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Transforming Service Quality in Healthcare: A Comprehensive Review of Healthcare 4.0 and Its Impact on Healthcare Service Quality

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Abstract: This systematic review investigates the transformative impact of Healthcare 4.0 (HC4.0) technologies on healthcare service quality (HCSQ), focusing on their potential to enhance healthcare delivery while addressing critical challenges. This study reviewed 168 peer-reviewed articles from the Scopus database, published between 2005 and 2023. The selection process used clearly defined inclusion and exclusion criteria to identify studies focusing on advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data analytics. Rayyan software facilitated systematic organization and duplicate removal, while manual evaluation ensured relevance and quality. The findings highlight HC4.0's potential to improve service delivery, patient outcomes, and operational efficiencies but also reveal challenges, including interoperability, ethical concerns, and access disparities for underserved populations. The results were synthesized descriptively, uncovering key patterns and thematic insights while acknowledging heterogeneity across studies. Limitations include the absence of a formal risk-of-bias assessment and the diversity of methodologies, which precluded quantitative synthesis. This review emphasizes the need for future research on integration frameworks, ethical guidelines, and equitable access policies to realize HC4.0's transformative potential. No external funding was received, and no formal protocol was registered.

Keywords: healthcare; healthcare 4.0; healthcare service quality; HCSQ; review; technological advancements

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1. Introduction

In the evolving industrial revolutions, various industries, such as manufacturing, finance, and much more, are impacted by the witnessed advancements. The most recent revolution, the Fourth Industrial Revolution (4IR), has caused a shift in the nature of improvements. According to Gupta, A. et al. [1], moving away from conventional technological progress, 4IR integrates advancements in automation, control, and information technology, applying them to various aspects of production processes. To that end, the healthcare sector stands at the forefront of technological evolution, experiencing significant impacts from digitization. Furthermore, Sheingold B.H and Hahn, J.A [2] stresses that this transformation is revolutionizing healthcare delivery, reshaping interactions between patients and caregivers and among governments and stakeholders.

Hence, introducing the 4IR has resulted in various impacts on healthcare. For example, Mosadeghrad A.M. [3] noted that leveraging the most recent advancements in artificial intelligence, deep learning, data analytics, home-based healthcare, and robotics, the 4IR caused a shift from traditional hospital-centric care to more virtual, patient-centered care. This shift led to introducing Healthcare 4.0 (HC4.0) in the healthcare industry. According to Kotzias K. [4], HC4.0 implements integrated healthcare platforms with progressive virtualized, distributed, and real-time healthcare services for patients, professionals, and formal and informal caregivers. The focus is primarily directed toward supporting, enabling, and

optimizing collaboration, coherence, and convergence to transition healthcare services from reliance on empirical data to precision medicine.

Although the healthcare industry has seen tremendous changes as it has evolved, its primary purpose remains to provide quality services to patients and stakeholders [3]. In the earlier phases, as discussed by Gupta, A. et al. [1], healthcare quality improvement resulted from seemingly unconnected cases and initiatives. However, Bloom B.S. [5] identified that healthcare organizations worldwide devote initiatives to enhancing the quality of healthcare offered to their citizens in the twenty-first century. This shift identified the importance of providing patients with high-quality care through a well-defined improvement process. As a result, Mosadeghrad A.M. [3] noted that this shift in healthcare would impact the quality of service provided to patients. However, Sheingold B.H and Hahn, J.A [2] reasoned that healthcare quality improvement can be complex and multidimensional due to the changes in the healthcare processes as time progresses. Therefore, Maphumu W.T. [6] emphasized that ensuring and enhancing quality remains challenging in the healthcare industry.

In the context of Healthcare 4.0, where precision medicine is a crucial goal, upholding service quality becomes vital. Healthcare service quality (HCSQ) is formally defined by Darzi M.A. [7] as the consistent satisfaction of patients by delivering effective, efficient, and clinically sound healthcare services following the latest guidelines and standards, meeting patient needs, and fulfilling provider expectations. This definition highlights the significance of adhering to the latest procedures and standards, addressing patient needs, and meeting provider expectations, which have evolved in HC4.0. Despite these advancements and impacts, Sheingold B.H and Hahn, J.A [2] highlights the need for more research on how HC4.0 impacts service quality in the healthcare sector. As a result, exploring and understanding the complex and multifaceted aspects of enhancing healthcare quality remains crucial as HC4.0 continues to evolve.

This comprehensive review is essential as healthcare systems progress in the era of HC4.0. Through bibliometric and content analysis, this study aims to offer insights into the evolving healthcare service quality landscape. As such, this study explores the following objectives: (1) to identify key areas in healthcare impacted by technological advancements, (2) to examine the influence of technological advancements on service quality in healthcare delivery, (3) to identify critical factors influencing service quality, and (4) to address gaps in the existing body of knowledge regarding service quality assessment in healthcare. This understanding is crucial for healthcare professionals, policymakers, and researchers, enabling them to make informed decisions, implement effective strategies, and deliver enhanced healthcare services to patients in this technologically advanced age. The review also highlights the distinctive features of HC4.0 and its current status.

2. Materials and Methods

This study uses a systematic approach to gather and analyze literature on the intersection of HC4.0 and HCSQ. The steps conducted are broken down as below:

Phase 1. Literature search—In this step, the search focuses on finding relevant literature using specific keywords. The goal is to cover all essential publications related to the chosen topic, marking the initial and crucial phase of the data collection process. As a result, the Scopus database was selected because it is the largest multidisciplinary abstract and citation database, offering publications from peer-reviewed journal literature, conference papers, trade journals, books, and patent records. The database was searched for relevant publications and articles with the keyword selection ("healthcare technological advancements" OR "healthcare service quality" OR "Healthcare 4.0") across abstracts, keywords, and titles. The process resulted in an initial list of 412 papers covering 2005 to 2023. The papers were then filtered using the following criteria:

- Type of publication and source: This review considered publications in the final publication stage, including articles, conference papers, and review papers.
- Language: Only records written in English were considered in this review.

- Subject Area: The included records were only in related areas and excluded keywords in unrelated fields, such as preventive healthcare maintenance and quality assurance.
- Year of publication: Papers retrieved and fit the selected criteria, starting from 2005, in Scopus.

This study sought data broadly to ensure a comprehensive and inclusive analysis of the selected literature. Instead of focusing on specific variables, the review aimed to capture diverse insights related to the intersection of service quality and technological advancements in healthcare. The inclusion process allowed for flexibility in the types of studies and data considered, ensuring that a wide range of perspectives and contexts were included.

All information was present during the data collection process. The inclusion criteria were applied comprehensively, and without strict limitations on variables, so there was no need to make assumptions about missing data. This broad approach ensured that the findings were representative and aligned with the research objectives.

Phase 2. Literature screening: The screening process in this paper follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, a widely acknowledged and comprehensive methodology for conducting systematic reviews and meta-analyses. This approach provides a structured framework to ensure the systematic identification, selection, and evaluation of relevant literature, thereby promoting the reliability and reproducibility of the review process [8]. The PRISMA flowchart developed for this paper is shown in Figure 1. After eliminating duplicates, 402 papers were initially identified. Through careful examination, irrelevant publications were excluded based on the title and abstract, resulting in a refined list of 237 reviews, papers, and publications spanning from 2005 to 2023.

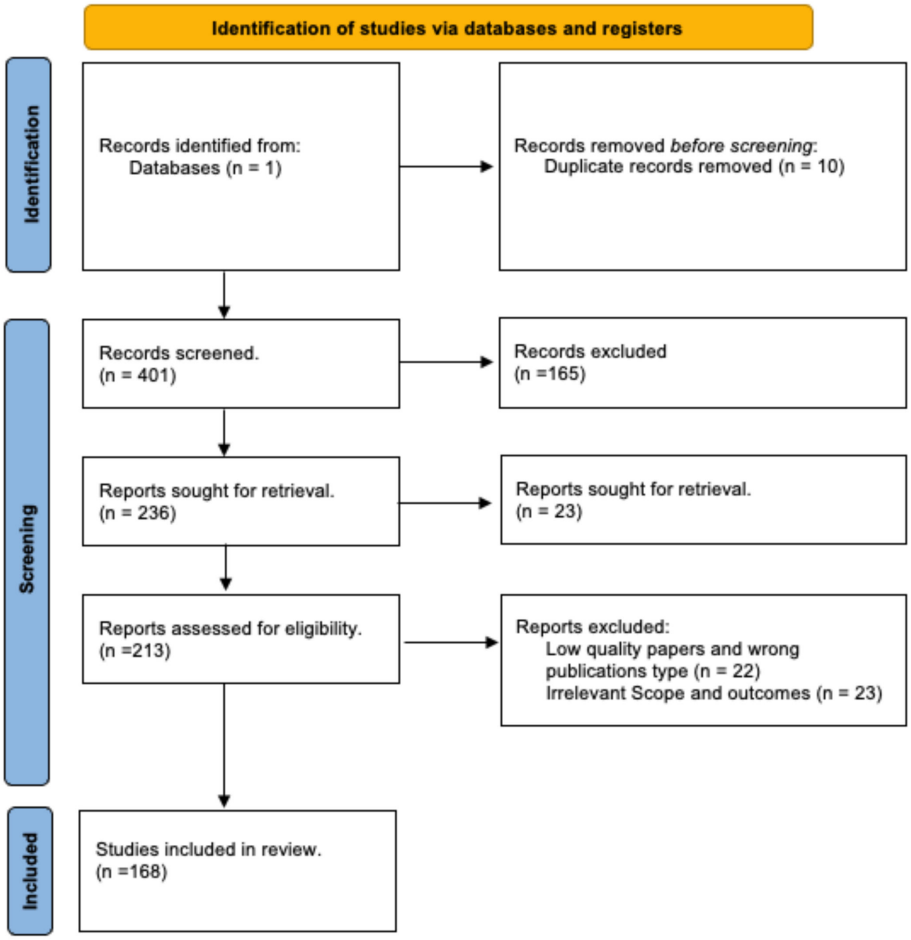

Figure 1. PRISMA approach and outcomes.

A single reviewer conducted the screening process, assessing titles and abstracts based on predefined inclusion and exclusion criteria. To enhance efficiency, Rayyan, an AI-powered tool for systematic reviews, was employed to eliminate duplicate records and systematically organize references [9]. This process initially identified 402 papers, and after excluding irrelevant publications, a refined list of 237 reviews, papers, and publications from 2005 to 2023 was compiled.

Although no formal bias assessment tool was utilized, the reviewer critically evaluated each study's methodology, data reporting, and relevance to the research objectives during the screening and selection process. Rayyan supported this effort by providing an organized and consistent workflow, ensuring systematic and unbiased study selection. To maintain accuracy and thoroughness, all evaluations were conducted manually.

In addition, this study's results were synthesized using a descriptive approach, as the diverse nature of the included studies did not support quantitative pooling or meta-analysis. The synthesis identified and summarized qualitative and quantitative findings related to service quality improvements, technological impacts, and patient satisfaction. Patterns, trends, and thematic insights were aggregated to provide a comprehensive understanding of the outcomes, aligning with the exploratory nature of the research.

Additionally, the results of individual studies were summarized and presented in tabular form to facilitate clarity and comparison. Tables were used to categorize studies based on their key characteristics, such as publication year, study focus, methodology, and assessed outcomes. Visual displays, where applicable, were generated to provide an overview of thematic insights and enhance the interpretability of the synthesized results.

As no meta-analysis was performed, sensitivity analyses were not conducted to assess the synthesized results' robustness. This study's exploratory nature and descriptive synthesis approach did not require quantitative robustness testing. Instead, the study focused on maintaining consistency and reliability by critically evaluating the quality and relevance of the included studies during the selection process. This ensured that the synthesized results reflected the diverse yet relevant evidence.

Furthermore, no formal methods were used to assess the risk of bias arising from missing results in the synthesis due to reporting biases. However, efforts were made to minimize the impact of potential reporting biases by including a broad range of studies, prioritizing those with transparent methodologies and comprehensive data reporting. This approach aimed to reduce the likelihood of excluding relevant results while maintaining the reliability of the synthesis.

In particular, as no statistical pooling of results was performed, methods to explore heterogeneity (e.g., subgroup analysis, meta-regression) were not applicable. Instead, variability across studies was acknowledged descriptively by highlighting the findings' thematic differences, patterns, and trends. This approach ensured that the analysis retained the contextual richness of the data while addressing the heterogeneity of study designs and methodologies.

Moreover, due to the descriptive nature of this study, no formal methods were applied to assess certainty or confidence in the body of evidence. The synthesis aimed to aggregate patterns, trends, and thematic insights without quantitatively evaluating the certainty of outcomes. However, efforts were made to enhance confidence in the findings by prioritizing studies with transparent methodologies, comprehensive data reporting, and alignment with the research objectives. The inclusion criteria ensured that only high-quality and relevant studies contributed to the synthesized results, thereby supporting the conclusions' reliability.

Figure 2 presents the timeline of paper growth in the selected topic. Notably, the number of published papers significantly increased starting in 2021. This trend is expected to continue beyond 2023, highlighting the ongoing importance of HC4.0 and HCSQ in research. This could be due to the continuing utilization of advanced technology in various areas of healthcare, such as disease diagnosis and patient monitoring.

