

## The 100 most cited articles on wearable technology in the area of Medical Informatics: A bibliometric analysis using Web of Science

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### Abstract

**INTRODUCTION:** Wearable technology has revolutionized healthcare in recent years thanks to its ability to collect accurate data on the health status of patients. Wearable devices, such as smartwatches, wristbands, and fitness trackers, are designed to be worn on the body and can measure various body parameters, including heart rate, blood pressure, physical activity, and sleep quality.

**OBJECTIVES:** To analyze the 100 most cited articles on wearable technology in the area of Medical Informatics.

**METHODS:** The Web of Science database carried out a bibliometric analysis of the 100 most cited articles on wearable technology in the area of Medical Informatics. The objective is to identify the main trends and themes in this area of research.

**RESULTS:** There is an increasing trend in the number of papers published and citations received in recent years, with some years with low publications but high citations and others with high publications but low citations. A positive and statistically significant correlation ( $r = 0.66$ ;  $P < 0.001$ ) was found between the number of documents published by the authors and the number of citations they received. The analysis of publications by country, reveals that the United States is the most productive country, with 49 documents, followed by the United Kingdom, China, and Italy. However, when considering the impact of the research, other countries such as Canada, Germany, China, and South Korea have significantly high average citations per paper and leadership.

**CONCLUSION:** The results of this study have several important implications for the research and development of wearable technology in the area of Medical Informatics. The increase in the number of papers published and citations received in recent years suggests a growing interest and advances in research. This indicates an increasing need to develop innovative real-time solutions for measuring and monitoring physical activity and health.

**Keywords:** wearable technologies; healthcare; wearable sensors; bibliometric analysis; VOSviewer.

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## 1. Introduction

Wearable technology has revolutionized healthcare in recent years thanks to its ability to collect accurate data on the health status of patients. Wearable devices, such as smartwatches, wristbands, and fitness trackers, are designed to be worn on the body and can measure various body parameters, including heart rate, blood pressure, physical activity, and sleep quality.<sup>1</sup>

This technology has become an essential tool in healthcare due to its ability to improve the efficiency of healthcare services, enhance patient-physician communication, improve access to remote healthcare, and enable patients to have greater control over their health.<sup>2</sup>

The data collected by wearable devices can provide valuable information to the doctor before the patient visit, allowing healthcare professionals to focus on each patient's specific needs and make informed decisions about their medical care.<sup>3-6</sup> In addition, patients can use the data collected by wearable devices to become more aware of their health status and adjust their lifestyle and eating habits.<sup>7,8</sup>

Wearable devices serve as tools in remote medical care through online platforms. Especially in patients who live in remote areas or have difficulties traveling to a medical care center, they are potentially helpful in reducing health costs.<sup>9-12</sup>

This article aims to analyze the 100 most cited articles on wearable technology in the area of Medical Informatics.

## 2. Methods

**Type of study:** The Web of Science database carried out a bibliometric analysis of the 100 most cited articles on wearable technology in the area of Medical Informatics. The objective is to identify the main trends and themes in this area of research.

**Search strategy:** A search of the Web of Science database was performed using the terms "wearable technology" and "weareable" in the category "Medical Informatics".

**Analysis techniques:** R and Medcalc software were used for statistical analysis, and Vosviewer was used to analyze the data collected from the qualitative and thematic points of view.

## 3. Results

Figure 1 presents the number of documents and citations received yearly on wearable technology in Medical Informatics. There is an increasing trend in the number of papers published and citations received in recent years, with some years with low publications but high citations and others with high publications but low citations.

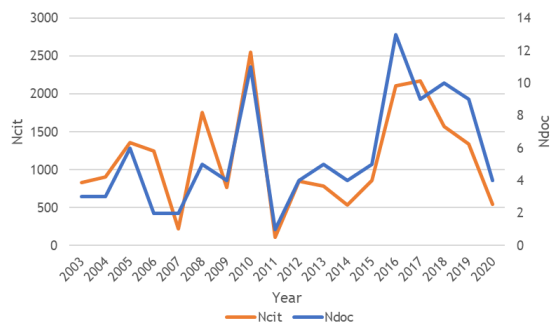


Figure 1. Number of documents and citations received per year.

