributing to the development of a more holistic view of telemedicine. It also illustrates the great need to develop a greater number of scientific publications dedicated to digital health, which will accelerate the establishment of telemedicine as an independent science [36].

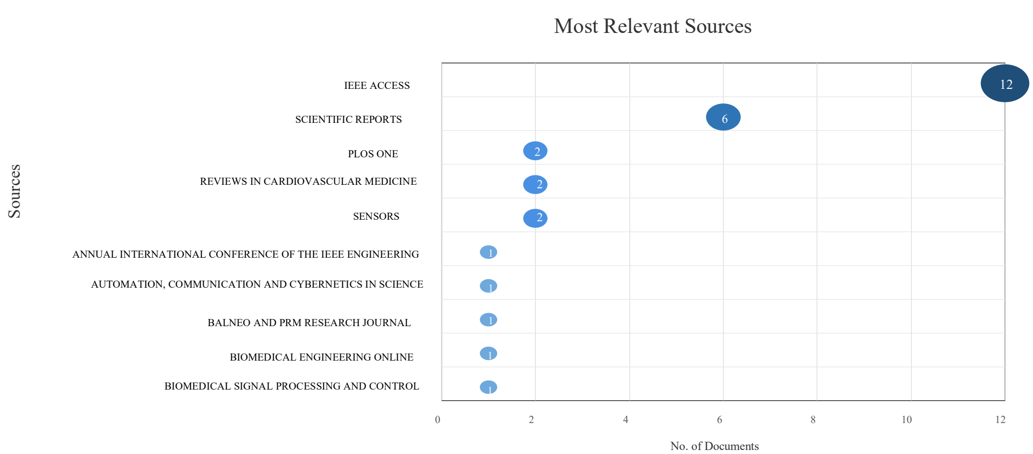

Fig. 1 Distribution by title of published articles

Many journals with a small number of published articles are also recognized for supporting the telemedicine research community; These include biomedical engineering, signal processing, automation, and many of the specialized scientific symposia mentioned above [37]. This diversity in journal types indicates that telemedicine is studied not only within one discipline but across various disciplines, leveraging technological, medical, and engineering approaches. In addition to supporting evidence of the interdisciplinary nature of telemedicine by demonstrating that its success depends on both technological and health sciences disciplines, these journals also support the advancement of the use of technologies to develop, refine, and validate digital devices used for remote patient monitoring and care. Despite having fewer published papers, the contribution of these sources is important because they will likely highlight substantial technological innovations that could ultimately have wide-ranging and far-reaching clinical applications.

3.1.4. Content Analysis

In total, the final analysis consisted of 55 articles based on the PRISMA methodology, according to predetermined inclusion and exclusion criteria. These articles examine how telemedicine technologies are implemented through remote monitoring, optimal performance metrics, ICT interoperability barriers, and future opportunities to improve remote healthcare systems [38]. Therefore, this article focused mainly on the research areas related to sensors and non-contact technologies, continuous monitoring and predictive analytics in the healthcare sector.

The research structured and ordered the revised content and facilitated the organization of the information. Subsequently, the information retrieved was highlighted by three general classification questions (interviews), which allowed the articles to be classified according to their most significant contribution, avoiding the dispersion of topics and culminating in a concise and focused presentation of the information contained in all the reviewed articles. The first question of this analysis examined how telemedicine technologies support non-contact monitoring technologies in terms of their effectiveness, including issues related to their accuracy, reliability, and applicability in the healthcare sector. The second question investigated the limitations and barriers associated with telemedicine technologies, specifically as it pertains to the technological (managed) and operational (real) aspects associated with real-world implementations. A comprehensive review of published research on remote monitoring technologies, especially non-contact sensors and predictive analytics, answers three main questions that ultimately identify opportunities to improve the quality of remote care through improved use of remote monitoring technologies. To answer these questions and provide a collective assessment of the body of knowledge on research in remote monitoring technologies in general (see Figure 7), this review will use the framework used in other research reviews in telemedicine and remote patient monitoring as a fundamental guide for conducting an objective analysis of the studies included in this review.

As in other research reviews on telemedicine and remote monitoring, the systematic approach of the literature will allow comparing the different methods of remote monitoring addressed in the three articles examined and their results. This will make it easier to identify important patterns and differences between studies on remote monitoring technology and help us understand how these technologies are currently being implemented and what can be done to optimize their use. In addition to synthesizing existing research on remote monitoring, this analysis will have the potential to offer practical implications and ultimately contribute to the creation of innovative, high-quality telemedicine services.

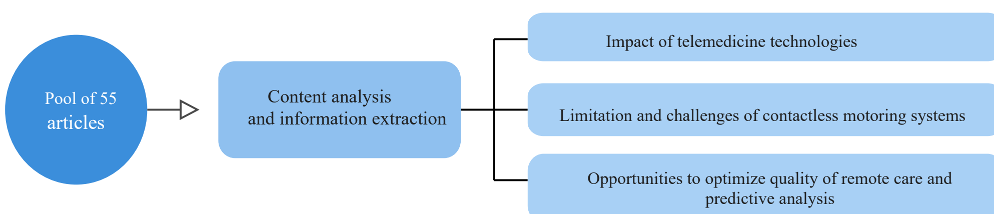

Fig. 7 Structure of systematic review of the contents

Impact of Telemedicine Technologies

Figure 8 shows the distribution of the 49 reviewed articles on telemedicine technologies according to the type of effect studied. In this way, the main areas of research in this group of articles were clearly identified. In addition, the area of performance/accuracy was studied in 20 papers, reflecting a clear interest in evaluating the performance, accuracy, and reliability of non-contact monitoring technologies. This area of research examines various critical technical characteristics, such as accuracy, measurement, signal consistency, and the ability of systems for continuous use and in different remote healthcare settings [39]. On the other hand, the focus on monitoring quality had a total of 13 publications. These articles mainly investigated whether these technologies presented consistent signal consistency, reliable data collected by them, and whether telemedicine technologies could provide sufficient and consistent data to support patient monitoring [40]. In addition, secondary research was conducted in the areas of clinical efficacy/technical efficacy and implementation, with 8 publications per topic. Clinical efficacy research studies how these systems improve the diagnosis, monitoring, and treatment of patients, while implementation research focuses on how these systems are used in practice and implemented in everyday use and in existing healthcare services [41, 42]. The main objective of research on contactless sensor-based telemedicine has been to demonstrate the validity of the quality and accuracy of remote monitoring tools. There is a lack of research dedicated to the implementation and clinical analysis of these tools in real healthcare settings; Therefore, there is a great need for further research on the efficacy of telemedicine in real healthcare settings.