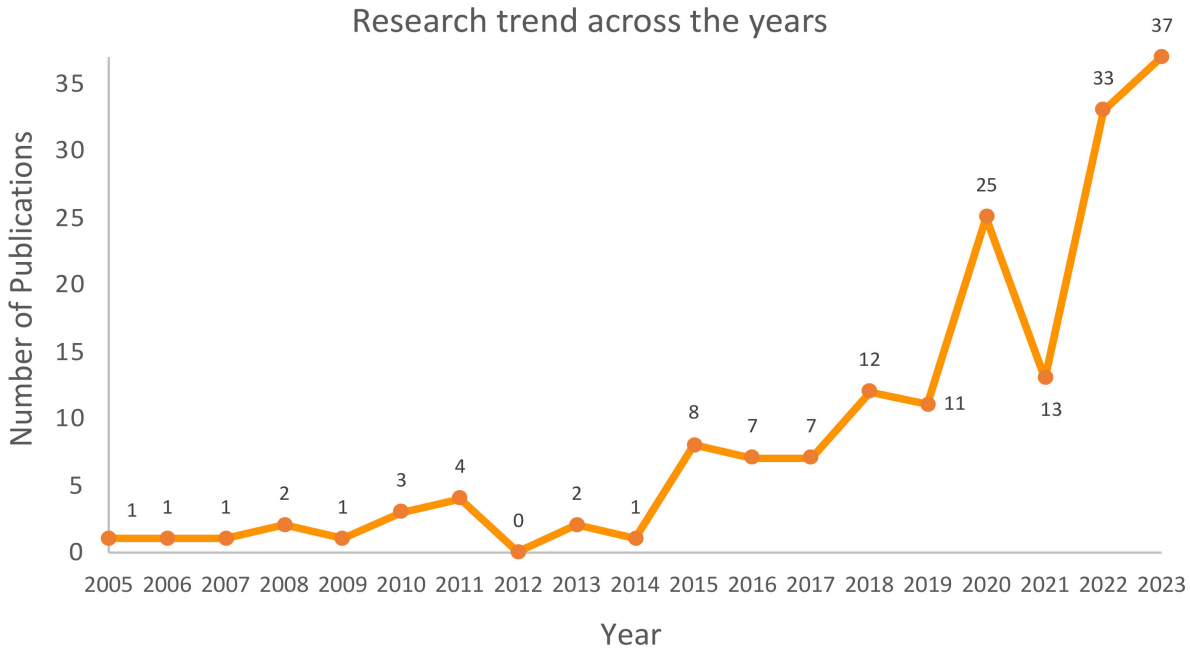

Figure 2. Number of papers in relation to HC4.0 and HSCQ (from 2005 to 2023).

Phase 3. Bibliometric analysis: A comprehensive bibliometric study was conducted on the 168 selected papers to initiate the analysis. This analysis utilizes advanced visual representation tools, particularly VOSviewer 1.6.20, to effectively explore and map the data. The study delves into various aspects, including identifying relevant authors, the geographic distribution of research (countries), prevalent keywords, document types, and the specific healthcare fields and research types covered. The bibliometric analysis provides valuable insights into the trends, patterns, and collaborative networks within the selected body of literature through these detailed visual representations.

Phase 4. Content analysis: In this stage, the refined list of papers is analyzed through a detailed review of their full text. The primary objective is to explore research trends and applications of advanced technology in HC4.0. Additionally, the content analysis aims to comprehend the impact of technological advancements on HCSQ to identify relevant research gaps. The methodology for this phase entails categorizing and classifying the papers into main categories and sub-categories. This systematic approach contributes to researchers' understanding of the progression of HC4.0 and its effects on HCSQ, simplifying the process of developing conclusions and insights from the accumulated information.

The following sections of this paper discuss the bibliometric and content analysis, respectively, adhering to the steps outlined in this section.

3. Bibliometric Analysis

This section presents an extensive analysis of HC4.0 and HCSQ, utilizing a broad range of literature from the Scopus database to comprehensively address the study's objectives, including the exploration of technological advancements in healthcare, their impact on service quality, and the identification of influencing factors. Thorough literature screening and data visualizations are used to identify significant trends and insights related to the impact of HC4.0 on HCSQ. In addition, VOSviewer is utilized to visually represent the research landscape, generating ten distinct visualization maps. These maps display circles that symbolize many elements, such as publications, researchers, and key terms. The size and font of the circles indicate their degrees of activity. This visualization method effectively demonstrates the connections between terms, with the proximity of two terms indicating the intensity of their association. It clearly depicts the dynamics and interactions within HC4.0 and its possible impact on HCSQ.

3.1. Co-Occurrence Map Based on Text Data

The relevant and frequently occurring terms were identified by analyzing the text data of the 168 selected publications. Text data analysis involves the extraction of pertinent terms from the titles and abstracts of chosen publications, followed by constructing a network using VOSviewer to establish co-occurrence connections among these terms. This analysis facilitates an understanding of emerging developments and the identification of significant terms within the field. The study yielded a total of 4461 terms, of which 132 terms meet the threshold, of which 79 terms were found relevant by 60% by VOSviewer based on relevance and occurrence, illustrated in Figure 3. Terms with a high relevance value indicate that the text data cover more specialized themes, whereas terms with a low relevance score are more generic [10]. It is essential to note that a thesaurus was generated and subsequently uploaded to VOSviewer by the software to standardize keywords and remove duplicate terms [11].

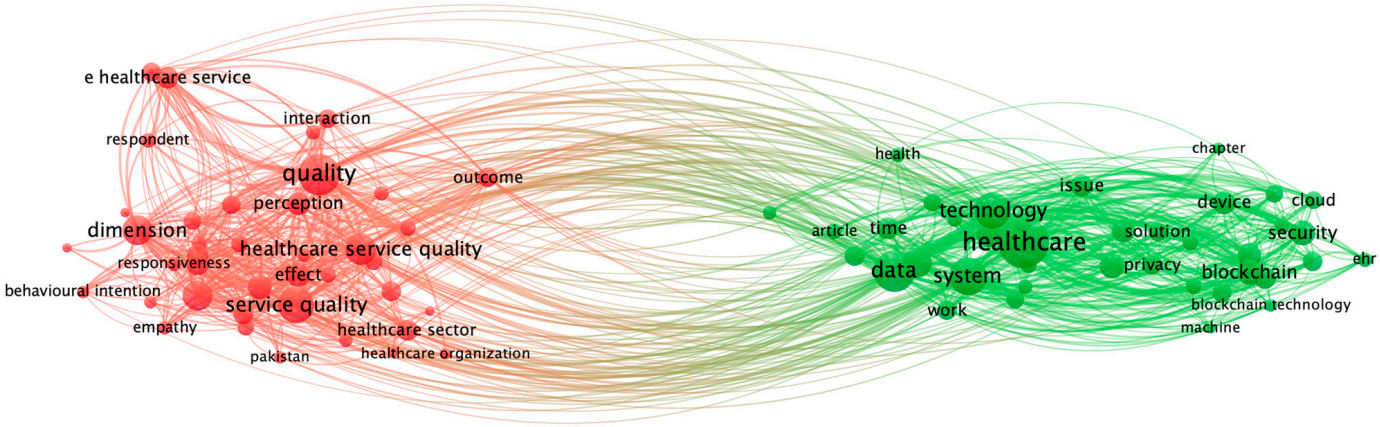

Figure 3. Co-occurrence map of text data.

As illustrated, the figure represents the network diagram of the interconnections of the terms within the HCSQ and technology domains, highlighting the impact of HC4.0 on HCSQ. Various terms such as "healthcare", "technology", "data", and "system" are predominant, reflecting their large co-occurrence in the literature. The presence of terms like "service quality" and "patient safety" emphasizes the focus on improving patient services through technological means. Moreover, the diagram acknowledges the practical aspects of HC4.0 adoption, addressing the alignment of technology with healthcare objectives, as terms such as "technology", "cloud", and "quality". The visualization represents a comprehensive research landscape, determining the terms and implications of implementing HC4.0 in enhancing HCSQ.

Additionally, the terms directly linked to HCSQ are shown in Figure 4. The findings indicate a strong relationship between HCSQ, "dimensions", and "technology". This illustrates that technological advancements in the field impact HCSQ. This development in the field has the potential to enhance service quality and the various dimensions of the field. However, the link of HCSQ with the terms "empathy" and "interaction" indicates that in addition to the technological aspects of healthcare delivery, patient-centered care and the quality of human interactions are crucial aspects influenced by, or which could impact, technological advancements. This connection suggests that although technology tools are essential in HC4.0, the human element remains necessary when researching this field.

On the other hand, "technology", in particular, is linked to various terms, as shown in Figure 5.

In addition to the HCSQ terms, it is seen that technology is strongly linked to HCSQ, which indicates the strong influence of technological advancements on healthcare outcomes. This could illustrate a strong link between technological advancements and quality of care, suggesting a research emphasis on integrating data and systems to enhance healthcare delivery. In contrast to the analysis presented in Figure 4, the terms "empathy" and

"interaction" in the context of "technology" suggest that technological advancements can improve the patient experience by enhancing these aspects rather than replacing the empathetic and interactive elements of patient care. As shown in Figure 5 it can be concluded that technological advancements in HC4.0 are anticipated to enhance the human-centric, qualitative aspects of healthcare and improve operations.

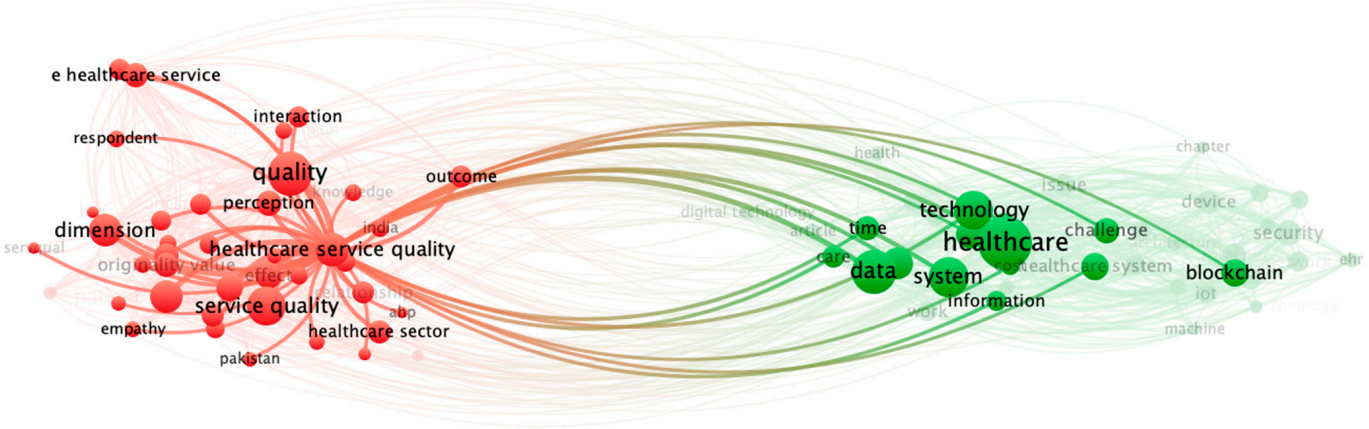

Figure 4. Terms directly linked to HCSQ.

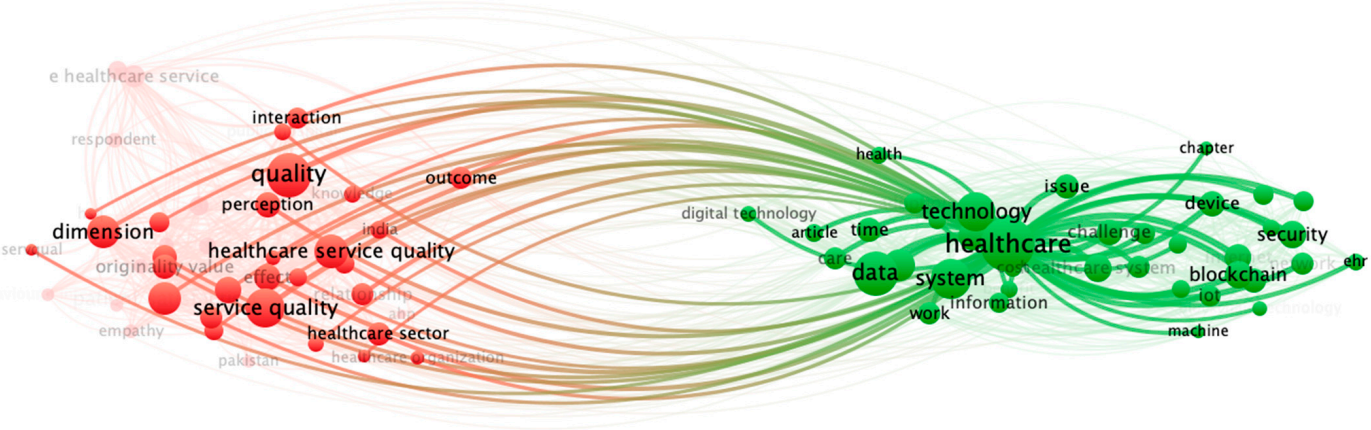

Figure 5. Terms directly linked to technology.

The ten most frequently occurring terms, with their number of occurrences, are listed in Table 1. Furthermore, the table also includes the relevance score of each term, which VOSviewer calculates. VOSviewer analyzes the distribution of (second-order) co-occurrences for each term and compares it to the overall co-occurrences across all terms. The Kullback–Leibler (KL) distance measures the difference between two probability distributions. A greater KL distance indicates a more significant divergence between the distributions, signifying that the term in question is more distinct or essential in differentiating them [12].

As shown in Table 1, a detailed analysis of the key terms frequently used in the context of HC4.0 is presented. These terms shed light on the diverse areas in HC4.0. The term "healthcare" suggests the importance of assessing the broad ecosystem of medical services and their related systems. This could include healthcare delivery models, medical facilities' infrastructure, and healthcare patients and professionals. Moreover, "data" indicates the importance of researching the information generated in the healthcare field. This could include areas such as patient, operational, or pharmacy data. The high occurrence of this term could also indicate the importance of data utilization in the decision-making process in the healthcare ecosystem. Moreover, "service quality" indicates the importance of assessing the quality of patient services and its essential role in research. This reflects

a collaborative research effort to enhance the effectiveness and patient-centeredness of healthcare delivery systems.

Table 1. Top 10 terms by occurrences.

