

Digital Transformation in Healthcare: A Bibliometric Analysis

¹Zhang Luxin, ²Wan Mohd Hirwani Wan Hussain

Submitted: 01/06/2024 **Revised:** 08/06/2024 **Accepted:** 15/06/2024

Abstract: This study systematically examines the digital transformation in healthcare through bibliometric analysis, offering a comprehensive overview. By analyzing 918 documents, we assessed various dimensions, including geographical distribution, publication year, research domains, prolific authors, institutions, publishers, and highly cited articles. Our findings highlight the growing importance and interdisciplinary nature of this field, emphasizing the need for collaborative efforts among researchers. As digital transformation evolves, academia, industry, and policymakers must work together to leverage technological advancements to improve healthcare outcomes and enhance human well-being. Sustained and expanded research efforts are essential to fully realize its potential benefits.

Key Words: *Digital transformation, healthcare, bibliometric, hospital, digitization*

1. INTRODUCTION

The concept of digital transformation is widely discussed and has profound consequences for organisations on a worldwide scale. Zaoui and Souissi (2020) argue that it fundamentally transforms how businesses interact with customers, organise their operations, control expenses, create value, and set strategic objectives. Digital transformation refers to the process of implementing changes in a business and its operations via the use of information technology. This strategy is more effective in generating higher income and reducing expenses for an organisation compared to previous transformation approaches. Organisations can enhance their operations and achieve various objectives by leveraging technologies such as social media, mobile technology, Internet of Things (IoT), cybersecurity, big data and analytics, cloud computing, robotic process automation (RPA), artificial intelligence

(e.g., machine learning), and blockchain. These technologies enable organisations to improve project management, personnel management, business expansion, marketing, customer communication, transaction facilitation, and completion, customer data analysis, and personalised service strategies (Tang, 2021; Winarsih et al., 2021). This phenomenon has also impacted managers across many industries, compelling them to acquire and implement relevant understanding of digital technology to adjust and embrace digital transformation. The healthcare business has played a significant role in driving digital transformation in recent years. The healthcare industry has undergone a digital transformation, resulting in a shift in the management model of hospitals, a decrease in communication costs between patients and clinicians, and an enhancement in the quality of healthcare services (Marques & Ferreira, 2020; Tang, 2021). According to a report by Siegel et al. (2020), 65% of hospitals have started implementing digital technology for healthcare services.

A growing number of academics are acknowledging the importance of digital transformation in healthcare. Marques and Ferreira (2020) performed a comprehensive analysis of

¹University of Kebangsaan Malaysia Graduate School of Business

Email: p127297@siswa.ukm.edu.my

²University of Kebangsaan Malaysia Graduate School of Business

Email: wmhwh@ukm.edu.my

Corresponding Author: Wan Mohd Hirwani Wan Hussain

existing literature on digital transformation in the healthcare sector. They found that the amount of literature on this subject has significantly increased in the last twenty years, with a greater emphasis on studying subjects related to technology. In their literature analysis, Dionisio et al. (2023) specifically examined the advancements that digital transformation has introduced to the healthcare sector and explored how managers might effectively implement these innovations in their management strategies. In a study conducted in 2023, researchers examined publications published from 2017 to 2021 that focused on the impact of digital technologies in the healthcare sector. The research found that COVID-19 played a significant influence in driving the adoption of digital technology in hospitals (Dal Mas et al., 2023).

While there is a substantial amount of literature on healthcare digitization, there is a dearth of research that examines overarching trends and patterns in this field. This study aims to conduct a thorough literature analysis on digital transformation in healthcare. The main objectives are to map the existing scholarship, identify the prominent contributors in the field using statistical data analysis, and predict future research directions based on the historical progress of the field. This will offer invaluable guidance to pertinent researchers, aiding their comprehension of present study patterns and forthcoming trajectories. Simultaneously, it will offer medical professionals novel viewpoints and concepts to assist them in effectively addressing the difficulties of digital transformation and formulating efficient management plans. This study aims to thoroughly examine and analyse the current literature to offer valuable references and assistance to scholars and professionals engaged in researching and implementing digital transformation in the healthcare sector.

To achieve these goals, This study will answer the following questions:

1. What is the current landscape of digital transformation in healthcare research?

2. What emerging trends are observable in recent publications on digital transformation in healthcare?

3. Which key authors, institutions, and countries are leading advancements in digital transformation in healthcare research?

4. Which journals and publications are central to groundbreaking studies in digital transformation in healthcare?

5. What remarkable papers have significantly shaped the discourse and direction of digital transformation in healthcare industry research?

This study examines the topic of digital transformation in the healthcare industry through bibliometric analysis. The bibliometric study will methodically arrange and evaluate the current pertinent literature to uncover the research trends, patterns, and focal points in the subject. This study aims to offer significant materials and insights to future researchers, while also leading the way for new research directions and providing a comprehensive academic roadmap for related topics.

This study aims to facilitate the comprehension of the driving forces in the area by doing comprehensive data analysis to identify prominent researchers, research organisations, and research countries. This study will undertake a comprehensive study of the literature to identify important themes and primary research areas for digital transformation in healthcare. The aim is to aid researchers, enabling them to better position and carry out their research in a more effective manner. Furthermore, this study aims to offer pragmatic advice to healthcare practitioners, enabling them to gain a comprehensive comprehension and effectively implement the most recent research discoveries concerning digital transformation. This article aims to provide healthcare organisations with useful references to overcome problems and enhance operational efficiency and service quality during digital transformation. It does so by analysing and summarising the best practices and success stories discovered in the existing literature.

This study aims to offer both theoretical support for academia and practical solutions through a thorough analysis. The main objective of this bibliometric analysis is facilitating more adoption and integration of digital transformation in the healthcare sector, to enhance the effectiveness and excellence of healthcare services.

Ultimately, this paper aims to offer an extensive examination of existing literature and empirical evidence to support the investigation of digital transformation in the healthcare sector using bibliometric analysis. This analysis will assist future researchers in identifying a distinct path and objective in this domain. Simultaneously, this study will establish a scientific foundation for the healthcare industry's implementation and facilitate its effective achievement of digital transformation.

2. BACKGROUND LITERATURE

According to research conducted in 1973, it is necessary to investigate how computer technology might assist practitioners working in medical centres that are distant from major cities. The researchers in this study set out to determine whether there was any merit in using computers in healthcare, with a focus on hospitals in rural areas. The study's findings show that there are several ways in which medical centres might benefit greatly from computer technology. Systems that help identify patients, organise their medical records and analyse statistical data are all examples of what is needed to support healthcare (Vallbona et al., 1973).