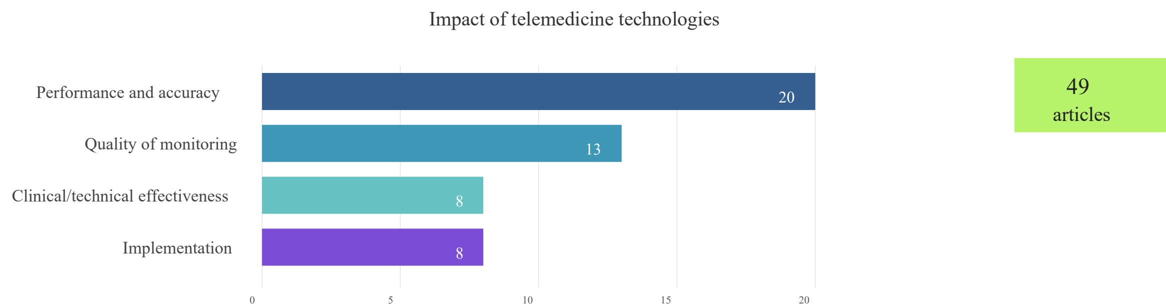

Fig. 8 Distribution of journals on the impact of telemedicine

Opportunities to Optimize the Quality of Remote Care and Predictive Analytics

Figure 9 shows the three publications related to opportunities to improve remote monitoring systems used in telemedicine (one article per subtopic). The articles were organized according to the most documented opportunity type, allowing us to easily identify the challenges associated with each of these technologies. The first research identifies opportunities for technical improvement and reliability of telemedicine devices by analyzing the difficulties associated with the accuracy of measurement devices and the reliability of continuous monitoring systems. The measurement accuracy of these devices and the reliability of their continuous operation can affect the quality of the information obtained and, consequently, the clinical decision-making process. Therefore, information about the reliability of telemedicine devices is critical for their widespread use. In addition, regular and constant monitoring of remote monitoring systems will provide greater security for both healthcare professionals and patients when using these telemedicine devices. This indicates that noise and latency issues affect signal quality and how quickly information is sent. Delays and distorted signals can limit the use of these systems when fast responses or accurate measurements are required [43]. In addition, these are some of the most difficult hurdles to ensuring the reliability of remote monitoring systems, especially in cases where instant control is required, and quick decisions must be made in a medical environment. A critical consideration in solving the problems associated with these problems is to create or use better signal management algorithms, develop an improved communication network, and increase the efficiency of data transmission protocols. Research has also been conducted on barriers to data privacy and the implementation of technology. This research highlights the need to protect patient data and address technical and organisational gaps for these technologies to be implemented in healthcare settings [44]. While there are a few articles related to this topic, many of them have identified numerous limitations and problems with signals. Addressing these issues will be critical to enabling the safe and effective use of this technology.

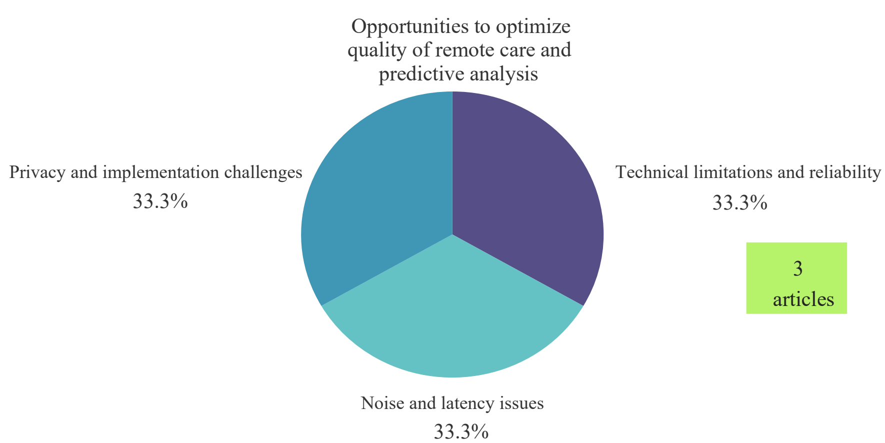

Fig. 9 Distribution by opportunities for improvement

Limitations and Challenges of Contactless Monitoring Systems

The results of the graphical representation showing the distribution of three articles, each representing one of the three sub-themes, are listed in Figure 10. Analysis of these items demonstrated the most prevalent type of challenge identified during the analysis phase, illustrating how these technologies create the greatest amount of difficulty. The research in the first set includes improving systems by analyzing performance and sensor improvements, as well as integrating contactless monitoring systems into remote care environments.

All this in order to optimize the performance, reliability and accuracy of the clinical applications of the technologies analyzed. Improved system performance and accuracy, coupled with the desire to optimize the operation of non-contact solutions, supports the need for increasingly accurate and reliable measurements for clinical applications rough advances in system components.

These advances not only seek to improve the technical quality of the system but also increase the confidence of healthcare professionals and thus facilitate the acceptance of the technologies analyzed for their viability in the provision of remote healthcare services. The research from the predictive analytics and system optimisation studies is consistent with the non-contact sensor research described above, as it will also use the data collected by the non-contact sensors for predictive purposes, facilitating early detection of clinical needs and decision-making in the clinical setting [45]. The method analyzed demonstrates that telehealth has the ability to move from being a passive and reactive provider of health services (patient monitoring) to becoming a proactive and more active provider of such services. The final section discusses research focused on Artificial Intelligence (AI) and Machine Learning (ML) methodologies as fundamental tools for improving the quality of remote care [46]. The studies examined demonstrate the ability of intelligent models to manage massive amounts of data while also making accurate predictions, thereby expanding opportunities for the development of telehealth technology.

In addition, another advantage of using these tools is the increased ability to review large volumes of medical data, which translates into greater diagnostic accuracy, early identification of high-risk patients, and the ability to make more timely medical decisions. While the number of studies in this area is somewhat limited, the available results have demonstrated significant potential for continued development. The opportunities identified are aimed at improving systems; predictive analytics, as well as the use of AI methodologies, could significantly improve the quality, effectiveness, and reach of remote healthcare services [47].