Figure 2 shows the co-authorship network of the articles included in the study on wearable technology in Medical Informatics. The most productive authors were Gerhard Troster, with 5 papers published and 1,393 citations received, followed by Guang-Zhong Yang and Benny Lo, with 3 articles published and 1,262 citations received each.

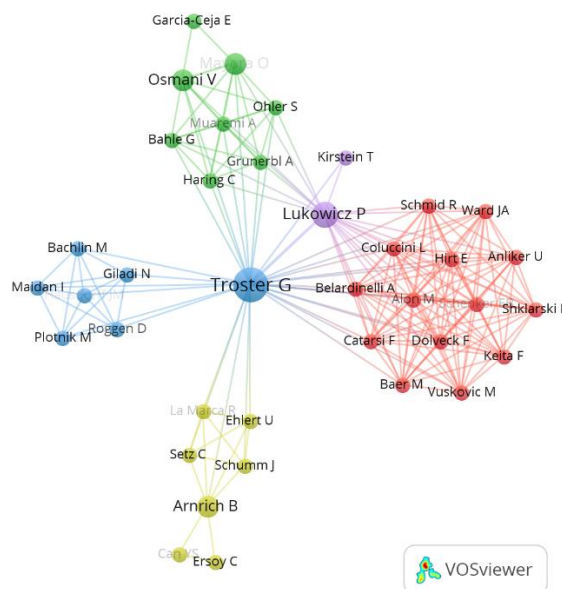


Figure 2. Co-authorship network.

In addition, a positive and statistically significant correlation ( $r = 0.66$ ;  $P < 0.001$ ) was found between the number of documents published by the authors and the number of citations they received (Figure 3). This suggests that authors who publish more papers tend to receive more citations, which may indicate their impact and productivity in the field of research.

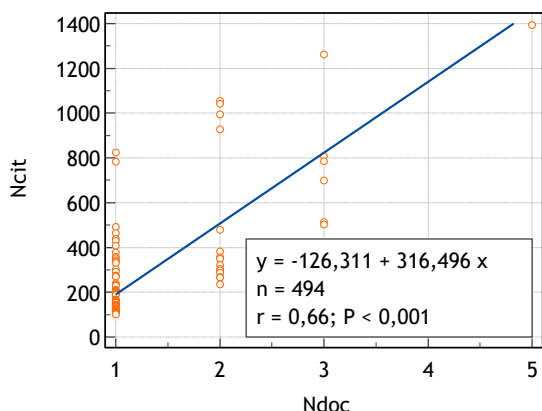


Figure 3. Correlation between the number of documents published and the number of citations received by the authors.

The analysis of Table 1, which analyzes the publications by country, reveals that the United States is the most productive country, with 49 documents, followed by the United Kingdom, China, and Italy. However, when considering the impact of the research, other countries such as Canada, Germany, China, and South Korea have significantly high average citations per paper and leadership. In addition, the UK and France also stand out for their high citation level and solid scientific leadership. It was found that the countries with the highest leadership level receive the highest number of citations on average (Figure 4).

Table 1. Bibliometric indicators by countries.