Computers can make patient identification systems far more reliable and efficient. Medical facilities can save time and effort by using digital tools to find patient records more rapidly with fewer mistakes made by humans and less manual processing. Computers have also made it easier and more methodical to maintain the documentation in medical records. Improved patient care is a direct result of electronic medical records' dual benefits of making data storage and retrieval more efficient and easing data exchange across

various healthcare organisations (Huang et al., 2023; Saifudin et al., 2021).

Statistical data processing and analysis also plays a significant role in healthcare administration. Improvements in healthcare service quality and efficiency have resulted from management decisions based on scientific evidence, made possible by the widespread adoption of computer technology in healthcare facilities, which allows for the efficient collection and analysis of massive volumes of medical data. Medical facilities can enhance the efficacy of healthcare services by analysing data thoroughly to spot trends and problems (Dal Mas et al., 2023).

In addition to laying the groundwork for future research and practice, this groundbreaking study from 1973 showed promise for the widespread use of computer technology in the medical field. As time goes on and technology advances, computer technology is being used more and more widely in the field of medicine. This has the potential to improve the efficiency and quality of medical services.

Information and communication technology (ICT) emerged as a major player in businesses during the 1990s, drastically altering internal company communication. One of the most important industries to see the rise of ICT was healthcare (HC) (Suggs, 2006). The goal of healthcare digital transformation is to increase the efficacy and security of healthcare services by utilising a new technology. Patients are far more satisfied because of digital transformation since it increases operational efficiency, increases doctor productivity, and reduces the cost of patient-staff communication.

According to Raimo et al. (2023), some of the most important digital technologies in healthcare today are online registration, EHR, electronic medical records, online healthcare, online health insurance, and big data analytics and prediction. The use of these technologies not only makes healthcare more efficient, but also makes service more convenient for patients.

According to Marques and Ferreira's literature study on healthcare digital transformation (DT), technological

studies have concentrated on seven main areas: 1, healthcare IT administration; 2, medical image processing; 3, electronic medical records; 4, healthcare IT integration with mobile devices; 5, e-health accessibility; 6, telehealth; and 7, the privacy of healthcare data. The significance of technology in enhancing the efficacy and quality of healthcare services is highlighted by these study directions.

2.1 Previous Research on Bibliometric Analysis in Digital Transformation in Healthcare

As Table 1 shows, although bibliometric analyses have been conducted in this area, however, there are still many gaps. First, existing studies have a limited time span for digital transformation in the healthcare industry. For example, the study by Sikandar et al. (2022) only covers the period from 2017 to 2021, whereas this study spans the period from 2010 to 2024. By expanding the time span, we can understand the historical process of digital transformation in the healthcare industry more comprehensively, providing us with a more in-depth perspective. Second, compared to previous studies, this study focuses more on the process of digital

transformation rather than just on the digital technology itself. This distinction is particularly important for organizations transforming, as it can provide these organizations with more targeted guidance and recommendations to help them better address the challenges and opportunities of the transformation process. In addition, compared to Yeung et al.'s (2022) study, which focused primarily on the use of digital technologies in cardiology, this study provides a more comprehensive view of digital transformation across the healthcare industry. By covering the entire healthcare industry rather than specific areas, we fill the gap of existing studies in terms of industry wholeness. In terms of language, neither study statistically analyzed the language of the literature. In contrast, this study did not restrict language during the literature analysis and statistically analyzed literature in languages. This approach contributes to a globalized perspective and provides a more comprehensive reflection of research findings in different linguistic contexts, providing us with a more diverse and inclusive academic perspective.

Table 1. Previous Bibliometric Analysis in Digital Transformation in the Healthcare Field

Author and year	Research objective	Bibliometric Attributes Examined	Database	Gaps	Contribution
Sikandar et al.(2021)	The study analyzes recent advancements in digital healthcare technologies, including ICT, smart/wearable devices, AI, big data, and telemedicine.	The study performed a bibliometric analysis to examine the temporal trends, leading journals, top authors, most productive countries, and keyword co-occurrence in the literature on digital healthcare technology.	Scopus 2017-2021	The study highlights unresolved issues in digital health technologies, including safety, testing, reliability, and ethical considerations.	The research contributes by providing insights into the evolution of digital technology literature in healthcare, identifying main authors, countries, journals, keywords, and research themes in the field of digital technologies in healthcare
Yeung et al. (2022)	The objective of the study was to conduct a bibliometric analysis to identify and analyze academic literature on digital technology uses in cardiology.	The study examined key publishing trends, characteristics, popular research topics, key authors, institutions, countries, and journals related to digital technology uses in cardiology.	Web of Science 1956-2020	The study identifies popular research topics, key authors, institutions, countries, and journals in the field of digital technology use in cardiology	The study contributes by providing insights into the productivity of institutions, countries, and journals in this field, as well as highlighting the cardiovascular conditions, diagnostic tools, and popular research topics within digital technology uses in cardiology

3. METHODS

Data for this research was retrieved from Scopus database on May 25, 2024. Researchers and academic institutions across the globe rely on Scopus, an authoritative academic database, because of its extensive coverage, high-quality material, and robust search capabilities. Scopus offers extensive resources and accessible services for literature search, academic research, and scientific evaluation (Burnham, 2006). Therefore, this study used Scopus as its data source to analyze the digital transformation of the healthcare industry.

3.1. Search Strategy

In the bibliometric analysis's search strategy section, we used the search phrases "Digital Transformation" and "Healthcare". This combination of phrases was created to capture research material on digital transformation in the healthcare industry. Using this specific keyword combination, we obtained a total of 1105 documents spanning the years 2010 to 2024, As shown in Figure 1, after careful screening, we removed 1 retracted document and 2 erratum documents, 52 conference reviews and 132 irrelevant documents, and finally obtained 918 valuable documents as our data.