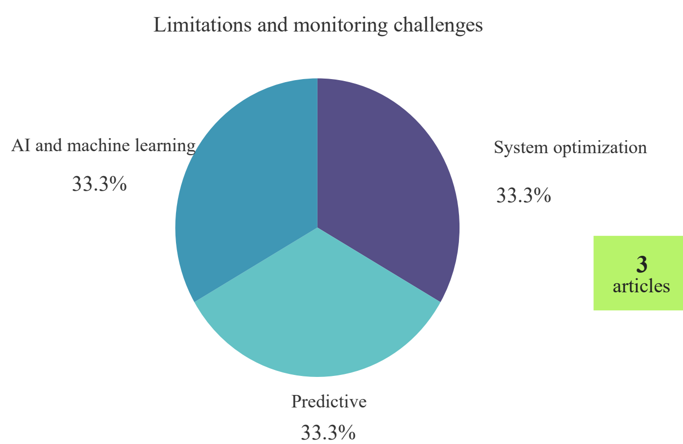

Fig. 10 Distribution by limitation and monitoring challenges

3.1.5. Comparative Synthesis of Non-Contact Monitoring Modalities

Furthermore, after analyzing the reviewed studies, we also considered the technology used for contactless monitoring. This made it easier to clearly compare the main detection approaches in the context of telemedicine and, in this way, identify their application in clinical settings, as well as their advantages and limitations. Therefore, Table 1 below shows the main modalities identified in the previous studies.As can be seen in Table 1, it was found that contactless monitoring systems encompass more than just optical or radar-based approaches. Although Doppler radar, UWB radar, and computer vision systems remain the most frequently reported modalities, radio frequency detection, ultrasonic techniques, fiber-optic systems, thermography, and hybrid approaches based on artificial intelligence are also being widely employed [48, 49]. However, evidence gathered from the scientific literature indicates that each of these modalities faces its own technical limitations, which are related to signal quality, environmental interference, privacy, equipment calibration, and clinical validation in real-world settings [50].

Table 1. Comparative analysis of technological modalities in non-contact monitoring systems

Technological modality	Main monitored parametes	Mainstrengths	Main limitations	Telemedicine applicability
Doppler radar / UWB radar	Heart rate, respirato y rate, body movement	Enables monitoring without physical contact; can operate under low-light conditions; useful for continuous vital sign assessment	Sensitive to body motion, distance, signal noise, and environmental interference	High, especially for home monitoring, sleep monitoring, neonatal care, and chronic disease follow-up
Optical and computer vision systems	Heart rate, respiratory rate, facial signs, movement patterns	Low-cost implementation using cameras; suitable for remote visual assessment and mobile platforms	Affected by lighting, camera resolution, patient position, privacy concerns, and movement artifacts	High, mainly in video-based telemedicine and home-based monitoring
Infrared and thermal sensing	Body temperature, thermal changes, fever screening, respiration-related thermal patterns	Useful in non-contact temperature assessment; can operate without visible light	Influenced by ambient temperature, distance, calibration, and device quality	Medium to high, especially for triage, fever screening, and infectin-control scenarios
Radio frequency sensing	Respiration, movemen, presence detection, human activity	Can detect physiological or movement-related signals without direct visual contact; may work in complex indoor environments	Requires advanced signal processing; may be affected by interference and environmental noise	Medium, with potential for smart-home and continuous monitoring applications
Ultrasonic sensing	Heart-related vibration, respiratory activity, motion	Non-invasive and contactless; may be useful for detecting small body surface movements	Limited range, sensitivity to positioning, and lower evidence compared with radar or optical systems	Medium, mainly for specific controlled or semi-controlled monitoring scenarios
Fiber-optic and pressure/mattress-based non-contact systems	Respiration, apnea/hypopnea events, nocturnal monitoring	Useful for sleep-related monitoring; can be integrated into bedding or home environments	Limited to specific contexts; may require specialized installation and validation	Medium to high, especially for sleep apnea and home respiratory monitoring
Hybrid and AI-supported systems	Multiple physiological signals, risk prediction, clinical alerts	Combine multiple data sources; improve robustness; support predictive analytics and decision-making	Greater system complexity; requires validation, interoperability, and data security strategies	High potential, especially for future intelligent telemedicine platforms

3.1.6. Categorization of Selected Studies

This final study on telemedicine technologies included 55 articles on telemedicine solutions that enable contactless monitoring.

The selection of articles was made using the methodology described in this review by researchers, who were able to identify common trends and contributions to telemedicine solutions related to contactless monitoring. In addition, each article was categorized thematically for a simpler and more logical organization of the results.

Each article was analyzed and categorized thematically in relation to one of the three Research Questions (IPs) of this study.

See Table 2 for summary information on each of the reviewed articles (authors listed, year of publication, article title, and research topic).

This will help identify additional trends and gaps in the literature assessed.

Table 1. Selected studies

No	Author	Year	Title	Research Question
[40]	Aydin Akgun F., Soytürk G., Dede M.	2023	A new IoT system for non-contact body temperature sensing and warning	PI1
[43]	Atilgan K., Onuk B.E., Köksal Coşkun P., Yeşil F.G., Aslan C., Çolak A., Çelebi A.S., Bozbaş H.	2021	Remote patient monitoring after cardiac surgery: The utility of a novel telemedicine system	
[55]	Azman N.N., Addi M.M., Al-Abed A.	2023	Development of an IoT Embedded Wearable Device with Non-Contact Temperature Detector for Early Detection of Fever	
[32]	Alvarez P., Sianis A., Brown J., Ali A., Briasoulis A.	2021	Chronic disease management in heart failure: Focus on telemedicine and remote monitoring	
[29]	Antevski K., Girletti L., Bernardos C.J., De La Oliva A., Baranda J., Mangues-Bafalluy J.	2021	A 5G-Based eHealth Monitoring and Emergency Response System: Experience and Lessons Learned	
[48]	Abugabah A., Nizamuddin N., Alzubi A.A.	2020	Decentralized telemedicine framework for a smart healthcare ecosystem	
[18]	Abo-Zahhad M., Ahmed S.M., Elnahas O.	2014	A wireless emergency telemedicine system for patients monitoring and diagnosis	
[42]	Anagnostaki A., Kyriacou E., Reynolds M., Pavlopoulos S., Koutsouris D.	2000	Integration of CEN/TC251/PT5-021 "VITAL" preENV standard and of "DICOM supplement 30.0" into a telemedicine system for vital signs monitoring from home	
[23]	Beck A.K., Kelly P.J., Deane F.P., Baker A.L., Hides L., Manning V., Shakeshaft A., Neale J., Kelly J.F., Gray R.M., Argent A., McGlaughlin R., Chao R., Martini M.	2021	Developing a mHealth Routine Outcome Monitoring and Feedback App ("SMART Track") to Support Self-Management of Addictive Behaviours	
[45]	Bitar D., Goubar A., Desenclos J.C.	2009	International travels and fever screening during epidemics: a literature review on the effectiveness and potential use of non-contact infrared thermometers.	
[50]	Cabrerizo-Carreño H., Muñoz-Esquerre M., Santos Pérez S., Romero-Ortiz A.M., Fabrellas N., Guix-Comellas E.M.	2024	Impact of the implementation of a telemedicine program on patients diagnosed with asthma	
[20]	Ding F., Qin Y., Zhang L., Lyu H.	2025	Driver Drowsiness Detection Based on Facial Video Non-Contact Heart Rate Measurement	
[36]	Dong Y., He H., Sheng W., Wu J., Ma H.	2017	A quantitative and non-contact technique to characterise microstructural variations of skin tissues during photo-damaging process based on Mueller matrix polarimetry	
[30]	Fan Y., Xu P., Jin H., Ma J., Qin L.	2019	Vital sign measurement in telemedicine rehabilitation based on intelligent wearable medical devices	
[1]	Galdino I., Soto J.C.H., Caballero E., Ferreira V., Ramos T.C., Albuquerque C., Muchaluat-Saade D.C.	2023	EHealth CSI: A Wi-Fi CSI Dataset of Human Activities	
[7]	Guo G., Sun G., Bin S., Shao F.	2019	Design and Analysis of Field Telemedicine Information Communication Protocol Based on Wireless Sensor Network	
[24]	Jüger-Madiot N., Gateau J., Fink M., Ings R.-K.	2017	Non-contact and through-clothing measurement of the heart rate using ultrasound vibrocardiography	
[4]	Kitagawa T., Yamamoto K., Endo K.,	2022	Multibeam Doppler Sensor-Based Non-	