Country	Ndoc	Ncit	Cpd	%Lead
USA	49	8588	175,3	71,4%
UK	12	3285	273,8	58,3%
China	9	1636	181,8	77,8%
Italy	9	1996	221,8	55,6%
Canada	7	1113	159,0	85,7%
France	6	2195	365,8	66,7%
Switzerland	6	1599	266,5	50,0%
Germany	5	936	187,2	80,0%
Australia	5	1452	290,4	60,0%
South Korea	4	671	167,8	75,0%
Israel	3	871	290,3	0,0%
New Zealand	3	502	167,3	100,0%
Qatar	2	220	110,0	50,0%
Japan	2	235	117,5	100,0%
Austria	2	322	161,0	50,0%
Belgium	2	220	110,0	100,0%
Cyprus	2	314	157,0	50,0%
Finland	2	927	463,5	100,0%
Iran	2	267	133,5	100,0%

India	2	230	115,0	50,0%
Greece	2	265	132,5	100,0%
Turkey	1	135	135,0	100,0%
Taiwan	1	114	114,0	100,0%
Sweden	1	128	128,0	0,0%
Singapore	1	198	198,0	100,0%
Egypt	1	162	162,0	100,0%
Czech Republic	1	203	203,0	0,0%
Brazil	1	139	139,0	100,0%
Ireland	1	206	206,0	100,0%
Saudi Arabia	1	104	104,0	0,0%
Netherlands	1	158	158,0	100,0%
Mexico	1	107	107,0	100,0%

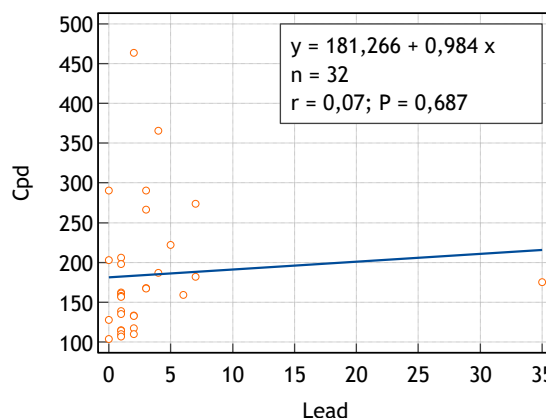


Figure 4. Correlation between citations by papers and scientific leadership by country.

Figure 5 shows the collaboration networks between countries, where the central role of the United States is observed.

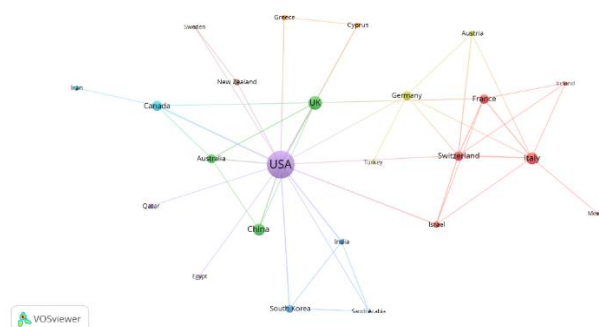


Figure 5. Collaboration networks between countries.

When the distribution of documents in different categories related to wearable technology in the area of Medical Informatics was analyzed (Figure 6), as expected, all the documents were in the Medical Informatics category. Still, they were represented by others such as Computer Science, Interdisciplinary Applications with 54,

and Mathematical & Computational Biology with 49. Computer Science, Information Systems and Health Care Sciences & Services are popular categories with 49 and 32 documents, respectively. Biomedical Engineering and Artificial Intelligence have a smaller presence, with 13 and 2 papers, respectively, and General & Internal Medicine only has one article.

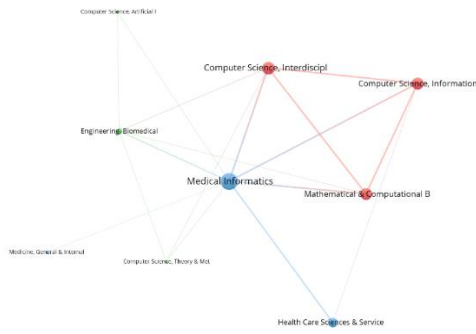


Figure 6. Networks of subject areas.

The term co-occurrence matrices are shown in Figure 7.