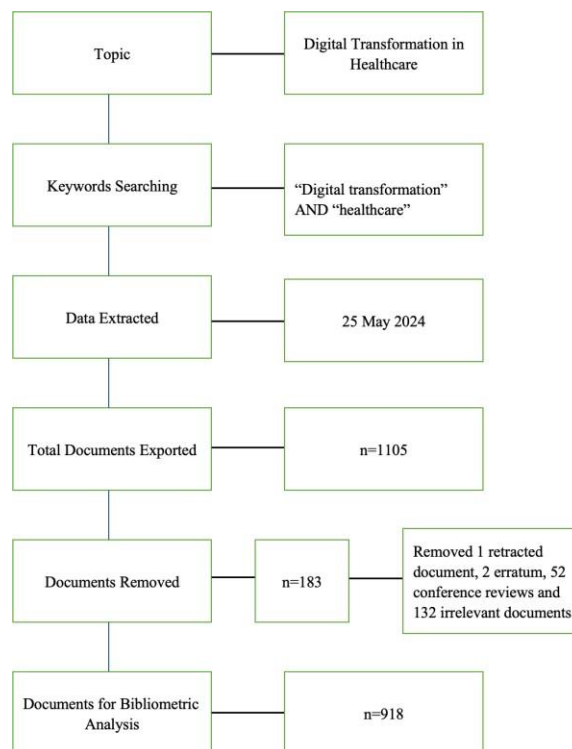


Figure 1. Flow diagram of the search strategy.

Source: Zakaria et al. (2021), Moher et al. (2010)

3.2. Data Cleaning and Harmonisation

Data cleaning is an important step in ensuring the accuracy of bibliometric analysis. In this study, biblioMagika (Ahmi, 2023) was used to carry out the bibliometric cleaning exercise to ensure data completeness and accuracy. The specific process is as follows:

First, the researcher exported literature data files in .csv format from the Scopus database. These files contain records of relevant literature in the study area and contain basic information such as author, title, journal name, and year of publication. To further refine the data processing, the researcher also downloaded the Scopus refine values,

which provide more detailed categorization and annotation about the data to help further filter and organize the data.

Next, the researcher imported the exported data files into biblioMagika@Split. This step aimed to utilize the powerful data processing capabilities of biblioMagika to split the large-scale literature data into small, manageable portions for subsequent detailed cleaning and analysis.

During the data cleaning process, the researcher manually and carefully organizes and removes errors and redundant information from the data. For example, duplicate bibliographies, misspellings, and formatting inconsistencies are corrected during this step. In addition, the researcher reviews the individual data fields of the documentation to ensure that each field is filled out completely and accurately. If missing data are found, the researcher manually fills them in to ensure the completeness and continuity of the dataset.

In the end, after careful cleaning and organizing, the researcher obtained an accurate and high-quality literature dataset. These data, after further analysis, can provide relevant scholars with a reliable reference basis. In the whole process, the rigorous data cleaning and processing steps not only improve the accuracy of the bibliometric analysis, but also provide a guarantee for the credibility of the research results.

4. RESULTS

In this section, we analyse the research landscape of digital transformation in the healthcare industry based on the cleaned data, answer research questions and provide valuable ideas and directions for related researchers. Through detailed bibliometric analyses, we can reveal the research hotspots, trends, and future research opportunities in this field.

4.1. Current Landscape

To answer the question, “What is the current state of research on digital transformation in healthcare?”, we analyzed literature types, source types, languages, and

subject areas as shown in Tables 2, 3, and 4. These data help us understand the distribution and characteristics of research in this field.

First, the analysis of literature types (Table 2) reveals different forms of scholarly contributions, such as journal articles, conference papers, and book chapters. This highlights the main dissemination channels of research in the field. Second, the analysis of source types (Table 3) provides insights into the sources of the literature, identifying key academic journals, conference proceedings, and books that have a high academic impact. Third, the language analysis (Table 4) shows the use of different languages in research, with English being dominant but other languages reflecting global diversity and collaboration. Finally, the analysis of subject areas reveals the interdisciplinary nature of digital transformation in healthcare, identifying major research areas and disciplinary intersections. These statistics offer a solid foundation for understanding the current state of research on digital transformation in healthcare and its development trends, providing valuable references for future research. Based on Table 2, the main document types in digital transformation research in healthcare are:

1. Articles: Accounting for 39%, they are the most dominant document type, reflecting sustained academic interest and providing comprehensive content for digital transformation in healthcare.
2. Conference Papers: Making up 20.45%, they represent the latest research findings and are crucial for academic communication, indicating wide attention and discussion at conferences.
3. Book Chapters: Representing 12.31%, they offer in-depth exploration of specific topics, providing comprehensive perspectives and discussions for academics. These data highlight the varied means of scholarly communication and the interdisciplinary and global nature of research in digital transformation in healthcare.

Table 2. Document Type

Document Type	TP	%
Article	431	39.00%
Conference Paper	226	20.45%
Book Chapter	136	12.31%
Review	86	7.78%
Book	22	1.99%
Editorial	9	0.81%
Note	6	0.54%
Letter	2	0.18%
Total	918	100%

This table succinctly shows the distribution of the five different source types. Journals are the most common source type, accounting for 48.33% of the total publications,

followed by conference proceedings with 20.45%. Books series and Book accounted for 12.31% and 1.99% of the total.

Table 3. Source Type

Source Type	TP	%
Journal	534	48.33%
Conference Proceeding	226	20.45%
Book Series	136	12.31%
Book	22	1.99%
Total	918	100%

Table 4 presents the distribution of publications by language, revealing that most of the documents retrieved were in English, accounting for 76.29% of the total publications. This finding highlights the dominance of English as the primary language for scientific communication in the digital transformation in the healthcare industry research domain. Meanwhile, publications in other languages such as German,

Russian, Spanish, Italian, French, Chinese, Croatian, Portuguese, Japanese, Korean, and Turkish were comparatively less common, with each accounting for less than 5% of the total. Notably, while publications in languages other than English make up a small proportion of the total, they still represent a diverse range of contributors to the field.

Table 4. Languages

Language	TP	%
English	843	76.29%
German	37	3.35%
Russian	23	2.08%
Spanish	9	0.81%
Italian	4	0.36%
Chinese	3	0.27%
French	2	0.18%
Croatian	2	0.18%
Portuguese	2	0.18%
Japanese	1	0.09%
Turkish	1	0.09%
Total	1107	100%

In the realm of digital transformation in healthcare industry research, an analysis of disciplines unveils its interdisciplinary nature and significance. The data reveals that computer science, medicine, and engineering constitute 45.25%, 36.38%, and 27.60% of total publications, respectively, underscoring the pivotal role of digital technology and engineering principles in propelling the healthcare industry's evolution. Additionally, fields such as

management, social sciences, and decision sciences play crucial roles, offering insights into management strategies, societal impacts, and decision-making frameworks. The interdisciplinary character of medical digital transformation underscores the importance of collaboration and integration across diverse domains, providing a comprehensive perspective and solutions to drive the healthcare sector toward digital transformation.