Rank	Term	Occurrences	Relevance Score
1	Healthcare	255	0.614
2	Data	166	0.2581
3	Service Quality	141	0.9642
4	System	138	0.4257
5	Technology	130	0.6428
6	Quality	126	0.9567
7	Healthcare Service Quality	96	0.6955
8	Application	80	0.3232
9	Dimension	76	1.5063
10	Patient Satisfaction	75	1.4184

3.2. Co-Occurrences Map Based on Keywords

This section identified the frequently occurring keywords by analyzing the bibliographic data of the 168 selected publications. A total of 1389 keywords were found, out of which 68 were selected, where the minimum number of occurrences of those terms was limited to 5. The network for all the keywords is shown in Figure 6. In VOSviewer, a thesaurus was utilized to standardize keywords and remove duplicate terms. This analysis examines all keywords, including both author keywords and index keywords. Author keywords are selected and provided by the authors of the articles. In contrast, indexers or databases assign index keywords to classify and categorize the articles for information retrieval and indexing [13].

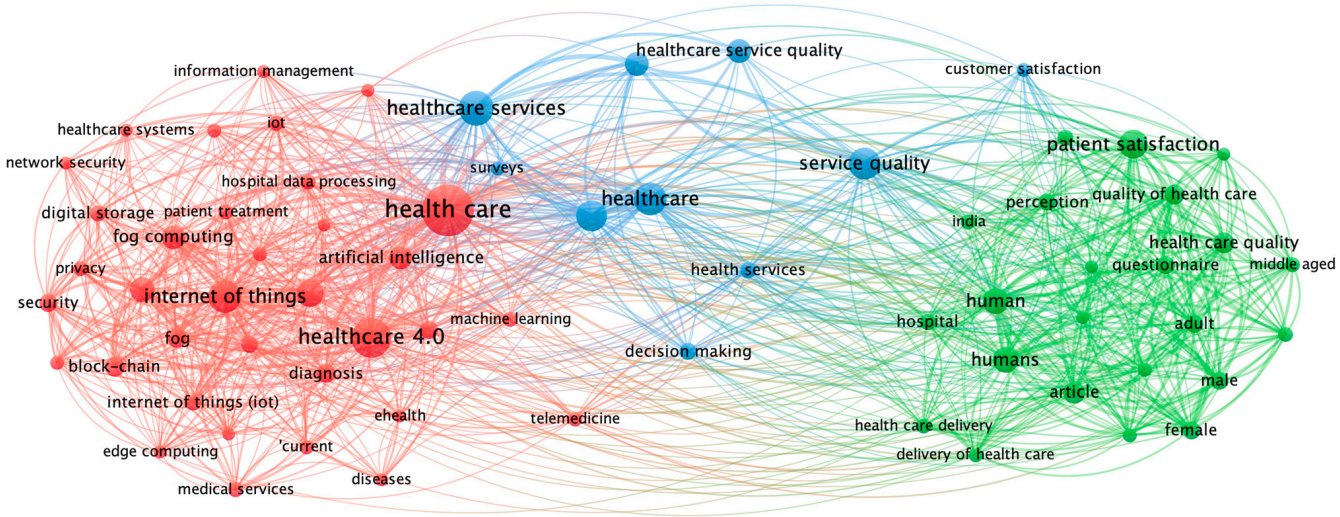

Figure 6. Co-occurrence map of all keywords.

Some of the most common keywords identified include "service quality", "patient satisfaction", "artificial intelligence", "telemedicine", "decision-making", "information management", and "Internet of Things". Moreover, the visualization map demonstrates the relationships between technological advancements such as IoT and blockchain and various fields of service delivery in the healthcare sector, including service quality and healthcare delivery. This illustrates the integration of advanced technologies into fundamental healthcare processes, highlighting modern healthcare systems' complex and multidimensional structure.

In particular, a list of the ten most frequently used keywords, their occurrence, and their total link strength are illustrated in Table 2. The total link strength refers to the combined

strength of the co-occurrence links between a specific keyword and other keywords [14]. The top ten keywords include various areas in the domain of HC4.0, which offers a central focus on the predominant areas of research. "Healthcare 4.0" emerges as the most prevalent keyword, reflecting the increased research in this evolution in the particular field. With a close occurrence, "healthcare services" shows the widespread recognition of various healthcare services impacted by technological advancements. Moreover, "Internet of Things" has shown a high occurrence that is close to the occurrence of "healthcare". This indicates the frequent research on utilizing IoT applications in the healthcare sector.

Table 2. Top 10 keywords by occurrences.

Rank	Term	Occurrences	Relevance Score
1	Healthcare 4.0	46	230
2	Healthcare Services	36	168
3	Healthcare	32	154
4	Internet of Things	32	207
5	Service Quality	30	145
6	Hospitals	27	146
7	Patient Satisfaction	24	162
8	Industry 4.0	21	93
9	Blockchain	18	115
10	Fog Computing	17	127

Further analysis is conducted in terms of the keywords cited by authors by creating a VOSviewer map. When generating the map, 534 keywords were identified, where 16 author keywords met the threshold of five occurrences in the dataset. This map is shown in Figure 7.

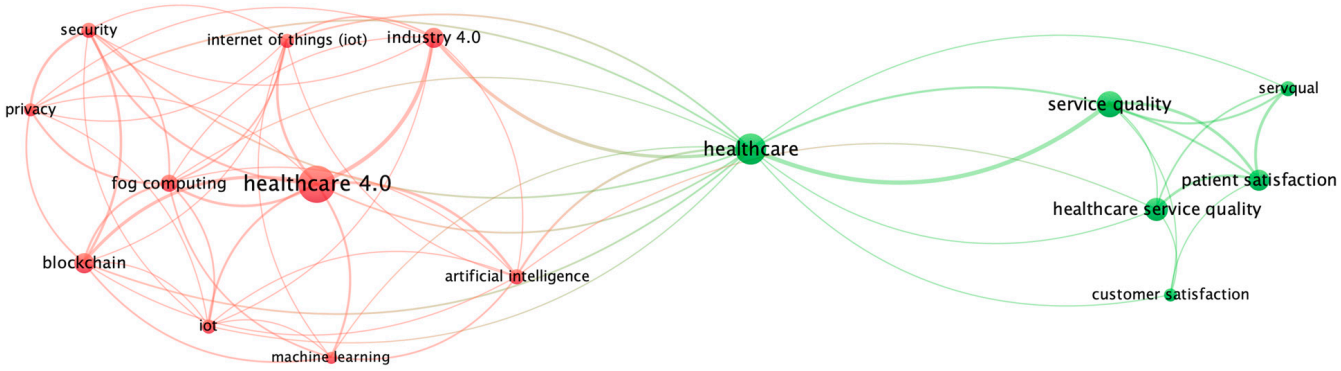

Figure 7. Co-occurrence map of author keywords.

The map in Figure 7 shows two noticeable branches from the word "healthcare", which indicates the importance of these two groups in the field of healthcare research. The group on the left in the figure shows the various technological terms that were found in the literature, indicating the rise in the research trend of these areas. This includes keywords such as "fog computing", "machine learning", and "artificial intelligence". On the other hand, the group on the right illustrates keywords linked to areas related to "service quality", indicating the importance of these elements in the field of healthcare. These elements are represented by keywords such as "patient satisfaction", and "healthcare service quality" and "servqual", one of the recent HCSQ models discussed in our content analysis.

Furthermore, in terms of keywords, a third map was developed to visualize the most reoccurring indexed terms. It was found that 1082 keywords were found, where 59 met the minimum threshold of five occurrences. The results are shown in Figure 8.

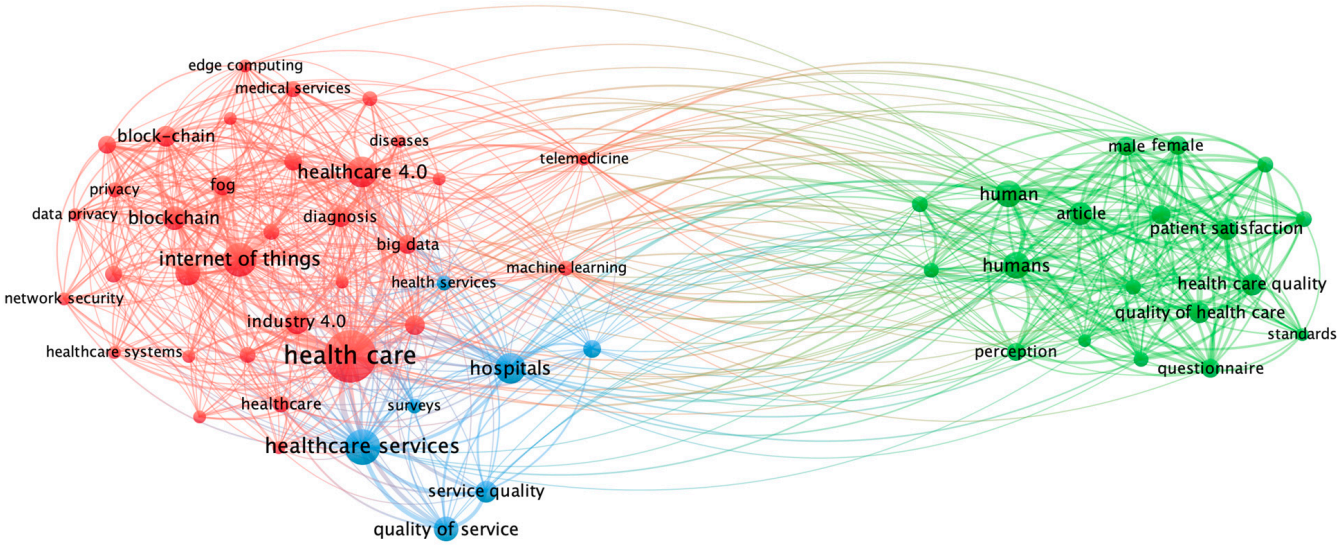

Figure 8. Co-occurrence map of index keywords.

The analysis of the keywords reveals a similar conclusion as the author keywords, where there is a link between the technological advancements and HCSQ, and the relevant terms of each area are grouped together. This map, similar to most of the previous maps, shows the recent link between HCSQ and the various technological advancements found in healthcare. The inclusion of various fourth-industry technology such as IoT, blockchain, and telemedicine shows the relevance of such technological introduction in healthcare research.

3.3. Co-Occurrences Map Based on Country of Co-Authorship

In this section, the 168 publications are analyzed in terms of the geographic distribution of the co-authorship in this field. From the 48 countries identified by VOSviewer, 13 meet the threshold of a minimum of five occurrences and are linked to other countries. The resulting network is shown in Figure 9.

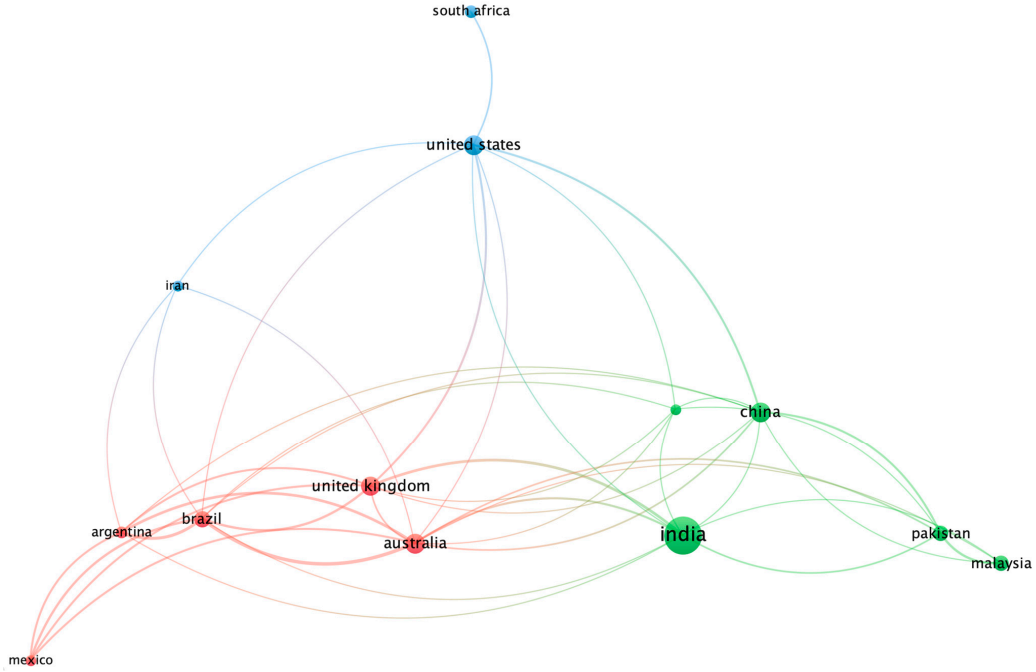

Figure 9. Country of co-authorship.

Based on Figure 9, it can be concluded that India is the leading country in terms of publications in this field. Furthermore, it is followed by the United Kingdom, the United States of America, Australia, and China. In addition, the top 10 countries on the map with the strongest links are mentioned in Table 3. The table displays a comprehensive list of countries, highlighting the global significance of this study topic and the collaborative efforts being made to enhance healthcare. It can be seen that Australia is at the forefront of collaborative research on healthcare quality and technology. Brazil and the UK are closely following, indicating their active engagement as well. Despite India's extensive publication record, its level of collaboration with other countries is very low. China, Mexico, the USA, Pakistan, and Malaysia exhibit a low level of global connectivity; however, this is accompanied by an increase in the level of their research.

Table 3. Top 10 countries by link strength.

Rank	Country	Documents	Citations	Total Link Strength
1	Australia	16	266	29
2	Brazil	11	178	27
3	United Kingdom	15	401	22
4	Argentina	6	107	20
5	India	58	2090	16
6	China	16	537	14
7	Mexico	5	82	13
8	United States	16	467	13
9	Pakistan	10	412	12
10	Malaysia	10	337	7

3.4. Co-Occurrences Map Based on Authorship

Moreover, this section investigates the relationships between the authors of the articles, recognizing the numerous authors involved. A threshold of a minimum of two citations per author was set for the map. A total of 538 authors were identified, where 48 met the threshold of a minimum of 2, while the largest set of connected authors included 8 authors. This result is shown in Figure 10. The links represented in Figure 10 demonstrate the collaborative and interdisciplinary nature of the research conducted within this field. This demonstrates the collaboration of authors from diverse countries and backgrounds in investigating this field of study. The present map indicates possibilities for future joint research aimed at comprehending the complex dynamics of healthcare across diverse locations.