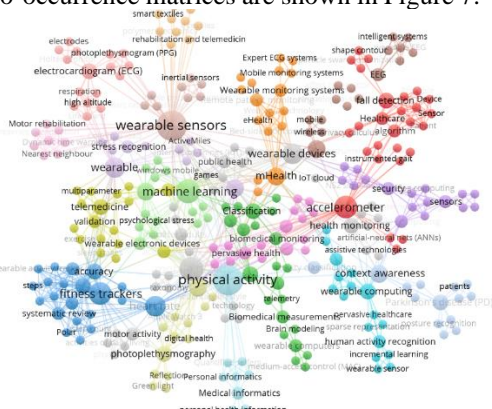


Figure 5. Term co-occurrence matrices.

#### 4. Discussion

Wearable technology has become a handy tool in the field of Medical Informatics, allowing the collection of real-time data on the well-being and health of patients. The quality of research in this field is paramount, as it can significantly impact clinical decision-making, policy and guideline development, and ultimately patient care and quality of life.

High-quality studies on wearable technology in the area of Medical Informatics can identify best practices and effective technologies for improving the health and well-being of patients.<sup>13-16</sup> In addition, these studies can significantly impact the scientific and medical community, leading to advances in disease diagnosis, treatment, and prevention.<sup>17</sup>

Combining our results, Burbano-Fernandez and Ramirez-Gonzalez (2018)<sup>18</sup> found that scientific production in wearable technology and health has experienced constant growth from 2004 to 2018. This indicates that wearable technology is an area of constantly

evolving research that remains relevant today. Regarding identifying relevant topics, they focused on monitoring physical activity, mental health, real-time health monitoring and cardiovascular health. These results may be helpful for researchers and health professionals interested in developing and applying wearable technology.

Different documents, such as research articles, reviews, patents and conferences, were also identified, and their impact and visibility were assessed. This provides a complete view of the scientific production in the field of wearable technology and may be helpful for researchers who wish to publish their work in this field.

Research in wearable technology can also be influential in developing policies and guidelines in Health Informatics, which can help improve the quality of care and reduce costs. Additionally, wearable technology can improve the quality of life for patients and their families by improving the accuracy of disease diagnosis and monitoring.<sup>19</sup>

It is important to highlight that research on wearable technology in Health Informatics is still at an early stage, and additional high-quality studies are needed to explore its potential in healthcare fully. Challenges include ensuring the accuracy of data collected, the privacy and security of patient information, and the effective implementation of these technologies in clinical settings.

Regarding the analysis by country, de-la-Fuente-Robles et al., 2022<sup>20</sup> show that the United States and the United Kingdom are the most productive countries in research on the application of wireless technology in health (WTH). Although the study highlights that other countries such as Italy, China, and Germany have also contributed significantly, our study emphasizes that countries such as Canada, Germany, China, South Korea, the United Kingdom, and France have a high impact in this field, measured by average citations per paper and solid scientific leadership.

The study by Kageyama et al.<sup>21</sup> focuses on the intellectual structure of research, specifically in the two leading countries in this research: China and the United States. It was found that China focuses more on basic research. In contrast, the United States focuses more on applied research, indicating a balance between applied and basic research in the wearable technology domain.

This suggests that although the United States has many publications on wearable technology in Health Informatics, other countries are making significant contributions to research in this field. The results also highlight the importance of considering the number of publications and their impact on the scientific community.

The analysis of the categories suggests great interest in wearable technology in the field of Health Informatics and a significant focus on the interdisciplinary application of the technology.