Table 5.Subject Area

Subject Area	TP	%
Computer Science	415	37.56%
Medicine	334	30.23%
Engineering	253	22.90%
Business, Management and Accounting	169	15.29%
Social Sciences	110	9.95%
Decision Sciences	97	8.78%
Mathematics	80	7.24%
Economics, Econometrics and Finance	74	6.70%
Health Professions	71	6.43%
Environmental Science	47	4.25%
Biochemistry, Genetics and Molecular Biology	45	4.07%
Materials Science	32	2.90%
Nursing	32	2.90%
Energy	22	1.99%
Chemical Engineering	19	1.72%
Physics and Astronomy	18	1.63%
Pharmacology, Toxicology and Pharmaceutics	13	1.18%
Psychology	12	1.09%
Chemistry	9	0.81%
Arts and Humanities	8	0.72%
Multidisciplinary	4	0.36%
Agricultural and Biological Sciences	3	0.27%
Earth and Planetary Sciences	3	0.27%
Immunology and Microbiology	3	0.27%
Neuroscience	2	0.18%

4.2. Publication Trends

To answer the question of emerging trends in recent publications on digital transformation in healthcare, we analyzed various metrics from 2010 to 2024. As shown in Table 7, Starting from 2010, with only one publication, we observed a significant increase in the number of publications beginning in 2016, culminating in a peak of 296 publications in 2023. This trend indicates a substantial rise in interest and research activity in the field of digital transformation in healthcare. The number of contributing authors (NCA) also increased annually, reflecting the growing involvement of researchers in this interdisciplinary field. In terms of citation metrics, the total citations (TC) showed a notable rise, peaking in 2021 before experiencing

a slight decline in subsequent years. Despite the relatively low number of publications in the early years, the high TC in 2010, with an average of 711 citations per publication (C/P), underscores the foundational impact of initial research efforts. This early high impact set a quality benchmark for future studies. The h-index and g-index, which measure the productivity and citation impact of publications, generally showed an upward trend, indicating an increasing influence of research in this domain. The m-index, which accounts for the h-index over a scholar's active years, also reflected a growing trend, signifying sustained research impact over time. However, it is noteworthy that the average citations per publication (C/P) and average citations per cited publication (C/CP) have shown a

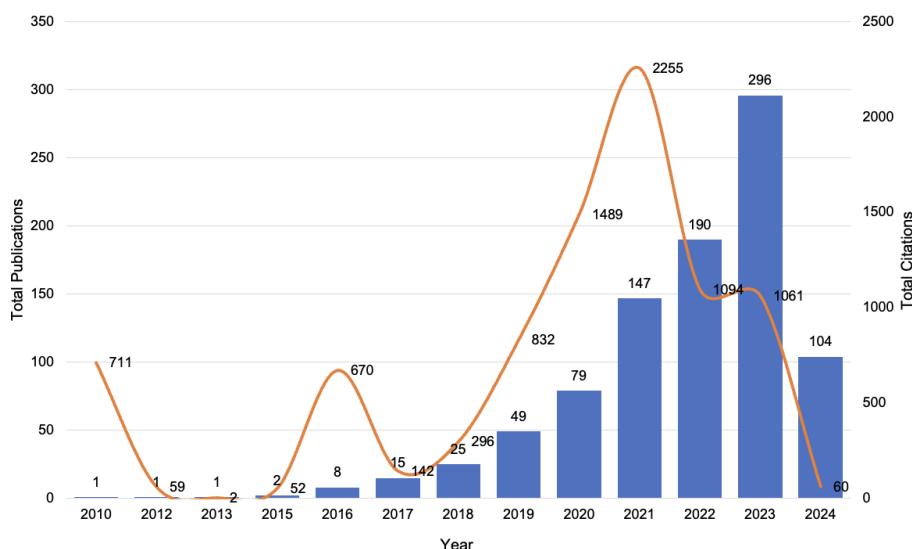
declining trend, it shows clear that the curve in Figure 2 has a sharp decline after 2021. This suggests that while the quantity of research is increasing, the average impact per

paper is decreasing. This calls for a renewed focus on maintaining high research quality to ensure that new publications continue to contribute significantly to the field.

Table 6. Publication by Year

Year	TP	NCA	NCP	TC	C/P	C/CP	h-index	g-index	m-index
2010	1	4	1	711	711.00	711.00	1	1	0.067
2012	1	1	1	59	59.00	59.00	1	1	0.077
2013	1	1	1	2	2.00	2.00	1	1	0.083
2015	2	6	2	52	26.00	26.00	2	2	0.200
2016	8	12	8	670	83.75	83.75	4	8	0.444
2017	15	34	10	142	9.47	14.20	5	11	0.625
2018	25	71	19	296	11.84	15.58	9	17	1.286
2019	49	162	46	832	16.98	18.09	15	28	2.500
2020	79	264	67	1489	18.85	22.22	19	37	3.800
2021	147	618	117	2255	15.34	19.27	23	44	5.750
2022	190	750	136	1094	5.76	8.04	15	26	5.000
2023	296	1179	154	1061	3.58	6.89	17	26	8.500
2024	104	405	14	60	0.58	4.29	3	7	3.000

Figure 2. Total publications and total citations by year



4.3. Publications by Authors

To address the question, "Which key authors, institutions, and countries are leading advancements in digital transformation in healthcare research?", we have created tables highlighting notable contributors in these areas.

These tables showcase key authors who have made significant contributions through their publications, leading institutions known for their impactful research, and countries at the forefront of this field. This analysis aims to facilitate collaboration and further advancements by

drawing attention to the most impactful contributors in this rapidly evolving research area.

Among authors who have published five or more papers, Sullivan, Clair stands out with 15 publications, achieving an NCP of 13 and a TC of 200. His h-index, g-index, and m-index are the highest in the group, indicating his significant impact and outstanding academic reputation. Sullivan's work provides a valuable foundation and inspiration for scholars in related fields. Another prominent author is Schiavone, Francesco, whose total citations of 461 exceed those of his peers despite having only five publications. His

C/P and C/CP of 92.20 highlight the high quality and far-reaching impact of his research.

Burton-Jones, Andrew also demonstrates significant impact with 126 citations and an h-index of 4. His C/P of 25.20 and C/CP of 31.50 underscore the quality and influence of his research. Staib, Andrew, with 151 citations and an h-index of 5, further demonstrates significant academic influence. His C/P and C/CP of 30.20 reflect the high quality and broad impact of his work, providing valuable insights for digital healthcare transformation scholars.