	Ohtsuki T.		Contact Heartbeat Detection Using Beam Diversity	
[28]	Kyo In C., Min B.C.	2025	Detection and Predictive Analysis of Drowsiness Using Non-contact Doppler Sensor	
[27]	Kang S., Kim D.-K., Lee Y., Lim Y.-H., Park H.-K., Cho S.H., Cho S.H.	2020	Non-contact diagnosis of obstructive sleep apnea using impulse-radio ultra-wideband radar	
[51]	Duan Z., Lian J.	2019	Non-Contact Detection of Vital Signs Using a UWB Radar Sensor	
[15]	Kosir J., Vella D., Jezersek M.	2020	Non-contact monitoring of the depth temperature profile for medical laser scanning technologies	
[52]	Kim J.D., Lee W.H., Lee Y., Lee H.J., Cha T., Kim S.H., Song K.-M., Lim Y.-H., Cho S.H., Cho S.H., Park H.-K.	2019	Non-contact respiration monitoring using impulse radio ultrawideband radar in neonates	
[21]	Laheba T.R., Govindaraju R., Andriani M.	2025	Telemedicine System Quality From Physicians' Perspectives: Key Determinants and Its Impact on Service Effectiveness via Interaction Quality	
[34]	Liu Z., Li C., Lin J., Xu H., Xu Y., Nan H., Cheng W., Li J., Wang B.	2024	Advances in the development and application of non-contact intraoperative image access systems	
[11]	Lee K.-C., Lin Y.-P., Tzeng Y.-L., Liao W.-C., Lo C., Chen P.-Y., Lu S.-H.	2025	The impact of age on comparative diagnostic accuracy of temporal artery thermometers and non-contact infrared thermometers for fever detection: a systematic review and meta-analysis	
[14]	Lee Y., Park J.-Y., Choi Y.-W., Park H.-K., Cho S.-H., Cho S.H., Lim Y.-H.	2018	A Novel Non-contact Heart Rate Monitor Using Impulse-Radio Ultra-Wideband (IR-UWB) Radar Technology	
[5]	Lucas A.R., Bass M.B., Rothrock N.E., O'Connor M.L., Sorkin M.R., Nawyn J., Albinali F., Wagner L.I.	2018	Development of an ehealth system to capture and analyze patient sensor and self-report data: Mixed-methods assessment of potential applications to improve cancer care delivery	
[12]	Li K.F.	2013	Smart home technology for telemedicine and emergency management	
[44]	Mutirangura P., Patel D., Akram H., Hughes A., Arriola-Montenegro J., Koukousaki D., Money J., Kosmopoulos M., Meyer M., Harata M., Toth A., Alexy T.	2025	Application of Telemedicine in the Management of Cardiovascular Diseases: A Focus on Heart Failure	
[31]	Mazlin V., Xiao P., Scholler J., Irsch K., Grieve K., Fink M., Boccara A.C.	2020	Real-time non-contact cellular imaging and angiography of human cornea and limbus with common-path full-field/SD OCT	
[26]	Milewski K., Małecki A., Orszulik-Baron D., Kachel M., Hirnle P., Orczyk M., Dunal R., Mikołajowski G., Janas A., Nowak Z., Kozak K., Roskiewicz W., Nierwińska K., Izworski A., Rybicki A., Buszman P.P., Piotrowicz R., Buszman P.E.	2019	The use of modern telemedicine technologies in an innovative optimal cardiac rehabilitation program for patients after myocardial revascularization: Concept and design of restore, a randomized clinical trial	
[37]	Nomura K.-I., Kaji R., Iwata S., Otao S., Imawaka N., Yoshino K., Mitsui R., Sato J., Takahashi S., Nakajima S.-I., Ushijima H.	2016	A flexible proximity sensor formed by duplex screen/screen-offset printing and its application to non-contact detection of human breathing	
[22]	Obika B.D., Dolezova N., Ponzo S., Valentine	2021	Implementation of an mHealth solution to	