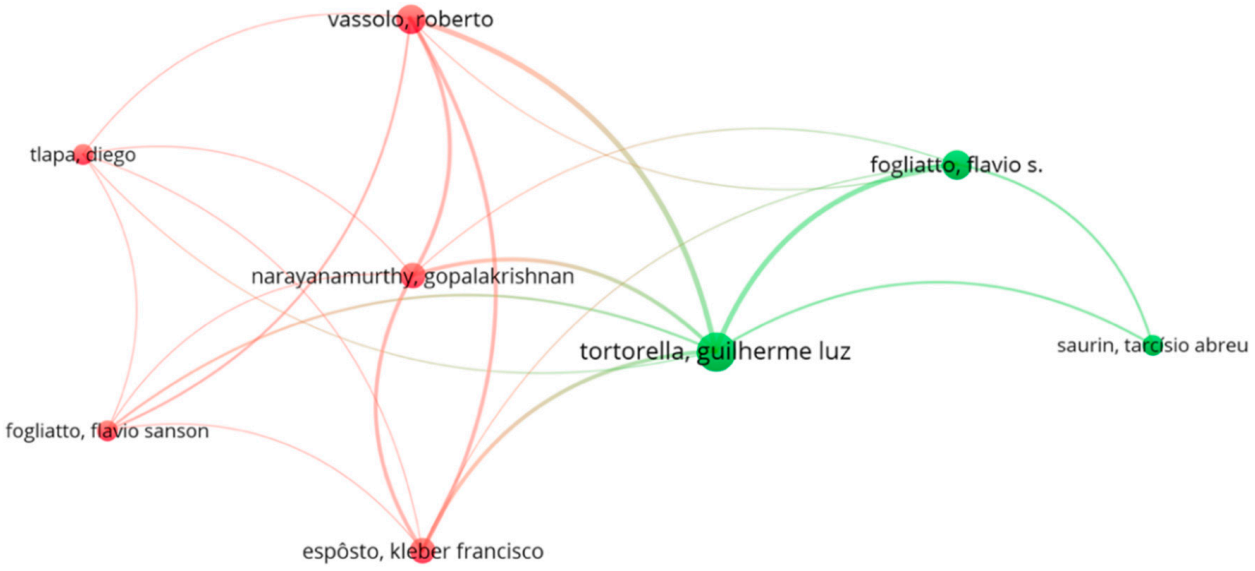

Figure 10. Co-occurrence map of authors.

On the other hand, the top 10 authors with the documents produced are shown in Table 4.

Table 4. Top 10 authors by documents published.

Rank	Author	Documents	Citations	Total Link Strength
1	Tanwar, Sudeep	11	1034	22
2	Tortorella, Guilherme Luz	7	170	19
3	Kumar, Neeraj	5	835	15
4	Tyagi, Sudhanshu	5	835	15
5	Bhattacharya, Pronaya	4	233	13
6	Fogliatto, Flavio S.	4	99	9
7	Gupta, Rajesh	4	313	9
8	Vassolo, Roberto	4	91	14
9	Espôsto, Kleber Francisco	3	76	12
10	Malik, Shahab Alam	3	260	3

Table 5 shows the key authors that have contributed to this field of research in terms of the number of citations. The considerably large number of documents and link strength show the importance of the research to authors in this domain.

Table 5. Top 10 authors by number of citations.

Rank	Author	Documents	Citations	Total Link Strength
1	Tanwar, Sudeep	11	1034	22
2	Kumar, Neeraj	5	835	15
3	Tyagi, Sudhanshu	5	835	15
4	Gupta, Rajesh	4	313	9
5	Malik, Shahab Alam	3	260	3
6	Shabbir, Asma	3	260	3
7	Bhattacharya, Pronaya	4	233	13
8	Nayyar, Anand	2	173	1
9	Tortorella, Guilherme Luz	7	170	19
10	Kumar, Adarsh	2	154	1

Moreover, the high number of citations from the top 10 authors shown in Table 5 shows the importance of the research conducted in this field for the research community. In particular, the author Sudeep Tanwar has a remarkable citation count of 1034. This count comes from the 11 documents that Sudeep Tanwar published in the field of HC4.0, particularly in the themes of data management, technology adoption, and blockchain adoption.

3.5. Co-Occurrences Based on Source of Publication

In this section, the sources of the 168 publications are analyzed. A total of 166 unique sources were found and then ranked by the number of publications in descending order. The top 10 sources with the highest number of publications are shown in Figure 11.

The International Journal of Health Care Quality and Assurance stands out as the most frequently cited publication in this field, boasting 13 articles. This collection of articles showcases the broad scope of research in healthcare, encompassing a range of topics that include technological advancements, communication strategies, and management practices. The sources collectively provide a comprehensive overview of the current trends and areas of focus in healthcare research, offering valuable insights into how quality, technology, and assurance are being promoted through scholarly research.

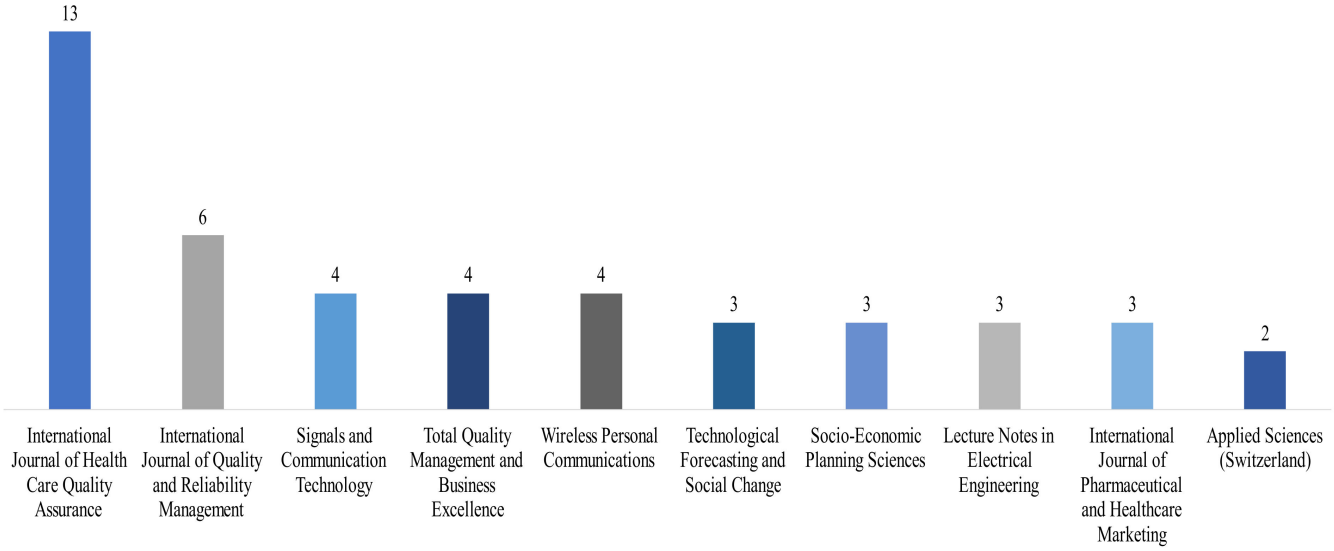

Figure 11. Graph of top 10 sources by number of publications.

3.6. Data Analysis on Document Type, Fields, and Healthcare Sector

In this section, different types of graphs were used to classify the 168 publications, based on their type, the sector, and the field they explored. The first step in this section explored the different document types, as shown in Figure 12. The most common type of publication is "article", which indicates its dominant role in the selected database with 101 occurrences. The next top publication type is "conference paper", indicating the importance of the topic in different conferences in various regions, with 44 occurrences. The last two types are "review" and "book chapter", with 10 and 13 occurrences, respectively.

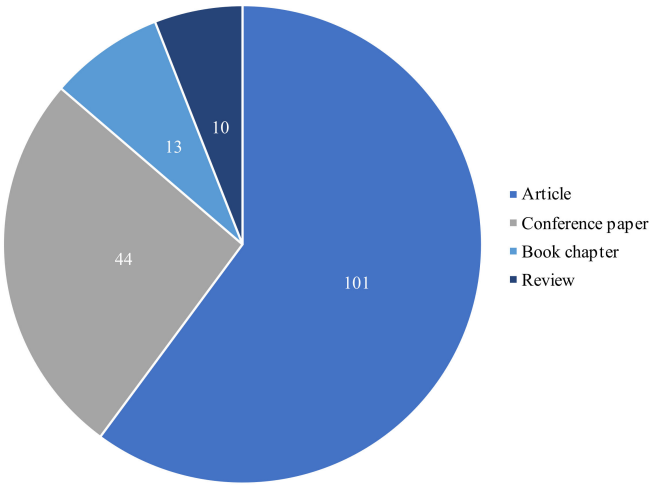

Figure 12. Occurrences of document types.

Further analysis was conducted to classify the healthcare institutions that were part of the research, illustrated in Figure 13. The majority of the research were categorized as "general" with 147 occurrences, indicating that they cover wide-ranging healthcare areas without identifying a specific type of institution. On the other hand, the "private" sector was found to be the most common research area, with 10 occurrences. This finding highlights a significant preference for researching and enhancing the efficacy and quality of services provided by private healthcare organizations, underscoring their critical role within the broader healthcare system. In addition, nine papers analyzed the "public" sector, demonstrating significant interest in the particular challenges and possibilities associated with healthcare systems that are supported by the government. These studies frequently

investigate factors such as service quality, patient happiness, and operational efficiencies in public hospitals and health services. They emphasize the significance of the sector in providing accessible and affordable healthcare.

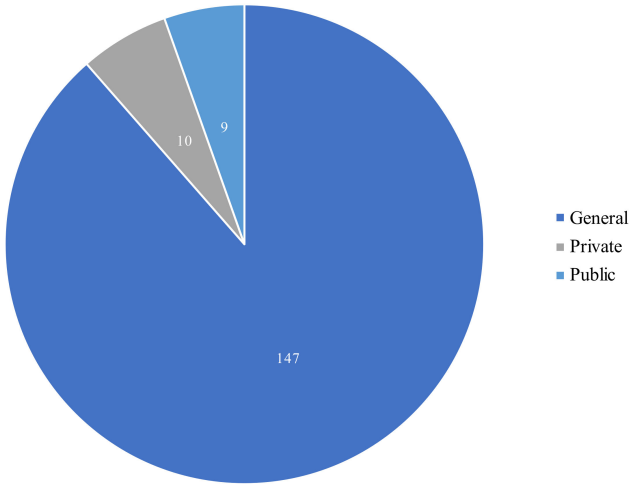

Figure 13. Occurrences of healthcare sector.

Moreover, the publications were classified based on the type of research conducted, as shown in Figure 14.

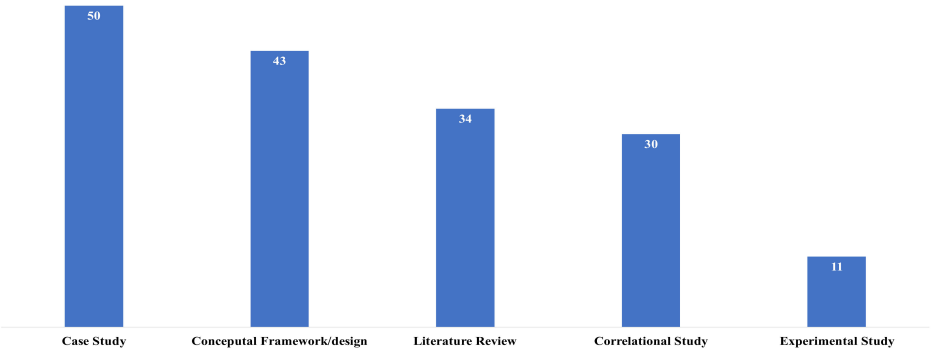

Figure 14. Occurrences of research type.

The most frequent type of research is "case study", with 50 occurrences. These studies aim to offer a thorough and comprehensive understanding of the subject. Case studies are valuable for gaining an in-depth understanding of a particular occurrence, analyzing the underlying challenges, and formulating hypotheses that can be statistically verified [15]. The case studies examined various technological implementations, such as AI in patient diagnostics and IoT devices for continuous monitoring. These extensive studies show how adopting new technologies in healthcare impacts performance. They also offer recommendations for improving patient outcomes, operational efficiency, and data security with these technologies. Researchers may shape HC4.0 by giving evidence-based advice to practitioners and policymakers through these case studies.

In addition, the second most frequent research type was "conceptual framework/design", with 43 occurrences. This study type tests or develops new technological integration or quality model frameworks to improve healthcare standards and effectiveness. These frameworks often address how blockchain, big data analytics, and machine learning can be easily integrated into healthcare infrastructures in Healthcare 4.0. Researchers may uncover implementation techniques and challenges by carefully constructing and analyzing these frameworks through case studies. This thorough approach allows technology deployment techniques to be continuously refined to improve operational efficiency and patient care.

These frameworks also determine regulatory compliance and patient safety standards, making them essential to healthcare system performance.

On the other hand, various "literature reviews" were found in this field, with 34 occurrences. This research methodology was utilized to assess the current state of HC4.0 and its continuing investigation, offering a comprehensive summary of the existing technologies and procedures. The analysis of specific research documents facilitated the identification of emerging trends and the evaluation of the practical application of advanced technologies in real-world contexts. This analysis provides a clear roadmap for future research and development, offering stakeholders valuable insights into effective techniques and areas that require additional exploration. These findings are crucial for shaping healthcare policy, facilitating the implementation of technology in healthcare settings, and directing academic research.