Table 7. Productive Author that published more than 5 Documents

Author's Name	TP	NCP	TC	C/P	C/CP	h	g	m	CSwHC
Sullivan, Clair	15	13	200	13.33	15.38	7	14	7	177
Lytras, Miltiadis D.	13	5	11	0.85	2.20	2	3	4	7
Pokvic, Lejla Gurbeta	6	5	7	1.17	1.40	2	2	2	4
Badnjevic, Almir	6	5	7	1.17	1.40	2	2	2	4
Staib, Andrew	5	5	151	30.20	30.20	5	5	7	151
Deumic, Amar	5	4	6	1.20	1.50	2	2	2	4
Schiavone, Francesco	5	5	461	92.20	92.20	3	5	4	457
Burton-Jones, Andrew	5	4	126	25.20	31.50	4	5	7	126
Butler-Henderson, Kerry	5	2	7	1.40	3.50	1	2	6	6

4.4. Publications by Institutions

To identify the key institutions leading advancements in digital transformation in healthcare research, we compiled and analyzed relevant data from various institutions. Effat University is notable with 12 publications and a total citation count (TC) of 7, showing significant research output with an m-index of 0.500. Witten/Herdecke University follows with 8 publications and a TC of 68, reflecting its impactful research with an h-index of 4, g-index of 8, and an m-index of 0.667. The University of Queensland has 8 publications and a TC of 139, boasting high h-index and g-index values of 6 and 8 respectively, and

an impressive m-index of 0.857. Similarly, the University of California has 7 publications, a TC of 111, h-index of 5, g-index of 7, and an m-index of 0.385, highlighting its research influence. The University of Naples Federico II stands out with 7 publications and an exceptionally high TC of 225, an h-index and g-index of 5, and an m-index of 1.000, indicating highly influential research. The University of Naples Parthenope contributes significantly with 6 publications, a TC of 201, an h-index of 3, g-index of 6, and an m-index of 0.375. University College London has 7 publications and a TC of 65, with an h-index and g-index of 4 and 7 respectively, and an m-index of 1.000, demonstrating high-quality research.

Table 8. Productive institution that published more than 5 Documents

Institution	TP	TC	NCP	C/P	C/CP	h	g	m	CSwHC
Effat University	12	7	3	0.58	2.33	2	2	0.500	6
Witten/Herdecke University	8	68	7	8.50	9.71	4	8	0.667	63
University of Queensland	8	139	7	17.38	19.86	6	8	0.857	133
University of Sarajevo	7	7	5	1.00	1.40	2	2	1.000	4
University College London	7	65	5	9.29	13.00	4	7	1.000	63
Verlab Research Institute for Biomedical Engineering	7	7	5	1.00	1.40	2	2	1.000	4
The University of Queensland	7	93	6	13.29	15.50	3	7	0.600	87
University of California	7	111	7	15.86	15.86	5	7	0.385	103
University of Naples Federico II	7	225	7	32.14	32.14	5	7	1.000	218
University of Naples Parthenope	6	201	5	33.50	40.20	3	6	0.375	197
University of Agder	6	48	6	8.00	8.00	4	6	0.571	45
Lakehead University	5	31	5	6.20	6.20	3	5	0.429	25
Vellore Institute of Technology	5	16	2	3.20	8.00	2	4	0.500	16
Norwegian University of Science and Technology	5	28	1	5.60	28.00	1	5	0.250	28
Universitätsklinikum Freiburg	5	7	1	1.40	7.00	1	2	0.167	7
Harvard Medical School	5	11	3	2.20	3.67	2	3	1.000	9
Bina Nusantara University	5	4	2	0.80	2.00	1	2	0.333	3
RMIT University	5	4	1	0.80	4.00	1	2	0.500	4
University of Oulu	5	20	1	4.00	20.00	1	4	0.167	20
Peter the Great St. Petersburg Polytechnic University	5	40	3	8.00	13.33	3	5	0.500	40
Queensland University of Technology	5	92	5	18.40	18.40	3	5	0.429	88
University of Edinburgh	5	54	4	10.80	13.50	4	5	0.800	54
Politecnico di Milano	5	71	4	14.20	17.75	3	5	0.429	70

4.5. Publications by Countries

In the field of digital healthcare transformation research, the United States plays a pivotal role. With a total of 117 documents (TP), the United States demonstrates significant involvement in digital healthcare transformation, spanning multiple domains. The United States also boasts an h-index of 18 and a g-index of 46, indicating the high quality of its publications in this field. Additionally, the United States m-index of 1.200 further underscores its substantial contribution to digital healthcare transformation research.

Germany ranks second with 109 documents (TP) and a total citation count (TC) of 938. Germany's h-index and g-index values stand at 15 and 30, respectively, reflecting the quality of its academic publications. Germany's m-index of 1.667 highlights its consistent and impactful research output in this domain. India follows with 95 documents (TP) and a TC of 897. India's h-index of 14 and g-index of 29 demonstrate its research influence, with an m-index of 1.167 indicating steady scholarly contributions. Italy, with 78 documents (TP), boasts a high TC of 1403 and an impressive m-index of 2.375, the highest among the top countries. Italy's h-index of 19 and g-index of 37 further highlight its significant impact and high-quality research in digital healthcare transformation.

The United Kingdom also exhibits high research quality with 76 documents (TP) and a TC of 1273. The UK's h-index and g-index are 17 and 35, respectively, with an m-index of 1.889, reflecting its substantial academic influence. Australia, with 54 documents (TP) and a TC of 686, has an h-index of 15 and a g-index of 26. Australia's m-index of 2.143 underscores its growing importance in this field. Russia, Spain, and Saudi Arabia also contribute significantly to this research area. Russia has 49 documents (TP) with a TC of 133, an h-index of 6, and a g-index of 11. Spain, with 42 documents (TP) and a TC of 232, has an h-index of 7 and a g-index of 15. Saudi Arabia, with 37 documents (TP) and a TC of 606, has an h-index of 7 and a g-index of 24.

China, despite having a lower total number of publications (33 TP), boasts a high TC of 689, an h-index of 10, and a g-index of 26, with an m-index of 1.667. This indicates that China's research in digital healthcare transformation is highly influential and widely cited.