	S., Shah S., Gledhill J., Plans D., Nicholson C., Walters C., Stephen L., Ng S., Ayres J., Petrou M., Bhudia S., Denny C., Schrauwers H., Markides V.		remotely monitor patients on a cardiac surgical waiting list: Service evaluation	
[56]	Oh S.H., Lee S., Kim S.M., Jeong J.H.	2021	Development of a heart rate detection algorithm using a non-contact doppler radar via signal elimination	
[53]	Oziel M., Korenstein R., Rubinsky B.	2017	Radar based technology for non-contact monitoring of accumulation of blood in the head: A numerical study	
[3]	Pop D., Tomoaia R., Cismaru G., Popescu M., Alexandra	2025	The role of telemedicine in the recovery of patients with ischemic heart disease	
[41]	Shin J., Song J.W., Flavin M.T., Cho S., Li S., Tan A., Pyun K.R., Huang A.G., Wang H., Jeong S., Madsen K.E., Trueb J., Kim M., Nguyen K., Yang A., Hsu Y., Sung W., Lee J., Phyo S., Kim J.-H., Banks A., Chang J.-K., Paller A.S., Huang Y., Ameer G.A., Rogers J.A.	2025	A non-contact wearable device for monitoring epidermal molecular flux	
[46]	Saikevičius L., Raudonis V., Dervinis G., Baranauskas V.	2024	Non-Contact Vision-Based Techniques of Vital Sign Monitoring: Systematic Review	
[33]	Scebba G., Da Poian G., Karlen W.	2021	Multispectral Video Fusion for Non-Contact Monitoring of Respiratory Rate and Apnea	
[47]	Shojaei E., Wong A., Rexachs D., Epelde F., Luque E.	2020	Investigating impacts of telemedicine on emergency department through decreasing non-urgent patients in Spain	
[38]	Seol B.R., Kang T.G., Gu B.	2019	Intraocular pressure according to different types of tonometry (non-contact and Goldmann applanation) in patients with different degrees of bilateral tearing	
[54]	Taylor W., Abbasi Q.H., Dashtipour K., Ansari S., Shah S.A., Khalid A., Imran M.A.	2020	A review of the state of the art in non-contact sensing for covid-19	
[16]	Thelen S., Czaplik M., Meisen P., Schilberg D., Jeschke S.	2016	Using Off-the-Shelf Medical Devices for Biomedical Signal Monitoring in a Telemedicine System for Emergency Medical Services	
[9]	van der Kamp M.R., Hengeveld V.S., Brusse-Keizer M.G.J., Thio B.J., Tabak M.	2023	eHealth Technologies for Monitoring Pediatric Asthma at Home: Scoping Review	
[49]	Wintergerst M.W.M., Petrak M., Li J.Q., Larsen P.P., Berger M., Holz F.G., Finger R.P., Krohne T.U.	2019	Non-contact smartphone-based fundus imaging compared to conventional fundus imaging: a low-cost alternative for retinopathy of prematurity screening and documentation	
[25]	Zhou L., Zhu X., Liu L., Wang L., Zheng P., Zhang F., Mao Z., Huang G., Cheng S., Liu H., Liu W.	2024	Recognition of apnea and hypopnea by non-contact optical fiber mattress and its application in the diagnosis of obstructive sleep apnea hypopnea syndrome: a retrospective study	
[10]	Zhao Y., Bergmann J.H.M.	2023	Non-Contact Infrared Thermometers and Thermal Scanners for Human Body Temperature Monitoring: A Systematic Review	
[17]	Zhang W., Thurow K., Stoll R.	2016	A context-aware mHealth system for online physiological monitoring in remote healthcare	

[8]	Lee W.-K., Phan R.C.-W., Goi B.-M., Chen L., Zhang X., Xiong N.N.	2018	Parallel and High Speed Hashing in GPU for Telemedicine Applications	PI2
[35]	Tang X., Chen W., Mandal S., Bi K., Ozdemir T.	2022	High-Sensitivity Electric Potential Sensors for Non-Contact Monitoring of Physiological Signals	
[6]	Kim J.-S., Lee K.	2020	Untact Abnormal Heartbeat Wave Detection Using Non-Contact Sensor through Transfer Learning	
[13]	Ahmed M.J., Afridi U., Shah H.A., Khan H., Bhatt M.W., Alwabli A., Ullah I.	2024	CardioGuard: AI-driven ECG authentication hybrid neural network for predictive health monitoring in telehealth systems	PI3
[19]	Guan S., Lyu Y., Li Y., Xia C., Qi L., Xu L.	2025	A review of deep learning methods for non-contact heart rate measurement based on facial videos	
[39]	Huang Y., Chen L., Li C., Peng J., Hu Q., Sun Y., Ren H., Lyu W., Jin W., Tian J., Yu C., Cheng W., Wu K., Zhang Q.	2024	AI-driven system for non-contact continuous nocturnal blood pressure monitoring using fiber optic ballistocardiography	

Regarding the impact of telemedicine, this review of the evidence shows that the use of technology has been steadily increasing. Approximately 80% of the studies detected a clear trend towards continuous and remote patient management, resulting in less physical contact with patients [56]. Therefore, these examples demonstrate that telemedicine has become an important means of boosting remote healthcare services by improving clinical workflows and accessibility to services in various settings [46]. In addition to the limitations and challenges identified, the evidence analyzed pointed to important technical barriers that these technologies still face, despite the benefits obtained. The main barriers to success include problems with the sensors and their reliability; the delay in the transmission of data; the level of noise present in the transmitted signals; privacy challenges; and the successful application of technologies in the real world [39]. These barriers significantly hinder the widespread use of telemedicine and, therefore, highlight the urgent need to develop more robust solutions that are compatible with diverse clinical scenarios and technology environments. Finally, developing a better quality of care for remote patient populations and providing better predictive analytics of the health system as a whole can leverage AI and machine learning techniques to optimize the effectiveness of non-contact monitoring solutions [10]. As a result, predictive analytics offers new opportunities to predict clinical situations, adjust monitoring, and make faster medical decisions. However, as a consequence of this, evidence indicates that the use of predictive analytics is still in its early stages and leaves ample scope for future studies on its integration into healthcare, improving systems for the use of these technologies, and continuously evaluating their true real-world impact [9].

4. Discussion

According to the findings, contactless monitoring systems in telemedicine settings are becoming increasingly important for the remote monitoring of patients, particularly in cases such as chronic diseases, post-surgical care, cardiorespiratory monitoring, and home monitoring.

Furthermore, some of the reviews analyzed agreed that these technologies can help reduce physical contact between patients and healthcare providers, thereby facilitating treatment adherence and expanding access to medical care in resource-limited or hard-to-reach areas [25]. Although it was also observed that many of the studies focused on a single technology, the present study compared different groups of solutions, including radar, optical, infrared, ultrasound, radiofrequency, fiber optics, and hybrid approaches.

The comparative analysis shows that radar systems (IR-UWB, Doppler, UWB) demonstrate high accuracy in measuring heart rate and respiration under controlled conditions, which is confirmed by the results of individual clinical studies, where the metrics are comparable to those of contact-based monitoring methods [29]. Meanwhile, video-based methods (rPPG, multispectral imaging) demonstrate high sensitivity in stable environments, but their accuracy decreases significantly with changes in lighting, patient movement, and camera characteristics.

Despite technological advances, significant limitations have been identified. The most frequently cited barriers include noise in transmitted signals, delays in data transmission, limited sensor reliability, concerns about privacy and cybersecurity, and difficulties integrating these technologies into existing medical IT infrastructures [57]. Even with the availability of international standards (e.g., IEEE 11073, HL7), many prototypes have limitations regarding interoperability. Compared to previous studies, which focused primarily on technical feasibility, this work highlights the need for a systemic integration of these technologies into real-world clinical processes, including training for medical staff and the adaptation of work protocols [58]. From a clinical perspective, limitations such as difficulty in understanding the patient's nonverbal cues or the dependence of diagnostic quality on video resolution can significantly influence clinical decisions. This confirms the findings of previous studies: technological accuracy does not guarantee clinical effectiveness without adequate organizational support [59]. The interdisciplinary nature of the publications (biomedical engineering, signal processing, automation, and clinical medicine) confirms that the success of telemedicine depends on the synergy between engineering and medical approaches [60]. To ensure continued progress and sustainable implementation, multicenter studies are needed that include larger and more diverse samples, standardized evaluation metrics, and enhanced protection of unified data for technological comparison. All of this will facilitate the transition from isolated experimental solutions to more reliable, scalable, and clinically applicable contactless monitoring systems.