Additionally, the study types "correlational study" and "experimental study" were identified with 30 and 11 occurrences, respectively. Correlational studies in this context often examine relationships between various variables within healthcare systems, such as the influence of technology implementation on patient satisfaction or staff productivity. These investigations are essential for detecting potential correlations that can provide valuable insights for more focused research and treatments. Conversely, experimental investigations, although less common, have an essential role in thoroughly evaluating hypotheses by modifying one or more variables to determine their impact on other variables. This form of research offers strong proof for causation and is crucial for verifying the effectiveness of new treatments, interventions, or healthcare practices before their widespread implementation.

3.7. Main Themes and Sub-Themes Identified

The initial analysis of the 168 identified papers revealed four main themes: Healthcare 4.0, with 68 publications; healthcare service provision, with 7 publications; healthcare service quality, with 92 publications; and the future of healthcare, with 1 publication. Each theme included specific sub-themes that illustrated the current research in these areas. The sub-themes and their corresponding number of occurrences are shown in Figure 15.

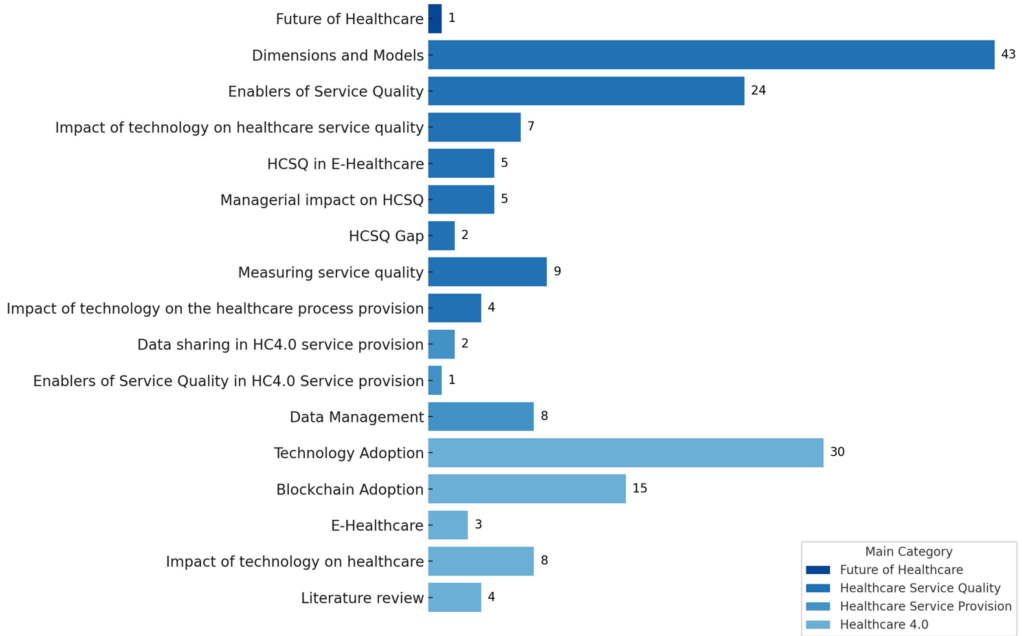

Figure 15. Summary of main theme and sub-theme occurrences.

In the next section, the content analysis will examine each theme and its sub-themes in detail. This examination will provide insights into the scope and focus of the research in each area, highlighting key findings and trends. By analyzing these sub-themes, it will be possible to understand the evolving landscape of healthcare research, especially in the

areas of Healthcare 4.0 and healthcare service quality. This detailed analysis will help to identify gaps in the literature and suggest directions for future research.

4. Content Analysis

The development of Healthcare 4.0 (HC4.0) has gained significant attention, bringing new opportunities and challenges to the healthcare sector. Technologies in HC4.0 are being closely studied across different healthcare areas, aiming to improve service delivery, patient care, and healthcare research. These advancements have a noticeable impact on healthcare service quality (HCSQ), making it crucial to enhance HCSQ.

The next section provides a detailed analysis of HC4.0 and HCSQ. It is structured to first explore the key technological advancements in HC4.0, their applications, and their effects on healthcare practices. Following this, the status of HCSQ is examined, with a focus on how HC4.0 technologies influence it. The content is divided into sub-themes to highlight the most important aspects of HC4.0 and its direct impact on healthcare service quality. This structured approach ensures a clear and focused look at the progress in HC4.0 and HCSQ, helping to identify key trends and areas for future research.

4.1. Technological Advancements and Impacted Areas in HC4.0

This section aligns with the first research objective: identifying key areas in healthcare impacted by technological advancements. It explores advancements such as AI, IoT, and blockchain and analyzes their roles in transforming healthcare processes such as diagnostics, monitoring, and patient engagement within the current, fully implemented era of HC4.0. The analysis is conducted based on identified sub-categories that explain the utilization and status of HC4.0 in addressing various needs within the healthcare sector.

4.1.1. Data Management

During the course of the research, a consistent theme centered around data-management objectives was identified, as outlined in Table 6. In healthcare, managing the huge amount and sensitive nature of the data is crucial, marking it as a critical aspect of ensuring secure and proficient care.

The findings presented in the table above provide insightful perspectives on various aspects of healthcare data management and privacy. The majority of authors recognize the pressing necessity for data storage and management in current healthcare systems. In particular, fog computing provides significant advantages in data gathering and analysis of patient information in the context of Healthcare 4.0. Nevertheless, the lack of understanding of the potential consequences for the security of patient data and data sharing creates a significant gap. Therefore, the gap is addressed by creating and suggesting different frameworks and approaches that establish a secure and organized system for managing data. This is achieved by employing advanced technologies such as encryption algorithms, artificial intelligence, and blockchain.

However, some issues associated with data collection and management have been emphasized. The issues have been highlighted as the root cause of unstructured data and the absence of integration in data systems. This was discovered to result in various silos in the sharing and management of data. As a result, it was determined that there is a requirement to empower patients as engaged participants in the healthcare system and convert historically isolated data storage locations into easily available ones.

Moreover, text mining methods have been employed to assess the complexity of evaluating the quality of healthcare services based on online reviews. This analysis specifically examines factors such as the efficiency of staff, utilization of technology, timeliness, and the relationship between providers and patients, while also considering the elements of data management. Although internet reviews are important for evaluating operations, they should not be the main basis for assessing clinical quality or the competency of healthcare personnel. These findings enhance comprehension of how healthcare stakeholders navigate

changing circumstances of patient feedback and quality assessment in healthcare provision in HC4.0.

Table 6. Data management in HC4.0.

Authors	Focal Point
Kovuri, K., et al. [16]	Outlines and explains how fog computing is used in medical and healthcare systems.
Maher, M., et al. [17]	Identifies the need of empowering patients as active stakeholders of the healthcare system and transforming traditionally siloed data repositories into accessible ones.
Jadav, N.K., et al. [18]	Proposes a secure and safeguarded structure for electronic health records (EHRs) in Healthcare 4.0, employing unmanned aerial vehicles (UAVs). The framework integrates onion routing (OR) networks and artificial intelligence (AI) methodologies.
Desai, S., et al. [19]	Suggests an approach for secure data storage and sharing that incorporates a selective encryption algorithm combined with fragmentation and dispersion. This method aims to enhance data safety and privacy, ensuring resilience against potential compromises of both transmission media (e.g., cloud servers) and encryption keys.
Qiu, H., et al. [20]	Presents a secure approach to store and share data, employing a selective encryption algorithm alongside fragmentation and dispersion. This method is designed to ensure the safety and privacy of data, even in scenarios where both the transmission media (e.g., cloud servers) and encryption keys face potential compromises.
Verma, A., et al. [21]	Addresses the challenges associated with data collection and privacy through the presentation of a structured survey on issues related to data localization. Additionally, privacy preservation mechanisms are explored, specifically within the healthcare industry context.
Adnan, K., et al. [22]	Recognizes challenges and problems in data-driven healthcare that emerge from the unstructured nature of data.
James, T.L., et al. [23]	Analyzes unstructured patient feedback on physicians through the application of text mining techniques, investigating the correlation between qualitative commentary and numerical ratings.

4.1.2. Technology Adoption

The study revealed that a range of applications and impacts of technology in healthcare have led to the emergence of HC4.0, as highlighted in Table 7. As such, examining these technologies and their roles in the field of healthcare is essential.

The findings highlight the various advancements achieved in HC4.0, with an emphasis on the application of advanced technologies including IoT, fog computing, cloud computing, machine learning, and data analytics. These technologies were shown to be critical in improving healthcare systems, including improved diagnostic precision, predictive analytics for disease prevention, and innovative approaches for patient care. For example, the use of hybrid IoT models for complex genome sequencing and advanced technologies for stomach tumor diagnostics demonstrate the importance of technology in tackling healthcare complex challenges. Furthermore, the analysis highlights the ability of machine-learning algorithms to properly forecast illnesses, lowering infection risks and increasing patient outcomes.

On the other hand, recent breakthroughs in healthcare technology identified illustrated a unique combination of digital healthcare and the metaverse, as part of the most recent studies on improving service quality. Moreover, various research papers were found to investigate the digital transformation of healthcare processes, while utilizing advanced technologies such as blockchain, fog computing, and the Internet of Medical Things (IoMT). These innovations are at the heart of the shift to more integrated and patient-centered care. Furthermore, there is a trend toward developing specialized systems for the remote monitoring and maintenance of medical equipment, guaranteeing that they satisfy the highest standards of healthcare quality and economic sustainability.

Table 7. Technological advancements in HC4.0.

Authors	Focal Point
Gupta, A. and Singh, A. [1]	Presents a systematic survey by investigating the recent trends, key constraints, application areas, and essential technologies required for the effective adoption of Healthcare 4.0.
Arora, D., et al. [24]	Provides a thorough examination of the latest technologies that are beneficial for Healthcare 4.0 systems. The primary emphasis is on developing technologies such as fog computing, cloud computing, machine learning, and big data analytics, all of which are centered around IoT-based healthcare applications.
Onyema, E.M., et al. [25]	Emphasizes the complications encountered in genome sequencing due to its complex nature. Additionally, a hybrid model that utilizes the Internet of Things (IoT) to analyze the genome sequences of patients within the framework of Healthcare 4.0 is presented.
Huang, J., et al. [26]	Seeks to improve the precision of stomach tumor diagnosis by the utilization of advanced technologies. Specifically, the difficulty of finding the tumor is discussed.
Kishor, A. and Chakraborty, C. [27]	Focuses on the problem of illness prediction to reduce the risk of infection through implementing forth a machine learning-based healthcare model that is capable of accurately predicting various diseases.
Mozumder, M.A.I., et al. [28]	Draws attention to the necessity of comprehending the possibilities of digital anti-aging healthcare in the context of the metaverse. Specifically, the impact of the metaverse environment on service quality is seen to be an important topic to explore.
Izzo, F., et al. [29]	Explores the impact of technology on healthcare organizations and how they may leverage digital transformation to attain an important role in the service ecosystem they operate in.
Lanza, B., et al. [30]	Outlines a demonstration of an extensive system that utilizes smart field sensors and a digital management system to enhance hospital procedures by employing flow diagrams and Business Process Models and Notation (BPMN).
Al-Jaroodi, J., et al. [31]	Explores the impact of human factors on the acceptance and adoption of Healthcare 4.0 and smart healthcare systems among various stakeholders.
Marandi, S.J., et al. [32]	Introduces studies on elderly people being monitored in the smart village system through the Internet. Finally, an architecture is proposed for a higher degree of comfort and the sending of real-time sensor data.
Mallick, S.R., et al. [33]	Proposes a blockchain–fog–IoMT framework for faster processing of healthcare data and reducing the storage and processing overhead on the cloud server.
Alazab, M., et al. [34]	Provides an overview and discusses recent advances in the use of digital twins for Healthcare 4.0.
Mishra, P. and Singh, G. [35]	Explores the idea of intelligent, networked, and personalized healthcare systems within the framework of the Internet of Medical Things (IoMT).
Sabah, S., et al. [36]	Reviews recent research focused on medical equipment predictive maintenance using advanced technology, as effective maintenance management of medical technology influences healthcare service quality delivery and the profitability of healthcare facilities.
Tortorella, G.L., et al. [37]	Examines the effect of five contingency factors on the adoption of H4.0 technologies and associated barriers to H4.0 adoption in emerging economies.
Yang, G., et al. [38]	Explores the emerging visions and features of cyber-physical system (CPS)-based Homecare Robotic Systems (HRSs).
Puri, V., et al. [39]	Suggests an artificial intelligence (AI)-enabled decentralized healthcare framework that accesses and authenticates Internet of Things (IoT) devices and create trust and transparency in Patient Healthcare Records (PHRs).
Hathaliya, J.J., et al. [40]	Proposes a mobile-based healthcare system for patient-monitoring systems and wearable devices in the Healthcare 4.0 era.
Parveen, S., et al. [41]	Illustrates the applicability of fog computing in Healthcare 4.0 and the transition of a hospital-centric healthcare (HCH) system to patient-centric care (PCC).
Sobhani, S., et al. [42]	Develops an IoT-based model in healthcare by developing an app that makes it easier for first responders of medical emergencies.

Table 7. *Cont.*

Authors	Focal Point
Miah, M.S.U., et al. [43]	Recommends an adaptive cloud and edge computing system with machine learning, reducing dependence on nurses and addressing current challenges.
Husak, M., et al. [44]	Explores Healthcare 4.0's integration of IoT in response to pandemics, emphasizing efficiency through machine learning.
Aceto, G., et al. [45]	Provides a detail study on various technologies such as the Internet of Things (IoT), cloud computing, fog computing, and big data facilitating the health sector.
Gupta, R., et al. [46]	Develops an approach, named AaYusH (Ethereum Smart Contract (ESC)) and IPFS-based TS systems, that aims to provide error-free real-time ultra-responsive surgical services remotely with high quality and accuracy.
Tortorella, G.L., et al. [47]	Proposes a method to rank integrating Industry 4.0 technologies in hospitals, considering healthcare value chain issues and the adoption rate of I4.0 tech.
Sigwele, T., et al. [48]	Introduces a healthcare collaboration framework using the Internet of Things (IoT), emphasizing secure information exchange across different healthcare systems.
Anand, D. and Khemchandani, V. [49]	Aims to tackle security and privacy challenges in Wireless Body Area Networks (WBANs) for healthcare applications, while exploring the integration of fog computing with the cloud to enhance IoT applications.
Park, A., et al. [50]	Details the implementation of seamless service trials, using IoT technology through near-field communication (NFC) tags and Bluetooth low-energy (BLE) beacons.
Dachyar, M. and Zahra, N.A. [51]	Identifies and selects suitable IoT solutions for hospitals while minimizing associated risks and challenges.
Osama, M., et al. [52]	Explores the integration of recent advances, trends, and requirements on the Internet of Medical Things (IoMT) and Healthcare 4.0 systems.