Table 9. Productive countries that published more than 20 Documents

Country	TP	TC	NCP	C/P	C/CP	h	g	m	CSwHC
United States	117	2138	84	18.27	25.45	18	46	1.200	1770
Germany	109	938	73	8.61	12.85	15	30	1.667	677
India	95	897	60	9.44	14.95	14	29	1.167	700
Italy	78	1403	54	17.99	25.98	19	37	2.375	1214
United Kingdom	76	1273	59	16.75	21.58	17	35	1.889	1085
Australia	54	686	38	12.70	18.05	15	26	2.143	569
Russian Federation	49	133	22	2.71	6.05	6	11	0.667	82
Spain	42	232	26	5.52	8.92	7	15	1.000	164
Saudi Arabia	37	606	23	16.38	26.35	7	24	1.167	549
China	33	689	22	20.88	31.32	10	26	1.667	653
Turkey	30	287	18	9.57	15.94	6	16	1.200	254
Canada	28	357	20	12.75	17.85	9	18	0.900	313
Portugal	26	182	15	7.00	12.13	6	13	0.857	159
France	26	689	23	26.50	29.96	6	26	0.667	645
Sweden	25	279	18	11.16	15.50	7	16	0.700	244
Norway	24	224	17	9.33	13.18	7	14	1.000	201

4.6. Publications by Source Titles

To identify central journals and publications in digital transformation in healthcare, we analyzed the most productive publishers with at least ten documents. The International Journal of Environmental Research and Public Health stands out with 21 publications, 249 total citations (TC), an h-index of 7, and a g-index of 15, highlighting its significant scholarly impact. While volume is important, publication quality and influence are crucial. Technovation excels with the highest TC of 383 and citations per

publication (C/P) of 25.53. Its h-index of 10, g-index of 15, and m-index of 5.000 underscore its excellence in scholarly discourse. IEEE Access also makes significant contributions with 11 publications, a TC of 237, and a remarkable C/CP ratio of 26.33. Its h-index of 7 and g-index of 11 reflect its substantial influence and relevance. In summary, the International Journal of Environmental Research and Public Health is a key platform for scholarly discourse, while Technovation and IEEE Access are noted for their high-quality contributions and significant impact in advancing digital transformation in healthcare.

Table 10. Journals and publications that published more than 8 Documents

Source Title	TP	NCA	NCP	TC	C/P	C/CP	h	g	m	CSwHC
International Journal of Environmental Research and Public Health	21	89	18	249	11.86	13.83	7	15	1.400	209
Studies in Health Technology and Informatics	19	65	13	52	2.74	4.00	5	6	0.625	32
Technovation	15	55	14	383	25.53	27.36	10	15	5.000	359
ACM International Conference Proceeding Series	12	47	5	6	0.50	1.20	1	1	0.200	2
Frontiers in Public Health	12	67	9	43	3.58	4.78	4	6	1.333	35
IEEE Access	11	43	9	237	21.55	26.33	7	11	1.167	234
Lecture Notes in Networks and Systems	11	39	4	10	0.91	2.50	2	3	0.400	8
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	10	38	6	38	3.80	6.33	4	6	0.667	36
Digital Transformation in Healthcare in Post-COVID-19 Times	9	23	3	3	0.33	1.00	1	1	0.500	1
Healthcare (Switzerland)	9	65	4	280	31.11	70.00	3	9	0.600	278
Communications in Computer and Information Science	8	31	3	5	0.63	1.67	2	2	0.400	4
International Journal of Medical Informatics	8	65	7	114	14.25	16.29	5	8	1.000	106

4.7. Highly Cited Documents

To answer the question, "Which journals and publications are central to groundbreaking studies in digital transformation in healthcare?", we analyzed the most

productive publishers that have published at least ten documents. Among these, the International Journal of Environmental Research and Public Health stands out with the highest volume of publications at 21, underscoring its

role as a primary platform in this domain. Its total citations (TC) of 249, h-index of 7, and g-index of 15 further affirm its significant scholarly impact. While publication volume is crucial, the quality and influence of publications are equally important. In this regard, Technovation is a standout, with the highest TC of 383 and citations per publication (C/P) of 25.53. Its h-index of 10, g-index of 15, and m-index of 5.000 highlight its exceptional quality and influence, making it a key contributor to advancing knowledge in digital transformation in healthcare. IEEE Access also

commands attention with 11 publications and a TC of 237. Its remarkable C/CP ratio of 26.33 underscores the high impact of its publications. Additionally, its h-index of 7 and g-index of 11 reflect its substantial influence and enduring relevance. In summary, while the International Journal of Environmental Research and Public Health serves as a central hub for scholarly discourse, Technovation and IEEE Access are distinguished by their high-quality contributions and significant impact on the field of digital transformation in healthcare.

Table 11. Highest Cited Documents Top 20 Part 1

No.	Author(s)	Title	Source Title	TC	Cites per Year	Year
1	Agarwal, R., et al.	The digital transformation of healthcare: Current status and the road ahead	Information Systems Research	711	47.40	2010
2	Dimitrov, D. V.	Medical internet of things and big data in healthcare	Healthcare Informatics Research	627	69.67	2016
3	Kraus, S., et al.	Digital transformation in healthcare: Analyzing the current state-of-research	Journal of Business Research	320	80.00	2021
4	Li, J.-P. O., et al.	Digital technology, tele-medicine and artificial intelligence in ophthalmology: A global perspective	Progress in Retinal and Eye Research	278	69.50	2021
5	Seh, A. H., et al.	Healthcare data breaches: Insights and implications	Healthcare (Switzerland)	217	43.40	2020
6	Mihai, S., et al.	Digital Twins: A Survey on Enabling Technologies, Challenges, Trends and Future Prospects	IEEE Communications Surveys and Tutorials	193	64.33	2022
7	Abdel-Basset, M., Chang, V., & Nabeeh, N. A.	An intelligent framework using disruptive technologies for COVID-19 analysis	Technological Forecasting and Social Change	192	48.00	2021
8	Mrabet, H., et al.	A survey of IoT security based on a layered architecture of sensing and data analysis	Sensors (Switzerland)	176	35.20	2020
9	Huynh-The, T., et al.	Artificial intelligence for the metaverse: A survey	Engineering Applications of Artificial Intelligence	170	85.00	2023
10	Gopal, G., et al.	Digital transformation in healthcare - Architectures of present and future information technologies	Clinical Chemistry and Laboratory Medicine	146	24.33	2019