5. Conclusion

The study effectively analyzed the advances, barriers, and opportunities to improve telemedicine through non-contact monitoring systems through a bibliometric analysis and a systematic review of fifty-five research articles. The results demonstrated a growing academic interest in telemedicine in recent years due to the need for safer, more effective and easier access to remote healthcare services, reflecting the importance of telemedicine becoming an essential resource for healthcare professionals to modify health systems and improve the quality of clinical follow-up of patients.

This article makes a valuable contribution to our current understanding of telemedicine by identifying the untapped potential of these technologies, both in terms of performance and feasibility in clinical settings. While telemedicine technology has developed and improved at an impressive rate, with clear advances in performance and accuracy, the current gap between the capabilities of technologies used for telemedicine and their practical application remains largely unresolved due to technical, operational, and ethical barriers.

This gap presents a challenging opportunity for future research from a multidisciplinary and applied perspective. In addition, the results of this review show that the use of contactless sensors in telemedicine will extend far beyond remote patient monitoring: their application with predictive models and smart technologies will enable risk prediction, adaptation of care plans, and provision of decision support tools for clinicians.

This review achieves two objectives: first, to summarize the literature on telemedicine and lay the groundwork for future research in this area; and second, to identify a path for the future development of telemedicine by outlining telemedicine research capabilities, including current trends, challenges, and opportunities, and providing recommendations for the development and implementation of smarter, safer, and clinically validated technology that will ultimately lead to more proactive healthcare, affordable and sustainable in the long term.

5.1. Gaps in the Literature

While the area of telemedicine and its associated support tools (e.g., non-contact monitoring systems) has progressed rapidly in recent years, there are still significant gaps in the scientific literature that prevent a full understanding of its impact [50]. The main one is the scarcity of longitudinal research that analyzes the good performance of these technologies over time in clinical contexts. Most studies evaluate only short-term outcomes (e.g. monitoring accuracy or potential technical problems), with little or no assessment of long-term efficacy, sustainability, or integration into the mainstream healthcare system [51].

In addition, many of the reports on these types of technologies were influenced by the pressures of the COVID-19 pandemic, where telemedicine was rapidly being incorporated due to reduced in-person contact, which has led to a very different set of circumstances than those typically studied [52, 53].

Therefore, although the rapid development of some technologies (e.g. remote monitoring) has occurred due to the pandemic, there has been a lack of comprehensive (multifaceted) assessments of their long-term reliability, sustainability, scalability and post-pandemic clinical validation [54]. There is no empirical research comparing the performance of these technologies before, during, and after the pandemic; This constitutes a significant limitation in the current state of knowledge about these technologies.

The concentration of scientific production in countries with advanced technological medical infrastructures was evident in the graphic distribution. However, there are very few studies published in countries with limited resources. This imbalance in the distribution of research makes it difficult to implement non-contact monitoring systems in different settings; therefore, it is essential to promote multicenter and interdisciplinary studies that consider different socioeconomic conditions [55]. By filling these research gaps, we will strengthen the conceptual basis for telehealth service delivery and establish stronger, more equitable, and sustainable methods for telehealth service delivery in the future.

Recommendations for Future Studies

Taking into account the research results and the gaps found in the literature, the following suggestions provide guidance for future research in this area:

- Longitudinal studies should be conducted to analyze the effectiveness and clinical performance of non-contact monitoring systems over time, especially in real-world healthcare settings.
- A thorough assessment of technical issues associated with sensor reliability, signal interference, transmission delays, and data integrity needs to be conducted in different clinical and home environments.
- The use of such systems requires an in-depth analysis of issues related to privacy, data security, and ethics.
- Interdisciplinary and multicentre studies should encourage the examination of different socio-economic contexts, thus allowing the evaluation of the global application and the potential for expansion.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Funding Statement

The University of Sciences and Humanities, through its Research Office, contributed to the payment of the Article Processing Charge (APC).

Acknowledgments

The authors wish to express their sincere gratitude to the University of Sciences and Humanities (UCH) of Lima, Peru, for their academic and institutional support during this research project. This university has supported the authors in developing an academic culture that encourages inquiry, critical thinking and the pursuit of lifelong learning. Likewise, access to scientific databases, research resources and academic advice were essential to complete this systematic review. Finally, the authors wish to acknowledge the continued support and encouragement provided during the preparation of this document.

References

[1] Iandra Galdino et al., “eHealth CSI: A Wi-Fi CSI Dataset of Human Activities,” *IEEE Access*, vol. 11, pp. 71003-71012, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[2] World Health Organization, Noncommunicable Diseases, World Health Organization, 2025. [Online]. Available: https://www.who.int/news-room/fact sheets/detail/noncommunicable-diseases

[3] Dana Pop et al., “The Role of Telemedicine in the Recovery of Patients with Ischemic Heart Disease,” *Balneo and PRM Research Journal*, vol. 16, no. 3, 2025. [Google Scholar]