Furthermore, the findings underline the importance of developing strategies for effectively implementing Industry 4.0 technologies in the healthcare industry. This includes identifying and overcoming challenges and establishing the acceptability of new technology, particularly in developing countries. This can be addressed by providing and demonstrating the advantages of innovative solutions, such as the AaYusH system for remote surgical services. Moreover, the wide utilization of IoT in responding to pandemics, as well as the use of digital twins for personalized healthcare planning, demonstrate Healthcare 4.0's dynamic potential in addressing current and future healthcare challenges.

Moreover, advanced technical developments have been utilized in areas related to human health monitoring. Among these are the use of mobile patient-monitoring devices and the monitoring of senior citizens in smart villages. On the other hand, security and privacy testing of the established monitoring systems is necessary. This would enable accurate monitoring, which could enhance the efficiency of the process. This pattern suggests a move towards more responsive and adaptive healthcare services delivered through technology.

4.1.3. Blockchain Adoption

Within the analysis of the status of technology utilization in HC4.0, it was found that blockchain is utilized frequently for various purposes, as illustrated in Table 8.

The research papers in this section present various findings on the integration of blockchain technology in the operational and practical aspects of the healthcare industry. Blockchain technology has been widely used by the healthcare industry since its launch in 2019, which represents a critical turning point toward digital innovation in healthcare systems. This integration has revealed a number of benefits while also highlighting some issues related to the phases of development, implementation, and governance. Blockchain technology, which uses encryption and a chain of data blocks to safeguard private information from illegal access, marks a new era of improved security and privacy for healthcare

data. Unlike conventional centralized data-management systems, it is decentralized, reducing the risk of data breaches and control of data management. Additionally, blockchain guarantees data traceability and credibility, providing an unchangeable and transparent verification process for medical records—a critical factor in maintaining patient confidence and regulatory compliance.

Table 8. Blockchain adoption in HC4.0.

Authors	Focal Point
Jain, S. and Kumar, A. [53]	Examines the application of technology to enhance the dependability of various systems, encompassing a succinct survey and comparative analysis of how blockchain and smart contracts are utilized in the development, operation, and maintenance of healthcare information systems.
Ming, Z., et al. [54]	Acknowledges IoT's importance in healthcare but notes challenges in speed and security for implementation. Proposes a platform merging blockchain with edge computing for efficient and secure real-time healthcare application processing.
Rana, S.K., et al. [55]	Explores the impact of distributed ledger technology (DLT) in the healthcare system and emphasizes its potential to significantly transform current business practices. The authors conduct a thorough assessment of existing DLT-supported approaches in healthcare, offering insights into both the benefits and limitations of recent advancements in this field.
Kumar, M., et al. [56]	Highlights the need for a solution that targets data security and exchange in healthcare. As such, advanced technology is utilized to address this issue.
Mahajan, H.B. and Junnarkar, A.A. [57]	Presents a unique concept for a secure biomedical image processing system, utilizing blockchain technology to ensure anonymity.
Mahajan, H.B. [58]	Conducts a systematic study on various blockchain-based solutions for the smart Healthcare 4.0 system.
Preethi Vinnarasi, A., et al. [59]	Explores strategies for enhancing healthcare data security by leveraging permissioned blockchain. Emphasizes the significance of authorized access and the secure storage, sharing, and retrieval of data within the framework of this advanced blockchain technology.
Abbate, S., et al. [60]	Suggests a blockchain platform for real-time sharing of extensive health data among authorized stakeholders, with a focus on maintaining a robust level of protection for health information.
Gupta, R., et al. [61]	Introduces VAHAK, a secure outdoor healthcare medical supplies system utilizing Ethereum Blockchain (BC) and unmanned aerial vehicles (UAVs).
Bodkhe, U., et al. [62]	Provides a structured survey of blockchain (BC) applications within Healthcare 4.0 ecosystems.
Jain, R., et al. [63]	Suggests a framework called blockchain–fog–IoMT, designed to expedite the processing of healthcare data and diminish storage and processing burdens on the cloud server.
Tanwar, S., et al. [64]	Examines various solutions aimed at overcoming current limitations in healthcare systems through the application of blockchain technology. This exploration includes the consideration of frameworks and tools designed to measure the performance of these systems.
Gupta, R., et al. [65]	Introduces BATS, a telesurgery system for 6G empowered by blockchain and AI. BATS is designed to be self-manageable, secure, transparent, and trustworthy, incorporating massive Ultra-Reliable Low-Latency Communication (mURLLC).
Kumar, A., et al. [66]	Designs a smart healthcare system through the integration of Blockchain 3.0 and Healthcare 4.0, emphasizing seamless interoperability and considering the practical aspects of the healthcare environment.
Hathaliya, J., et al. [67]	Propose the implementation of a healthcare system that utilizes a permissioned blockchain to effectively manage healthcare data, ensuring privacy and authorized access.

The articles have indicated that incorporating smart contracts into health information systems is a notable step in simplifying and automating comprehensive administrative processes. Smart contracts refer to software programs or transactional protocols aiming to automatically execute, regulate, or record events and activities that comply with the specifications laid out in an agreement between parties. The investigation of blockchain and smart contracts in healthcare information systems highlights the ability to significantly improve the reliability, security, and operational effectiveness of healthcare networks. Although there are specific difficulties in using this technology, the benefits of creating a data-management system that is secure, transparent, and efficient significantly enhance the healthcare industry. For example, automated transactions provide seamless, accurate, and effective transactions, hence reducing the need for agents and reducing administrative expenses.

Nevertheless, the implementation of blockchain technology raises multiple challenges. These include multiple aspects, such as the growing volume of healthcare data, demanding blockchain solutions that offer effective transaction processing capabilities to address scalability challenges. The task of achieving connectivity between different healthcare information technology (IT) systems and blockchain designs remains a significant barrier. The development of global standards is necessary in order to facilitate the efficient and uninterrupted transfer of data. Furthermore, the addition of expanding regulatory and legal framework provides another dimension of complexity. The effective use of blockchain technology in the healthcare sector demands compliance to strict health information privacy laws, establishing clear standards for data ownership, and an awareness of cross-border data transfer limitations. Furthermore, the implementation of blockchain-enabled systems involves significant change-management initiatives, including the involvement of relevant stakeholders, the offering of user training, and the modification of current workflows to align with the unique blockchain-driven processes.

On the other hand, despite the ongoing difficulties faced by the healthcare industry, the advancement of blockchain technology shows potential in transforming healthcare information systems. This technology has the ability to establish more reliable, transparent, and patient-focused systems, thereby significantly changing how healthcare data are managed. The integration of the Internet of Things (IoT) into healthcare emphasizes the difficulties related to its swift deployment and ensuring privacy and confidentiality. These results suggest that the integration of blockchain technology with IoT has potential in offering a robust and efficient solution, facilitating secure and optimized real-time data processing for health applications. However, the finding show that the current design aims to significantly enhance the efficiency of the healthcare systems, with a particular emphasis on addressing challenges associated with the utilization of IoT.

In addition, the implementation of advanced blockchain technology has facilitated the achievement of high standards in data-management systems. Distributed ledger technology (DLT), which falls under the general category of blockchain, aims to transform existing business practices by providing a secure and decentralized framework for the management of healthcare data. The utilization of this technology has allowed the automation of several tasks within the healthcare industry, including transactions and the maintenance of records. The utilization of blockchain technology ensures the real-time synchronization of data, therefore preserving the security and reliability of healthcare information during the exchange among authorized systems. Blockchain technology offers a reliable and durable structure, ensuring the accurate and secure exchange of healthcare data while maintaining their confidentiality and reliability.

Blockchain technology is utilized not just for information management but also for specific domains like biological image processing. The utilization of blockchain technology enables the establishment of robust systems that efficiently regulate privacy through the implementation of rigorous validation and monitoring protocols for accessing biological images. The security of the confidentiality and privacy of sensitive data over all stages of development is of essential importance in maintaining an effective level of security for biomedical image processing. The diverse utilization of blockchain technology in the

healthcare sector showcases its ability to tackle a variety of issues within the organization, including improving security protocols, promoting ease of access, and enabling real-time data processing. Blockchain technology has the potential to revolutionize the accessibility, security, and operational efficiency of healthcare systems, therefore encouraging a future in which data management is enhanced in terms of security, efficiency, and patient-centricity.

4.1.4. e-Healthcare

In recent healthcare advancements, various processes have shifted to digital formats, replacing conventional methods. Consequently, the introduction of e-healthcare has emerged, focusing on utilizing information technology to improve healthcare services through digital tools like electronic health records and telemedicine. Table 9 summarizes the research conducted in the field of e-healthcare.

Table 9. e-Healthcare in HC4.0.

Authors	Focal Point
Talati, R., et al. [68]	Outlines potential future research directions and examines the difficulties facing e-healthcare.
Bardalai, P., et al. [69]	Investigates the Software-Defined Networking (SDN) approach's network quality of service (QoS) control mechanism for e-health services in a fog-based healthcare environment.
Mammadova, M. and Ahmadova, A. [70]	Analyzes the essence and goals of e-healthcare and the problems hindering its development and highlights its structural components.

Based on the identified literature, an important gap exists in various areas in e-healthcare. There is an important gap in effectively addressing the security challenges that are inherent in e-Healthcare 4.0. To address these challenges, a comprehensive review was conducted to identify the most pressing challenges that shall be addressed. The challenges presented by e-healthcare data in terms of security, privacy, and confidentiality necessitate a reassessment of conventional information security concepts and practices. It was identified that the existing literature is still lacking for users to fully withstand the security threats present for e-Healthcare 4.0. The literature also includes several aspects of the threats and how the present arrangements counteract them.

On the other hand, part of the security challenges arises from the lack of data management within e-healthcare. The fundamental sensitivity of health information, combined with the growing digitalization of medical records and the connection of healthcare systems, provides potential for security breaches and illegal access. In response to this challenge, techniques and models for network architecture have been formulated to enhance the administration of data. With respect to the optimization of network efficacy and reduction in end-host response time, the Software-Defined Networking (SDN) methodology has proven to be particularly effective.

Although there is a rising academic interest in e-healthcare, it is important to recognize that there are numerous challenges that need to be addressed. These challenges include concerns regarding the security of data, as previously noted, as well as difficulties connected to the compatibility of various healthcare systems. Furthermore, the issue of safeguarding patient information privacy while adopting digital improvements continues to be complex. In addition, the constantly changing technology environment requires the healthcare industry to consistently adjust and develop new ideas. Although some progress has been achieved, the journey towards fully leveraging the potential of e-healthcare and effectively addressing the related challenges is an ongoing effort.

4.1.5. Impact of Technology on Healthcare

With all the advancements identified in earlier sections, it was identified that the technological advancements impact various areas in the healthcare process. Table 10 explains the papers that discuss the various impacts of technological advancements.

Table 10. The impact of technology on the healthcare process in HC4.0.

Authors	Focal Point
Abbate, S., et al. [71]	Examines the healthcare sector's technology innovation from a knowledge management perspective and how 4.0 technologies affect knowledge generation processes (socialization, externalization, combination, and internalization).
Tortorella, G.L., et al. [72]	Identifies bundles of HC4.0 digital applications and measures the impacts of their adoption on patient-centered performance.
Tortorella, G.L., et al. [73]	Categorizes bundles of technologies and associated implementation barriers that could be viewed as part of HC4.0 and tests their impact on performance improvement in a sample of hospitals.
Al-Jaroodi, J., et al. [74]	Discusses why it is important to approach the transformation efforts to HC4.0 as a holistic system engineering problem and to have a strategic long-term vision for the transformation efforts.
Marques da Rosa, V., et al. [75]	Presents an exploratory investigation of the upside of ten digital technologies derived from HC4.0 in terms of their perceived contribution to six healthcare services and the four abilities of resilient healthcare: monitor, anticipate, respond, and learn.
Tortorella, G.L., et al. [76]	Assesses the effect of HC4.0 implementation on healthcare costs' reduction in hospitals located in developing economies.
Pang, Z., et al. [77]	Presents a brief history and key enabling technologies of Industry 4.0, exploring its revolutionary impact on HC4.0 and its transformation of the entire healthcare value chain.
Detwal, P.K., et al. [78]	Investigates the existing research on the correlation between operational excellence and Healthcare 4.0 (H4.0) within healthcare organizations.

The results emphasize the importance of these technologies in improving communication between healthcare providers and patients, as well as the implementation of digital learning tools such as virtual reality and smart glasses to promote employee learning, enhance patient care quality, and improve overall organizational performance. Furthermore, the implementation of HC4.0 and various digital applications was classified into four groups. These bundles have demonstrated a clear correlation between the deployment of technology and enhancements in patient-centered performance.

Furthermore, the findings divide the HC4.0 technologies into two functional groups—sensing-communication and processing-actuation—each playing an important role within healthcare. The integration of these technologies not only enhances hospital performance but also demonstrates a strategic approach to digital adoption in healthcare processes. Likewise, the communication advantage provided by the introduction of technology supports the ability of stakeholders to collaboratively navigate the complexities of digital transformation in healthcare. The navigation would include the management and security of personal data of patients with the use of digital platforms. Moreover, it was identified that an efficient healthcare process relies on patients' and providers' openness and willingness to use digital platforms.