Table 12. Highest Cited Documents Top 20 Part 2

No.	Author(s)	Title	Source Title	TC	Cites per Year	Year
11	Arabi, Y. M., et al.	How the COVID-19 pandemic will change the future of critical care	Intensive Care Medicine	137	34.25	2021
12	Hermes, S., et al.	The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients	Business Research	130	26.00	2020
13	Leone, D., et al.	How does artificial intelligence enable and enhance value co-creation in industrial markets? An exploratory case study in the healthcare ecosystem	Journal of Business Research	110	27.50	2021
14	Erol, T., et al.	The Digital Twin Revolution in Healthcare	4th International Symposium on Multidisciplinary Studies and Innovative Technologies, ISMSIT 2020 - Proceedings	110	22.00	2020
15	Wan, J., et al.	Reconfigurable smart factory for drug packing in healthcare industry 4.0	IEEE Transactions on Industrial Informatics	109	18.17	2019
16	Haleem, A., Javaid, M., et al.	Medical 4.0 technologies for healthcare: Features, capabilities, and applications	Internet of Things and Cyber-Physical Systems	96	32.00	2022
17	Yigitcanlar, T., et al.	Artificial intelligence technologies and related urban planning and development concepts: How are they perceived and utilized in Australia?	Journal of Open Innovation: Technology, Market, and Complexity	92	18.40	2020
18	Bansal, G., et al.	Healthcare in Metaverse: A Survey on Current Metaverse Applications in Healthcare	IEEE Access	88	29.33	2022
19	Marques, I. C. P., & Ferreira, J. J. M.	Digital transformation in the area of health: systematic review of 45 years of evolution	Health and Technology	87	17.40	2020
20	Uslu, B. Ç., et al.	Analysis of factors affecting IoT-based smart hospital design	Journal of Cloud Computing	85	17.00	2020

5. DISCUSSION

This study uses bibliometric analysis to examine 918 documents, providing a comprehensive research landscape for digital transformation in healthcare. It highlights major trends, key players, and highly cited articles, offering

insights and future directions in the field. Findings show significant growth in the importance of digital transformation in healthcare, driven by technological advancements and the COVID-19 pandemic. Efforts to digitize operations have improved healthcare quality,

efficiency, performance, and patient satisfaction. This study emphasizes the potential for future development in this domain. Geographical analysis identifies the United States as the leading country, attributed to its advanced technology sector and world-class medical and academic institutions (Massa & Anzera, 2023). Germany follows, known for its innovation and strong medical education, dating back to 1386 (Nikendei et al., 2009). India ranks third, driven by economic growth and a focus on information technology (Erumban & Das, 2020). With 17.76% of the world's population (Statista, 2024), India has produced many eminent scholars. The United Kingdom and Australia also contribute significantly, reflecting strong research capabilities. This analysis highlights regional powerhouses in digital healthcare transformation, providing valuable insights for researchers. Understanding these trends offers a clearer picture of the global research landscape, guiding future efforts, fostering collaborations, and informing strategic decisions in advancing digital healthcare.

5.1. Recommendations for Future Research

For future researchers, international collaboration is crucial for academic advancement. Sharing knowledge and collaborating with scholars from leading countries like the United States and Germany can foster significant developments in the field of healthcare digital transformation. This emerging field requires high levels of innovation from those involved, making it essential for researchers to be aware of cutting-edge practices and advancements.

Encouraging interdisciplinary collaboration is also vital. Given that healthcare digital transformation is inherently an interdisciplinary area encompassing computer science, medicine, engineering, and management, researchers should promote cross-disciplinary studies. Integrating knowledge and techniques from various fields can comprehensively advance the digital transformation of healthcare. Moreover, localized development should not be

overlooked. Different countries have varying economic levels and population structures, and emphasizing localized development can enhance the diversity and applicability of academic research. Researchers should tailor solutions to the specific needs and contexts of different regions, which will not only enrich the research but also ensure its practical relevance.

Additionally, researchers must prioritize privacy protection and legal considerations. As digital transformation in healthcare evolves, issues related to data privacy, security, and regulatory compliance become increasingly important. Focusing on these aspects can help develop robust and ethical frameworks that support the sustainable growth of this relatively new field.

5.2. Implication of the Study

By conducting a bibliometric analysis, we have outlined the development landscape and trajectory of research in digital transformation in healthcare. This guides researchers in the field, helping them to establish a theoretical foundation. Additionally, it offers practical insights for professionals in the industry, encouraging innovation. Through a thorough analysis of research trends and key contributors in this domain, we aim to promote continuous advancement in the field, enhance the quality and efficiency of healthcare services, and ultimately improve patient satisfaction.

5.3. Limitations and Future Directions

This study has limitations, such as the keyword coverage, which enhances relevance but omits some important studies—a necessary trade-off. The reliance on specific databases like Scopus and Web of Science improves data consistency but sacrifices multi-source diversity, affecting comprehensiveness and representativeness. The time frame is also limited; the quality and impact of 2024 publications remain unverified due to insufficient time for thorough evaluation. Future research should update data to reflect the latest trends.

Future research can expand and optimize keyword selection to cover a broader range of topics. Leveraging AI-based text mining can automate keyword identification and expansion. Incorporating qualitative methods, such as case studies and expert interviews, will provide deeper insights into content and applications. Continuous data updates and longitudinal studies are essential to capture the newest trends and ensure research timeliness and reliability.

6. CONCLUSION

This study employs bibliometric analysis to examine the development of digital transformation in healthcare research over the past decade. We analyzed 918 documents and identified the United States and Germany as leaders in this field. Our findings indicate that this research area is gaining increasing attention and prominence. Moreover, the study reveals the highly interdisciplinary nature of digital transformation in healthcare, encouraging researchers from various fields to engage in collaborative efforts to advance this domain comprehensively. Healthcare is intrinsically linked to societal well-being, and the future of digital healthcare promises to enhance human welfare. However, realizing this potential requires concerted efforts from all sectors of society.

DISCLOSURE STATEMENT

The author reports no potential conflicts of interest.

DECLARATION OF USING AI TO ASSIST IN PARAPHRASING

In this study, some content has been paraphrased using ChatGPT. The authors have reviewed the content to ensure the accuracy of the text and data.