Burbano-Fernandez and Ramirez-Gonzalez (2018)<sup>18</sup> observed a trend towards interdisciplinary collaboration in wearable technology, especially between medical informatics and engineering. This suggests that collaboration between different disciplines is essential for

advancing and applying wearable technology. On the other hand, some challenges and limitations were also identified in the use of wearable technology in clinical practice, such as the lack of standardization in data measurement and interpretation, the need for greater integration of the technology in the health of the system, and concern for the privacy and security of patient data.<sup>22</sup>

The qualitative analysis reveals that most articles focused on using wearable devices for health monitoring, especially in preventing and treating chronic diseases. In particular, the use of sensors for the detection of physical activity, the measurement of heart rate and the monitoring of sleep patterns are highlighted. Similarly, the identified clusters denote the growing interest in using wearable technology to improve diagnosis and clinical decision-making, especially in telemedicine and remote medical care.<sup>23-27</sup> In this sense, the advances in the development of automatic learning algorithms for the early detection of pathologies and the prediction of the risk of complications in patients are highlighted.<sup>28</sup>

Considering that these are the most cited articles, with a high pattern of academic consumption, the term co-occurrence matrix provides valuable information on relevant topics and critical interrelationships. The most pertinent terms such as "wearable sensors", "physical activity", "mobile health", "machine learning" and "fitness trackers".<sup>29,30</sup> These terms suggest that physical activity and health monitoring through wearable sensors and wearable devices, data analysis and pattern detection using machine learning techniques are central topics in wearable technology research. In addition, other relevant terms include "heart rate", "ECG" and "photoplethysmography", which are related to health measurement and heart rate monitoring. "Telemedicine" is a necessary term associated with wearable technology for remote medical care.<sup>31-33</sup> At the same time, "Parkinson's disease" and "fall detection" are related to the early detection of falls in people with Parkinson's and other diseases.<sup>34</sup>

### Study limitations

An essential limitation of the study is that only the Web of Science database was used to select the articles to be analyzed.<sup>35</sup> Although this database is widely used in the scientific community, it does not include all relevant scientific journals. It may have missed some crucial articles on wearable technology in Health Informatics. Therefore, the results may not represent the totality of research in this field.<sup>36,37</sup>

Furthermore, another possible bias is the selection of the 100 most cited articles, which may have excluded some relevant and novel articles that have not had enough time to be cited. This may limit the representativeness of the results and may not consider the latest research.<sup>38,39</sup>

Another limitation is that the bibliometric evaluation, although helpful in measuring the impact of the research, does not provide detailed information on the quality or relevance of the articles. Therefore, it is important to consider the quality and relevance of the articles beyond their number of citations.<sup>40</sup>

Finally, it is important to note that the analysis focused on the most common terms in the selected articles, which may not have captured all the important themes and the relationships between them.

## 5. Conclusions

The results of this study have several important implications for the research and development of wearable technology in the area of Medical Informatics.

The increase in the number of papers published and citations received in recent years suggests a growing interest and advances in research. This indicates an increasing need to develop innovative real-time solutions for measuring and monitoring physical activity and health. Considering that there was a correlation between the number of documents published by the authors and the number of citations received indicates that the most productive authors have a more significant impact on the field of research. This may suggest encouraging and supporting productive and collaborative research in this field to achieve more significant effects and scientific progress.

Findings on the productivity and impact of research across countries are relevant to resource allocation and strategic planning for wearable technology research. It is important to consider countries with solid scientific leadership and a high average number of citations per paper to identify collaborations and funding opportunities.

Identifying the most relevant categories suggests that the areas of Medical Informatics, Computer Science, Interdisciplinary Applications and Mathematical & Computational Biology are the most important in this field. This can be of great help for the planning of research strategies and the allocation of resources in the development of wearable technology in the area of Medical Informatics.

Finally, the term co-occurrence matrices provide valuable insights into key topics in wearable technology research, such as measuring physical activity and health through wearable sensors and wearable devices, data analysis, and research pattern detection using machine learning techniques. These results can guide the research and development of more advanced and accurate wearable technology for real-time health and physical activity monitoring.

The results of this study have important implications for the development of wearable technology in the area of Medical Informatics. They can be used by researchers, decision-makers and other key players in the field of health and technology to guide future research and development.

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