Consequently, it was identified that overcoming silos within the healthcare process is essential to realize the full potential of HC4.0. The development of an integrated healthcare process is possible through the elimination of silos, which allows for the opportunity for coordinated efforts to share resources and align objectives. Since H4.0 technologies have demonstrated a major impact on ERs (Emergency Rooms) and ICUs (Intensive Care Units), the discussed strategy is beneficial in these settings. Digital non-invasive care connected medical emergency support and digital platforms for data exchange are some of

the technologies that are essential to improving service resilience in these high-complexity environments and meeting the demand for robust performance.

Furthermore, the utilization of advanced technology has illustrated benefits in terms of cost reduction. Research conducted in Brazil, India, Mexico, and Argentina demonstrates that the use of H4.0 technologies lowers healthcare expenditures; however, the exact technology arrangement used will determine the exact difference in savings. This financial gain enhances the benefits of HC4.0 in terms of improving clinical operations and patient care.

Healthcare 4.0 is expected to integrate advanced technologies driven by artificial intelligence and interaction between humans and machines, including robotics, cognitive computing, and smart homes. These developments represent another phase of innovative healthcare solutions and promise major breakthroughs in independent living, supportive services, and patient rehabilitation.

4.1.6. Previous Literature Reviews on HC4.0

Many papers have conducted literature reviews regarding HC4.0 in the last two years. The scope of these papers is shown in Table 11.

Table 11. Previous literature review on HC4.0.

Authors	Focal Point
Küçükönder, H. and Görçün, O. [79]	Reviews the latest literature on employing Multiple Criteria Decision-Making (MCDM) frameworks to address diverse evaluation challenges encountered in the healthcare industry.
Ahsan, M.M. and Siddique, Z. [80]	Analyzes the impact of Industry 4.0 on healthcare (integrated healthcare (IHC)) systems.
de Mendonça, B.S. and Rodrigues, L.F. [81]	Explores the present status of the HC4.0 revolution. The study employs a systematic methodology to select relevant documents retrieved from Web of Science and Scopus.

The literature reviews reveal a strong emphasis on the integration of Industry 4.0 technologies in the healthcare sector, as well as the use of advanced technologies and decision-making techniques. The notable increase in research on the use of technology in healthcare highlights the industry's rapid development and the increasing significance of academic research.

An important advancement in this HC4.0 is the establishment of an integrated healthcare (IHC) framework, which addresses various important factors including scheduling issues, security concerns, the influence of pandemics, digital supply chains, blockchain technology, and artificial intelligence. This framework illustrates the collaborative development of the healthcare sector and Industry 4.0 technologies in response to the COVID-19 pandemic. It addresses major challenges such as data security, resource allocation, and the assurance of data transparency.

On the other hand, the increasing volume of research on HC4.0, especially since 2018, indicates a growing interest in this field of study. It was identified that India is a dominant contributor in this discipline, succeeding in both the quantity of published papers and the impact of its authors. Although IEEE journals are not often linked to the health field, they have played a vital role in spreading research related to HC4.0. Nevertheless, the study highlights the absence of a clear and globally acknowledged definition for HC4.0, while also identifying the most often employed technology in this developing field. These findings demonstrate the dynamic nature of HC4.0 and emphasize the need for ongoing research and standardization in order to take full advantage of its promise for enhancing healthcare delivery and outcomes.

4.2. Healthcare Service Provision in HC4.0

Technology has revolutionized healthcare provision by reshaping methods and approaches to service delivery. In line with the second research objective, this section explores the influence of technological advancements on service quality within the era of HC4.0. It

examines how innovations such as AI and IoT enhance key dimensions of service quality, including efficiency, reliability, and patient satisfaction. Furthermore, it highlights their transformative impact on patient engagement, communication, diagnostics, and treatment outcomes, providing a comprehensive perspective on the evolving landscape of healthcare delivery.

4.2.1. Impact of Technology on the Healthcare Process Provision

The utilization of technology has been witnessed to impact not only the healthcare process but also the provision of healthcare services, enhancing patient engagement, streamlining communication between providers and patients, and significantly improving the accuracy of diagnostics and treatment outcomes. Table 12 illustrates the findings.

Table 12. Impact of technology on healthcare provision process.

Authors	Focal Point
Gezimati, M. and Singh, G. [82]	Explores the present comprehension of THz systems, obstacles in the use of these systems in clinical settings, and possible areas for study in order to enhance and reduce the size of systems and biosensors.
Balouei Jamkhaneh, H., et al. [83]	Aims to assess the effects of HC4.0 digital technologies on healthcare processes and thereafter create a conceptual framework to analyze the impact of these technologies on different parts of the process.
Mwanza, J., et al. [84]	Attempts to close that gap by investigating the impact of Industry 4.0 on healthcare systems in emerging economies.
Tortorella, G.L., et al. [85]	Explores the impact of ten HC4.0 digital technologies on four abilities of resilient systems (monitor, anticipate, respond, and learn) in the context of hospitals.

The transformative impact of Terahertz Technology (THz) and Industry 4.0 digital technologies in healthcare has been identified in the literature. THz imaging and sensing are recognized as new techniques that have the potential to be applied in different medical areas. These include cancer identification, diabetes monitoring, the assessment of internal injuries, measuring hydration levels, and the assessment of DNA and proteins. These applications can enhance diagnostic procedures by providing harmless, rapid, and accurate detection methods that could significantly improve patient care, service provision and treatment outcomes.

The integration of Industry 4.0 technologies, including the Internet of Things (IoT), artificial intelligence (AI), cloud and fog computing, and big data analytics, into healthcare generates a robust and effective environment that is capable of supporting these advanced THz applications. The use of 5G technology, wireless internet, Augmented Reality (AR), cryptography, and Content-Based Image Retrieval (CBIR) systems significantly increases the capacity for prompt data analysis and the secure transmission of medical information.

Moreover, the implementation of technology not only enhanced the precision and efficiency of service delivery techniques, but also influenced consumer perception and engagement. The results show that three important factors should be considered when evaluating digital technologies in healthcare: customer engagement, customer service, and service delivery speed. The use of Industry 4.0 technologies in service delivery has a major impact on these elements, which are essential to improving the patient experience.

On the other hand, the results highlight two significant findings about how HC4.0 technology impacts healthcare quality. According to the first finding, all quality indicators have been found to be significantly impacted by the combination of sensing technologies and communication tools, such as digital sensors and mobile health (mHealth) applications. Clinical efficacy has been demonstrated by these instruments surpassing the effectiveness of other technologies like IoT and remote patient monitoring. The second conclusion highlighted the critical role that digital technologies play in detecting patients at high risk and improving the management of chronic patients, both of which eventually

contribute to enhanced service provision. Particularly, the ability of digital technologies to enable personalized care plans and remote patient monitoring is an important milestone in healthcare. This capability is especially important in managing chronic diseases and providing care to patients in remote locations, as it ensures the continuity of care and timely medical interventions.

4.2.2. Data Sharing in HC4.0 Service Provision

The literature findings highlight the importance of data sharing and communication when performing tasks that lead to the provision of healthcare services. These findings are listed in Table 13.

Table 13. Data sharing in HC4.0 service provision.

Authors	Focal Point
Wang, X., et al. [86]	Proposes an effective privacy-enhanced multi-area task assignment (PMTA) strategy for Healthcare 4.0. As such, the authors identified that hospitals cannot directly exchange medical data through data sharing, even for better treatment development, causing a lot of data silos in healthcare.
Nwauka, O., et al. [87]	Explores the performance cause-and-effect relationships within hospitals, examining the impact of a deficiency in integrated information and communication systems.

The findings of this section emphasize the crucial importance of data sharing in the advancement of HC4.0, showcasing its ability to significantly change healthcare delivery into a more integrated, effective, and patient-centered system. A key component of this transformation is improving the ability of different healthcare information systems to work together effectively. Efficient data sharing among platforms enables healthcare practitioners to access accurate and updated patient records, facilitating well-informed decision-making and the creation of customized treatment plans based on unique patient requirements.

Furthermore, enabling data sharing is crucial for enhancing patient outcomes. Data sharing facilitates the delivery of coordinated and comprehensive care by making patient data easily accessible to all relevant healthcare professionals. It is essential for managing chronic diseases, reducing medical errors, and tailoring treatment methods, which results in improved health outcomes for patients. Data sharing in healthcare systems improves operational efficiency, as emphasized in the literature. Data sharing leads to cost savings and improves the efficiency of healthcare systems by simplifying operations, removing redundant procedures, and decreasing administrative costs, allowing them to better serve a bigger patient population.

The research also highlights the difficulties related to data privacy and security when sharing data. With the growing interconnection of healthcare systems, it is crucial to prioritize the protection of patient data from potential breaches to ensure confidentiality and integrity. It is crucial to have strong data protection procedures to uphold trust in the healthcare system and safeguard patient privacy during the current era of digital healthcare evolution.

4.2.3. Enablers of Service Quality in HC4.0 Service Provision

The findings revealed that one of the papers addressed the operational aspects of enabling service quality in HC4.0 service providing. Table 14 presents the paper that was discovered.

The findings from the identified paper highlight a considerable improvement in the service quality offered within the context of Healthcare 4.0. By applying an advanced appointment-scheduling optimization methodology, the study demonstrates how strategic improvements can lead to significant improvements in operational efficiency and, as a result, service quality in healthcare environments. The study highlights the importance of incorporating advanced scheduling strategies to reduce waiting times, optimize resource allocation, and ensure a smoother patient flow across ambulatory care facilities.

Table 14. Enablers of service quality in HC4.0 service provision.

Authors	Focal Point
Gao, Y., et al. [88]	Investigates the appointment-scheduling issue using a robust optimization framework to minimize operational costs while ensuring the improvement of healthcare service quality in the Ambulatory Care Center (ACC) service delivery. The ACC is a medical care facility that offers outpatient healthcare evaluation and treatment.

Furthermore, the research emphasizes the means by which the implementation of these distinctive scheduling solutions not only improves the standard of care provided to patients but also promotes a healthcare environment that is more flexible. A shift toward a more flexible and patient-centric care model is demonstrated by the capacity to rapidly adapt to operational demands and patient demands. This shift is of the highest priority for HC4.0, which aims to transform the healthcare industry by placing patient satisfaction, operational efficiency, and high-quality service provision at its core.

4.3. Healthcare Service Quality

Aligned with the third research objective, this section focuses on identifying and analyzing critical factors that influence service quality in healthcare, particularly within the context of HC4.0. Building on the conclusions drawn in Section 4.2.3, which highlighted the growing importance of service quality, it categorizes key factors such as responsiveness, empathy, and data security. These factors are examined in relation to their impact on healthcare outcomes, offering insights into how they shape the quality-of-service delivery. The themes and findings from the review are systematically presented and analyzed, providing a comprehensive understanding of the role these factors play in enhancing healthcare services in HC4.0.

4.3.1. Dimensions and Models

From the literature findings, it was concluded that various dimensions and models exist, which consist of the factors, models, and aspects that are related to or impact service quality. This theme is essential in the context of healthcare service quality because it emphasizes the complex and diverse nature of the evaluation and enhancement of the patient service experience. The models and dimensions highlighted in the publications emphasize the essential elements of healthcare delivery, including patient safety, medical professionalism, responsiveness, and empathy. These factors are crucial in determining patients' impressions of quality. As such, the papers are illustrated in Table 15.

Table 15. Dimensions and models of service quality in healthcare.

Authors	Focal Point
Ali, J., et al. [89]	Explores the literature of healthcare service quality to identify and analyze the healthcare service quality models and dimensions and to present future research insights pertaining to the applications of these models and dimensions.
Ali, J., et al. [90]	Presents a conceptual framework of healthcare service quality (HCSQ) constituting the modified dimensions of SERVQUAL and their influence on patient satisfaction. The extensive literature review and organization of various service quality dimensions paved the way to add new contextual dimensions to the HCSQ model.
Senapati, S. and Panda, R.K. [91]	Employs consumer-perceived experiences to unveil novel intricacies within the realm of healthcare quality assessment, with the aim of quantifying healthcare service quality to understand the correlation between service delivery and consumer expectations.
Vanacore, A. and Pellegrino, M.S. [92]	Explores whether a patient's age and gender matter for patient prioritization of quality improvements in healthcare services.

Table 15. *Cont.*

Authors	Focal Point
Ampaw, E.M., et al. [93]	Provides empirical evidence on healthcare service quality, focusing on its precursors, such as patient satisfaction and continuous service utilization. By addressing these aspects, the study aims to tackle long-standing social and economic objectives in both less developed and developed countries, while meeting the urgent demand for high-quality healthcare services.
Mahmud, M.S., et al. [94]	Explores the outbound medical tourists' satisfaction and loyalty on the basis of the quality of the healthcare service provided by foreign medical institutions.
Bucke, V., et al. [95]	Examines the impact of service quality (SERVQUAL) dimensions on the satisfaction of service users (patients or patients' legal guardian or escort) with healthcare services and to develop a model of service quality management at healthcare institutions.
Kamalasanan, A., et al. [96]	Determines the validity and reliability of the Healthcare Quality Perception (HQP) questionnaire tool designed to capture employees' perceptions of healthcare quality in Indian hospitals.
Nie, R.-X., et al. [97]	Introduces a cloud-supported QFD model for enhanced healthcare quality in order to prioritizes patient requirements to exceed expectations, translating them into technical requirements and considering bounded rationality.
Khambhati, R., et al. [98]	Proposes a conceptual performance evaluation and a comparison model to assess public-health-care-service quality in a fuzzy environment using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).
Ahmed, S., et al. [99]	Explores service quality, patient satisfaction, and loyalty within the healthcare sector of Bangladesh. It assesses healthcare quality conformance, patient satisfaction, and loyalty with a focus on demographic factors like gender, age, and marital status. Furthermore, the study investigates variations between the public and private healthcare sectors concerning service quality, patient satisfaction, and loyalty.
Sumaedi, S., et al. [100]	Constructs and evaluates a multi-level healthcare service quality (HCSQ) model in Jakarta, Indonesia. Furthermore, this paper aims to identify the primary dimensions and subdimensions of HCQ.
Shabbir, A., et al. [101]	Examines patient loyalty and healthcare service quality (physician treatment, nurses' care, supportive staff, operational activities, and physical maintenance). It also investigates perceived service quality and how it affects patient satisfaction and loyalty in public and private healthcare providers, considering patient satisfaction as a mediator.
Estima, A., et al. [102]	Identifies factors influencing healthcare quality in the Iranian context. It provides an observation relating to the importance of tangible and intangible attributes in obtaining improvements in service quality.
Boakye, K.G., et al. [103]	Introduces and assesses a healthcare framework involving service quality, perceived value, and satisfaction in Ghana. The study specifically explores the impact of service quality on both patient satisfaction and perceived value within the context of healthcare delivery in Ghana.
Bautista, J.M.S., et al. [104]	Creates a comprehensive framework for evaluating hospital service quality by incorporating perspectives from patients, health professionals, and hospital management. This multi-perspective approach, validated through statistical methods, ensures a holistic assessment that goes beyond traditional measurements, emphasizing the satisfaction of all stakeholders for improved service quality.
Aydemir, E. and Sahin, Y. [105]	Explores the impact of technical and functional quality on healthcare service quality and patient satisfaction, utilizing the Grey Relational Analysis (GRA) method for evaluation.
Mohamed, B. and Azizan, N.A. [106]	Seeks to enhance healthcare quality research and its results in a developing country, namely a Malaysian public hospital. The study aimed to quantify healthcare service quality based on patient perceptions using a hierarchical model, examine the impact of patient satisfaction and compliance on patient satisfaction, and propose service quality enhancements for public hospitals.