REFERENCE

- [1] Agarwal, R., DesRoches, C. M., & Jha, A. K. (2010). The Digital Transformation of Healthcare: Current Status and the Road Ahead.
- [2] Ahmi, A. (2023). *biblioMagika*. <https://www.aidi-ahmi.com/index.php/bibliomagika>
- [3] Arabi, Y. M., Azoulay, E., Al-Dorzi, H. M., Phua, J., Salluh, J., Binnie, A., Hodgson, C., Angus, D. C., Cecconi, M., & Du, B. (2021). How the COVID-19 pandemic will change the future of critical care. *Intensive care medicine*, 47, 282-291.
- [4] Burnham, J. F. (2006). Scopus database: a review. *Biomedical Digital Libraries*, 3(1), 1. <https://doi.org/10.1186/1742-5581-3-1>
- [5] Burton-Jones, A., Akhlaghpour, S., Ayre, S., Barde, P., Staib, A., & Sullivan, C. (2020). Changing the conversation on evaluating digital transformation in healthcare: Insights from an institutional analysis. *Information and Organization*, 30(1), 100255.
- [6] Dal Mas, F., Massaro, M., Rippa, P., & Secundo, G. (2023). The challenges of digital transformation in healthcare: An interdisciplinary literature review, framework, and future research agenda. *Technovation*, 123, 102716. <https://doi.org/https://doi.org/10.1016/j.technovation.2023.102716>
- [7] Dimitrov, D. V. (2016). Medical internet of things and big data in healthcare. *Healthcare informatics research*, 22(3), 156.
- [8] Dionisio, M., de Souza Junior, S. J., Paula, F., & Pellanda, P. C. (2023). The role of digital transformation in improving the efficacy of healthcare: A systematic review. *The Journal of High Technology Management Research*, 34(1), 100442. <https://doi.org/https://doi.org/10.1016/j.hitech.2022.100442>
- [9] Erumban, A. A., & Das, D. K. (2020). ICT investment and economic growth in India: An industry perspective. *Digitalisation and Development: Issues for India and Beyond*, 89-117.

- [10] Hermes, S., Riasanow, T., Clemons, E. K., Böhm, M., & Krcmar, H. (2020). The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. *Business Research*, 13(3), 1033-1069.
- [11] Huang, C.-W., Lai, Y.-C., Chiu, C.-Y., Jan, P.-T., & Chen, Y.-H. (2023). Key Strategies for Digital Transformation-A Non-medical Center Hospital in Taiwan as An Example. *Journal of Internet Technology*, 24(2), 389-400.
- [12] Kraus, S., Schiavone, F., Pluzhnikova, A., & Invernizzi, A. C. (2021). Digital transformation in healthcare: Analyzing the current state-of-research. *Journal of Business Research*, 123, 557-567.
- [13] Leone, D., Schiavone, F., Appio, F. P., & Chiao, B. (2021). How does artificial intelligence enable and enhance value co-creation in industrial markets? An exploratory case study in the healthcare ecosystem. *Journal of Business Research*, 129, 849-859.
- [14] Li, J.-P. O., Liu, H., Ting, D. S., Jeon, S., Chan, R. P., Kim, J. E., Sim, D. A., Thomas, P. B., Lin, H., & Chen, Y. (2021). Digital technology, tele-medicine and artificial intelligence in ophthalmology: A global perspective. *Progress in retinal and eye research*, 82, 100900.
- [15] Marques, I. C., & Ferreira, J. J. (2020). Digital transformation in the area of health: systematic review of 45 years of evolution. *Health and Technology*, 10(3), 575-586.
- [16] Massa, A., & Anzera, G. (2023). STATES VS. TECH GIANTS. *The Routledge Handbook of Soft Power*.
- [17] Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, P. (2010). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *International journal of surgery*, 8(5), 336-341.
- [18] Nikendei, C., Weyrich, P., Jünger, J., & Schrauth, M. (2009). Medical education in Germany. *Medical Teacher*, 31(7), 591-600.
- [19] Raimo, N., De Turi, I., Albergo, F., & Vitolla, F. (2023). The drivers of the digital transformation in the healthcare industry: An empirical analysis in Italian hospitals. *Technovation*, 121, 102558.
- [20] Saifudin, A., Aima, M., Sutawidjaya, A., & Sugiyono, S. (2021). Hospital digitalization in the era of industry 4.0 based on GHRM and service quality. *International Journal of Data and Network Science*, 5(2), 107-114.
- [21] Siegel, S., Hall, B., & Taylor, K. (2020). Digital Transformation-Shaping the Future of European Healthcare. *London: Deloitte Centre for Health Solutions*.
- [22] *statista*. (2024). <https://www.statista.com/statistics/262879/countries-with-the-largest-population/>
- [23] Tang, D. (2021). What is digital transformation? *EDPACS*, 64(1), 9-13.
- [24] Uslu, B. Ç., Okay, E., & Dursun, E. (2020). Analysis of factors affecting IoT-based smart hospital design. *Journal of Cloud Computing*, 9(1), 67.
- [25] Vallbona, C., Tobias, P. R., Moffet, C., Baker, R. L., & Beggs, S. (1973). Computer support for a neighborhood health clinic: design and implementation. *IEEE Transactions on Biomedical Engineering*(3), 180-184.
- [26] Winarsih, Indriastuti, M., & Fuad, K. (2021). Impact of covid-19 on digital transformation and sustainability in small and medium enterprises (smes): A conceptual framework. *Complex, Intelligent and Software Intensive Systems: Proceedings of the 14th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS-2020)*,

- [27] Yeung, A. W. K., Kulnik, S. T., Parvanov, E. D., Fassl, A., Eibensteiner, F., Völkl-Kernstock, S., Kletecka-Pulker, M., Crutzen, R., Gutenberg, J., & Höppchen, I. (2022). Research on digital technology use in cardiology: Bibliometric analysis. *Journal of medical Internet research*, 24(5), e36086.
- [28] Zakaria, R., Ahmi, A., Ahmad, A. H., Othman, Z., Azman, K. F., Ab Aziz, C. B., Ismail, C. A. N., & Shafin, N. (2021). Visualising and mapping a decade of literature on honey research: A bibliometric analysis from 2011 to 2020. *Journal of Apicultural Research*, 60(3), 359-368.
- [29] Zaoui, F., & Souissi, N. (2020). Roadmap for digital transformation: A literature review. *Procedia Computer Science*, 175, 621-628. <https://doi.org/https://doi.org/10.1016/j.procs.2020.07.090>
- [30] Zhou, W.-J., Wan, Q.-Q., Liu, C.-Y., Feng, X.-L., & Shang, S.-M. (2017). Determinants of patient loyalty to healthcare providers: An integrative review. *International Journal for Quality in Health Care*, 29(4), 442-449.