[4] Tsukiko Kitagawa et al., “Multibeam Doppler Sensor-based Non-Contact Heartbeat Detection using Beam Diversity,” *IEEE Access*, vol. 10, pp. 16242-16253, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[5] Alexander R. Lucas et al., “Development of an eHealth System to Capture and Analyze Patient Sensor and Self-Report Data: Mixed-Methods Assessment of Potential Applications to Improve Cancer Care Delivery,” *JMIR Medical Informatics*, vol. 6, no. 4, pp. 1-13, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[6] Jin-Soo Kim, and Kangyoon Lee, “Untact Abnormal Heartbeat Wave Detection using Non-Contact Sensor through Transfer Learning,” *IEEE Access*, vol. 8, pp. 217791-217799, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[7] Gang Guo et al., “Design and Analysis of Field Telemedicine Information Communication Protocol based on Wireless Sensor Network,” *IEEE Access*, vol. 7, pp. 50630-50635, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[8] Wai-Kong Lee et al., “Parallel and High Speed Hashing in GPU for Telemedicine Applications,” *IEEE Access*, vol. 6, pp. 37991-38002, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[9] Mattiènne R. van der Kamp et al., “eHealth Technologies for Monitoring Pediatric Asthma at Home: Scoping Review,” *Journal of Medical Internet Research*, vol. 25, pp. 1-37, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[10] Yuanzhe Zhao, and Jeroen H.M. Bergmann, “Non-Contact Infrared Thermometers and Thermal Scanners for Human Body Temperature Monitoring: A Systematic Review,” *Sensors*, vol. 23, no. 17, pp. 1-28, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[11] Kwo-Chen Lee et al., “The Impact of Age on Comparative Diagnostic Accuracy of Temporal Artery Thermometers and Non-Contact Infrared Thermometers for Fever Detection: A Systematic Review and Meta-Analysis,” *BMC Infectious Diseases*, vol. 25, no. 1, pp. 1-17, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[12] Kin Fun Li, “Smart Home Technology for Telemedicine and Emergency Management,” *Journal of Ambient Intelligence and Humanized Computing,* vol. 4, no. 5, pp. 535-546, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[13] Muhammad Jamal Ahmed et al., “CardioGuard: AI-Driven ECG Authentication Hybrid Neural Network for Predictive Health Monitoring in Telehealth Systems,” *SLAS Technology*, vol. 29, no. 5, pp. 1-12, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[14] Yonggu Lee et al., “A Novel Non-Contact Heart Rate Monitor using Impulse-Radio Ultra-Wideband (IR-UWB) Radar Technology,” *Scientific Reports*, vol. 8, no. 1, pp. 1-10, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[15] Jure Kosir, Daniele Vella, and Matija Jezersek, “Non-Contact Monitoring of the Depth Temperature Profile for Medical Laser Scanning Technologies,” *Scientific Reports*, vol. 10, no. 1, pp. 1-10, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[16] Sebastian Thelen et al., “Using Off-The-Shelf Medical Devices for Biomedical Signal Monitoring in a Telemedicine System for Emergency Medical Services,” *IEEE Journal of Biomedical and Health Informatics*, vol. 19, no. 1, pp. 117-123, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[17] Weiping Zhang, Kerstin Thurow, and Regina Stoll, "A Context-Aware mHealth System for Online Physiological Monitoring in Remote Healthcare," *International Journal of Computers, Communications and Control*, vol. 11, no. 1, pp. 142-156, 2016. [Google Scholar] [Publisher Link]

[18] M. Abo-Zahhad, Sabah M. Ahmed, and O. Elnahas, "A Wireless Emergency Telemedicine System for Patients Monitoring and Diagnosis," *International Journal of Telemedicine and Applications*, vol. 2014, no. 1, pp. 1-11, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[19] Shuyue Guan et al., "A Review of Deep Learning Methods for Non-Contact Heart Rate Measurement based on Facial Videos," *Journal of Biomedical Engineering*, vol. 42, no. 1, pp. 197-204, 2025. [Google Scholar]

[20] Fusheng Ding et al., "Driver Drowsiness Detection based on Facial Video Non-Contact Heart Rate Measurement," *Journal of Advanced Computational Intelligence and Intelligent Informatics*, vol. 29, no. 2, pp. 306-315, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[21] Timothy Rey Laheba, Rajesri Govindaraju, and Made Andriani, "Telemedicine System Quality from Physicians' Perspectives: Key Determinants and its Impact on Service Effectiveness via Interaction Quality," *IEEE Access*, vol. 13, pp. 96894-96910, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[22] Bernard Dillon Obika et al., "Implementation of an mHealth Solution to Remotely Monitor Patients on a Cardiac Surgical Waiting List: Service Evaluation," *JAMIA Open*, vol. 4, no. 3, pp. 1-5, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[23] Alison K. Beck et al., "Developing a mHealth Routine Outcome Monitoring and Feedback App ('SMART Track') to Support Self-Management of Addictive Behaviours," *Frontiers in Psychiatry*, vol. 12, pp. 1-14, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[24] Nathan Jeger-Madiot et al., "Non-Contact and Through-Clothing Measurement of the Heart Rate using Ultrasound Vibrocardiography," *Medical Engineering and Physics*, vol. 50, no. 1, pp. 96-102, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[25] Ling Zhou et al., "Recognition of Apnea and Hypopnea by Non-Contact Optical Fiber Mattress and its Application in the Diagnosis of Obstructive Sleep Apnea Hypopnea Syndrome: A Retrospective Study," *PeerJ*, vol. 12, pp. 1-17, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[26] Krzysztof Milewski et al., "The use of Modern Telemedicine Technologies in an Innovative Optimal Cardiac Rehabilitation Program for Patients after Myocardial Revascularization: Concept and Design of Restore, A Randomized Clinical Trial," *Cardiology Journal*, vol. 26, no. 5, pp. 594-603, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[27] Sun Kang et al., "Non-Contact Diagnosis of Obstructive Sleep Apnea using Impulse-Radio Ultra-Wideband Radar," *Scientific Reports*, vol. 10, no. 1, pp. 1-7, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[28] Chung Kyo, and Byung Chan Min, "Detection and Predictive Analysis of Drowsiness using Non-Contact Doppler Sensor," *Technical Bulletin*, vol. 19, no. 1, pp. 42-48, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[29] Kiril Antevski et al., "A 5G-based eHealth Monitoring and Emergency Response System: Experience and Lessons Learned," *IEEE Access*, vol. 9, pp. 131420-131429, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[30] Yimeng Fan et al., "Vital Sign Measurement in Telemedicine Rehabilitation based on Intelligent Wearable Medical Devices," *IEEE Access*, vol. 7, pp. 54819-54823, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[31] Viacheslav Mazlin et al., "Real-time Non-Contact Cellular Imaging and Angiography of Human Cornea and Limbus with Common-Path Full-Field/SD OCT," *Nature Communications*, vol. 11, no. 1, pp. 1-14, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[32] Paulino Alvarez et al., "Chronic Disease Management in Heart Failure: Focus on Telemedicine and Remote Monitoring," *Reviews in Cardiovascular Medicine*, vol. 22, no. 2, pp. 403-413, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[33] Gaetano Scebba, Giulia Da Poian, and Walter Karlen, "Multispectral Video Fusion for Non-Contact Monitoring of Respiratory Rate and Apnea," *IEEE Transactions on Biomedical Engineering*, vol. 68, no. 1, pp. 350-359, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[34] Zhengnan Liu et al., "Advances in the Development and Application of Non-Contact Intraoperative Image Access Systems," *BioMedical Engineering OnLine*, vol. 23, no. 1, pp. 1-14, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[35] Xinyao Tang et al., "High-Sensitivity Electric Potential Sensors for Non-Contact Monitoring of Physiological Signals," *IEEE Access*, vol. 10, pp. 19096-19111, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[36] Yang Dong et al., "A Quantitative and Non-Contact Technique to Characterise Microstructural Variations of Skin Tissues During Photo-Damaging Process based on Mueller Matrix Polarimetry," *Scientific Reports*, vol. 7, no. 1, pp. 1-10, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[37] Ken-Ichi Nomura et al., "A Flexible Proximity Sensor Formed by Duplex Screen/Screen-Offset Printing and its Application to Non-Contact Detection of Human Breathing," *Scientific Reports*, vol. 6, no. 1, pp. 1-12, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[38] Bo Ram Seol, Tae Gu Kang, and Bonhyeok Gu, "Intraocular Pressure According to Different Types of Tonometry (Non-Contact and Goldmann Applanation) in Patients with Different Degrees of Bilateral Tearing," *PLoS One*, vol. 14, no. 9, pp. 1-9, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[39] Yandao Huang et al., "AI-Driven System for Non-Contact Continuous Nocturnal Blood Pressure Monitoring using Fiber Optic Ballistocardiography," *Communications Engineering*, vol. 3, no. 1, pp. 1-11, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[40] Fatma Aydin Akgun, and Giray Soytürk, Muhtalip Dede, "A New IoT System for Non-Contact Body Temperature Sensing and Warning," *Sigma Journal of Engineering and Natural Sciences-Sigma*, vol. 41, no. 5, pp. 892-899, 2023. [CrossRef] [Google Scholar]

[41] Jaeho Shin et al., "A Non-Contact Wearable Device for Monitoring Epidermal Molecular Flux," *Nature*, vol. 640, no. 8058, pp. 375-383, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[42] A. Anagnostaki et al., "Integration of CEN/TC251/PT5-021 'VITAL' preENV Standard and of 'DICOM Supplement 30.0' into a Telemedicine System for Vital Signs Monitoring from Home," *Proceedings of the 22nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (Cat. No.00CH37143)*, Chicago, IL, USA, vol. 2, pp. 1368-1371, 2000. [CrossRef] [Google Scholar] [Publisher Link]

[43] Kıvanç Atilgan MD et al., "Remote Patient Monitoring after Cardiac Surgery: The Utility of a Novel Telemedicine System," *Journal of Cardiac Surgery*, vol. 36, no. 11, pp. 4226-4234, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[44] Pornthira Mutirangura et al., "Application of Telemedicine in the Management of Cardiovascular Diseases: A Focus on Heart Failure," *Reviews in Cardiovascular Medicine*, vol. 26, no. 6, pp. 1-16, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[45] D. Bitar, A. Goubar, and J.C Desenclos, "International Travels and Fever Screening during Epidemics: A Literature Review on the Effectiveness and Potential use of Non-Contact Infrared Thermometers," *Euro Surveillance*, vol. 14, no. 6, pp. 1-5, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[46] Linas Saikevičius et al., "Non-Contact Vision-based Techniques of Vital Sign Monitoring: Systematic Review," *Sensors*, vol. 24, no. 12, pp. 1-20, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[47] Elham Shojaei et al., "Investigating Impacts of Telemedicine on Emergency Department through Decreasing Non-Urgent Patients in Spain," *IEEE Access*, vol. 8, pp. 164238-164245, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[48] Ahed Abugabah, Nishara Nizamuddin, and Ahmad Ali Alzubi, "Decentralized Telemedicine Framework for a Smart Healthcare Ecosystem," *IEEE Access*, vol. 8, pp. 166575-166588, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[49] Maximilian W.M. Wintergerst et al., "Non-Contact Smartphone-based Fundus Imaging Compared to Conventional Fundus Imaging: A Low-Cost Alternative for Retinopathy of Prematurity Screening and Documentation," *Scientific Reports*, vol. 9, no. 1, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[50] Héctor Cabrerizo-Carreño et al., "Impact of the Implementation of a Telemedicine Program on Patients Diagnosed with Asthma," BMC Pulmonary Medicine, vol. 24, no. 1, pp. 1-8, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[51] Zhenzhen Duan, and Jing Liang, "Non-Contact Detection of Vital Signs using a UWB Radar Sensor," *IEEE Access*, vol. 7, pp. 36888-36895, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[52] Jong Deok Kim et al., "Non-Contact Respiration Monitoring using Impulse Radio Ultrawideband Radar in Neonates," *Royal Society Open Science*, vol. 6, no. 6, pp. 1-28, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[53] Moshe Oziel, Rafi Korenstein, and Boris Rubinsky, "Radar based Technology for Non-Contact Monitoring of Accumulation of Blood in the Head: A Numerical Study," *PLoS One*, vol. 12, no. 10, pp. 1-20, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[54] William Taylor et al., "A Review of the State of the Art in Non-Contact Sensing for COVID-19," *Sensors*, vol. 20, no. 19, pp. 1-19, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[55] Nayli Nabila Azman, Mitra Mohd Addi, and Amr Al-Abed, "Development of an IoT Embedded Wearable Device with Non-Contact Temperature Detector for Early Detection of Fever," *International Journal of Integrated Engineering*, vol. 15, no. 3, pp. 15-27, 2023. [Google Scholar] [Publisher Link]

[56] Sang Hoon Oh et al., "Development of a Heart Rate Detection Algorithm using a Non-Contact Doppler Radar Via Signal Elimination," *Biomed Signal Process Control*, vol. 64, pp. 1-5, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[57] Uday Debnath, and Sungho Kim, "A Comprehensive Review of Heart Rate Measurement using Remote Photoplethysmography and Deep Learning," *BioMedical Engineering OnLine*, vol. 24, no. 1, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[58] Yoo Jin Choo et al., "Application of Non-Contact Sensors for Health Monitoring in Hospitals: A Narrative Review," *Frontiers in Medicine*, vol. 11, pp. 1-8, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[59] Sara Guarducci et al., "Key Fundamentals and Examples of Sensors for Human Health: Wearable, Non-Continuous, and Non-Contact Monitoring Devices," *Sensors*, vol. 25, no. 2, pp. 1-33, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[60] Muhammad Salman Raheel et al., "Contactless Vital Sign Monitoring Systems: A Comprehensive Survey of Remote Health Sensing for Heart Rate and Respiration in Internet of Things and Sleep Applications," *Sensors and Diagnostics*, vol. 3, no. 7, pp. 1085-1118, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[61] Eva Senechal, et al., "Next Generation of Non-Contact and Wireless Vital Sign Monitoring Technology in the Neonatal Intensive Care Unit: A Systematic Review," *Pediatric Research*, vol. 99, no. 7, pp. 1-9, 2025. [CrossRef] [Google Scholar] [Publisher Link]