Table 15. *Cont.*

Authors	Focal Point
Javed, S.A. and Ilyas, F. [107]	Examines how patients' expectations regarding healthcare service quality influence their satisfaction with nursing in both public and private hospitals in Pakistan.
Shafei, I., et al. [108]	Identifies the most effective measure among various alternatives (SERVQUAL, weighted SERVQUAL, SERVPERF, weighted SERVPERF) and creates a scale that healthcare providers can utilize for assessing healthcare service quality.
Javed, S.A. and Liu, S. [109]	Examines how patient satisfaction with outpatient services in Pakistan relates to five aspects of healthcare quality. Different models are utilized, like Deng's grey incidence analysis, to understand this connection and make decisions when things are uncertain.
Kondasani, R.K.R. and Panda, R.K. [110]	Studies the link between perceived service quality and customer satisfaction in influencing loyalty towards healthcare service providers.
Fatima, T., et al. [111]	Explores patients' perspectives on private healthcare service providers, specifically focusing on hospital service quality. It evaluates the relative importance of quality metrics in predicting patient satisfaction and loyalty, examining the mediating role of patient satisfaction between the quality of hospital healthcare services and patient loyalty.
Qin, H., et al. [112]	Explores how gender moderates the connections between urgent care quality, patient satisfaction, and behavioral intention.
Johnson, D.M. and Russell, R.S. [113]	Enhances comprehension of the determinants influencing overall patient satisfaction in medical clinics and investigate the potential of patient satisfaction metrics to support ongoing efforts in continuous process improvement.
Lee, D.H. [114]	Examines how healthcare service quality is measured based on past research, quality awards, and international service quality accreditation systems.
Pai, Y. and Chary, S.T. [115]	Emphasizes the significance of patient perceptions as valuable indicators of healthcare quality, particularly within the context of a patient-centric approach in healthcare, despite ongoing debates about how healthcare assessment should be conducted.
Mikaeili, M., et al. [116]	Employs text mining on a set of textual feedback to assess patients' perceptions of service quality and utilize this understanding to identify undesirable processes.
Rejikumar, G., et al. [117]	Identifies major healthcare service quality (HCSQ) dimensions, their most preferred service levels, and their effect on HCSQ perceptions of patients using a Taguchi experiment.
Jandavath, R.K.N. and Byram, A. [118]	Examines the impact of healthcare service quality (HCSQ) dimensions on patient satisfaction and behavioral intentions within chosen corporate hospitals in South India.
Singh, A. and Prasher, A. [119]	Introduces an integration of fuzzy set theory and SERVQUAL methodology for assessing the service quality (SQ) of four hospitals in the Punjab state of India.
Butt, M.M. and de Run, E.C. [120]	Creates and validates the SERVQUAL model scale for evaluating the quality of private health services in Malaysia.
Al Khattab, S.A. and Aborumman, A.H. [121]	Assesses healthcare service quality in Jordan and compares the quality of services offered by different providers, specifically public and private hospitals.
Elleuch, A. [122]	Aims to contribute to the existing knowledge on healthcare quality and patient satisfaction by exploring the Japanese context, characterized by a distinct healthcare system and cultural differences from the USA and Europe.
Ramsaran-Fowdar, R.R. [123]	Concentrates on utilizing an augmented SERVQUAL instrument to assess the service expectations and perceptions of patients in the private sector by identifying the relative importance of the factors.
Lee, W.-I., et al. [124]	Investigates customer attributes by integrating qualitative research and Kano's model, exploring how customer satisfaction or dissatisfaction behaves, and analyzing the relationship between customer satisfaction and the quality of healthcare services.
Koubaa Eleuch, A. [125]	Evaluates Japanese patients' perceptions of healthcare service quality and identifies the most meaningful service features, building upon a previous study published in IJHCQA Vol. 21 No. 7.

Table 15. *Cont.*

Authors	Focal Point
Chahal, H. and Kumari, N. [126]	Creates and validates a multidimensional scale for assessing healthcare service quality (HCSQ) using a modified hierarchical model. Additionally, the study explores the predictive capability of HCSQ for significant service outcomes through two distinct models. The first model measures the direct effects of service quality dimensions on image. The second model measures the direct effects of physical environment and interaction quality on service quality through outcome quality.
Naidu, A. [127]	Produces a comprehensive model for understanding and measuring factors influencing healthcare quality based on patient satisfaction.
Hoxha, M.A. [128]	Creates and evaluates a modified service quality (SERVQUAL) model scale tailored for assessing healthcare service quality in Kosovo.
K S, S., et al. [129]	Evaluates the dimensions of patient-perceived healthcare service quality and its impact on both patient satisfaction and care outcomes.
Panchapakesan, P., et al. [130]	Investigate the moderators and mediators in the context of healthcare service quality from the perspectives of patients and their attendants in India.
Shafei, I., et al. [131]	Formulates a model that encompasses the constructs and sub-constructs utilized by consumers in assessing healthcare service quality (HCSQ) in Egypt.

The findings emphasize the development and implementation of models and dimensions for assessing healthcare service quality (HCSQ) since the introduction of SERVQUAL. SERVQUAL is a research tool introduced in the 1980s by Parasuraman, Zeithaml, and Berry [130]. Its purpose is to evaluate service quality by comparing customers' expectations with their views of the actual service they receive. This underscores the ongoing efforts to improve and adjust the evaluation of service quality in the healthcare industry. A significant discovery involves the advancement and customization of SERVQUAL, resulting in the integration of additional, situational aspects such as patient safety and medical professionalism. These additions seek to address the complex nature of healthcare services and more accurately represent the complex details of contemporary healthcare delivery. For example, the adaptation of SERVQUAL into a conceptual framework with seven factors demonstrates a strategic method to include a wider range of healthcare quality aspects. As a result, various studies focused on the incorporation of patient safety and medical professionalism into the HCSQ model, which is seen to be essential for effectively measuring patient satisfaction. These adjustments emphasize the changing understanding of what defines quality in healthcare from the patient's point of view, emphasizing the necessity for models to encompass the various aspects of patient experiences and expectations by including the relevant factors.

The research highlights the key role of adaptability in healthcare service quality models and emphasizes its necessity at different operational levels, ranging from departmental to individual service delivery. This finding challenges the traditional strategy of "one-size-fits-all". It encourages the use of models that can adapt to the specific circumstances and demands of various healthcare departments, while also catering to the specific needs of individual patients. Adaptability is crucial to ensure that healthcare services can effectively satisfy the diverse expectations and preferences of patients, who may have varying healthcare journeys and experiences according to their health conditions, demographic origins, and individual preferences. Healthcare practitioners can enhance patient satisfaction and the perceived quality of care by implementing adaptive models that allow for a more individualized and patient-centered approach to care delivery. This comprehensive understanding of service quality, based on the distinct requirements and views of patients at both the group and individual levels, emphasizes the complex nature of healthcare provision and the necessity for ongoing development in quality evaluation frameworks to accurately encompass and address the constantly shifting context of patient care needs and expectations.

Nevertheless, this analysis uncovers multiple weaknesses and limitations in the existing healthcare service quality models and the included factors. An ongoing theme is the necessity for new models, which include a comprehensive list of factors that consider the unique features of healthcare services in various settings, encompassing cultural and regional variations. Moreover, the primary emphasis has been on gathering feedback from patients, while the viewpoints of service providers and patient companions have received minimal consideration. This missing component may restrict the thoroughness of quality evaluations, as it neglects to include the provider's perspectives on enhancing service quality. Similarly, the findings emphasizes the importance of incorporating patient safety and medical professionalism into the evaluation of healthcare service quality. However, it also highlights that these topics have not been adequately explored in academic studies. The discrepancy illustrates the clear necessity for future research to comprehensively examine these aspects, exploring further the potential impact on patient satisfaction and perceived quality of services. It is crucial to address this research gap in order to develop a more thorough understanding of healthcare quality. This involves going beyond typical measures and considering how patient safety and provider competency impact patient experiences and outcomes. The exploration of such factors is essential for the improvement of healthcare practices and the enhancement of service quality, with a focus on the patient's perspective.

Moreover, the findings reveal significant constraints in the current research, including the difficulty of generalizing findings across diverse healthcare systems and cultural contexts. Furthermore, the reference to specific contexts such as Kosovo and Ghana highlights a broader challenge: numerous HCSQ models are formulated and validated within specific economic, social, cultural, and healthcare infrastructures, which may not accurately represent or be relevant to other regions with unique healthcare dynamics and patient expectations. This finding highlights the importance of continuous, context-specific research on the quality of healthcare services. Future research should address the need to understand and integrate the unique features of different healthcare settings, patients, and cultural norms. This will guarantee that HCSQ models are truly comprehensive and reflective of the diverse global circumstances of healthcare service delivery.

4.3.2. Enablers of Service Quality

Building upon the dimensions and models of healthcare service quality, enablers of service quality were identified as a critical element in research. Therefore, this theme is critical as these enablers and the methods utilized to assess them can significantly enhance the delivery and effectiveness of healthcare services and contribute to enhanced research in this field. The summary of the papers and their focus is shown in Table 16.

Table 16. Enablers of service quality in healthcare.

Authors	Focal Point
Gupta, N., et al. [132]	Identifies, analyzes, and prioritizes the enablers that impact the delivered service quality using the DEMATEL (Decision-Making Trial and Evaluation Laboratory) method to analyze the data collected.
Al Owad, A., et al. [133]	Establishes empirical relationships between patient flow problems, healthcare service quality, and patient satisfaction with Emergency Department (ED) service factors from the patient perspective.
Nguyen, P.-H. and Pham, H.-A. [134]	Assesses and ranks the service quality of the healthcare system utilizing a Fuzzy Analytical Hierarchical Process (AHP) and Grey Relational Analysis (GRA) technique.
Halaweh, M. and Salameh, F.F. [135]	Explores patients' perception of service quality in the UAE, a topic that has not yet been extensively studied. Grounded theory techniques were used to analyze online feedback and comments on clinical services posted by patients.
Wu, H., et al. [136]	Examines patients' use of different compliments for healthcare service quality through a three-stage process in the transaction cycle: pre, during, and after-sale.

Table 16. *Cont.*

Authors	Focal Point
Pourmadadkar, M., et al. [137]	Introduces an integrated approach using Failure Modes and Effects Analysis (FMEA), Multiple-Criteria Decision-Making (MCDM), mathematical modeling, and Quality Function Deployment (QFD) techniques, for risk assessment and service quality enhancement in Coronary Artery Bypass Grafting (CABG) as a treatment for Cardiovascular Diseases (CVDs).
Singh, A., et al. [138]	Identifies the parameters of service quality that would improve patient satisfaction and also generate priority weights from the perspectives of both service reviewers, i.e., patients, and service providers, i.e., doctors and employees.
Awang, N.A., et al. [139]	Aims to discover the perception of Persons with Disabilities (PWDs) towards Facilities Management (FM) service quality at hospital buildings in Malaysia.
Narang, R., et al. [140]	Highlights patient-independent quality dimensions like structure, process, and outcome as precursors to overall quality. The objective of this paper is to offer a fresh perspective by examining the interplay between hospital atmosphere, healthcare quality, and the perceived outcome.
Kondasani, R.K.R., et al. [141]	Evaluates and compares various private healthcare settings in the Indian context based on perceived service quality, employing the Analytical Hierarchy Process (AHP). The Indian private healthcare sector is characterized by three types of healthcare settings: nursing clinics (NCs), non-corporate hospitals (NCHs), and corporate hospitals (CHs).
Turan, A. and Bozaykut-B, T. [142]	Examines how the quality of healthcare services affects patient satisfaction, their intention to return, and positive word-of-mouth at a women and children's hospital. The goal is to assess and compare patient expectations and experiences using a total quality management approach.
Um, K.H. and Lau, A.K.W. [143]	Addresses a gap in existing research by investigating how healthcare service quality influences patient dissatisfaction, consequently triggering various asymmetric negative behavioral responses when a healthcare service falls short.
Izadi, A., et al. [144]	Seeks to measure service quality for surgical and medical inpatients at Kerman Medical Sciences University (KUMS) in 2015, aiming to offer an objective guide for managers and policymakers to enhance services and overall patient satisfaction.
De Felice, F., et al. [145]	Explores the factors influencing customer satisfaction in Indian hospitals, with a focus on identifying both moderators and mediators in the satisfaction process. This study is potentially the first of its kind to examine the influence of attendants in predominantly shaping patient satisfaction. It emphasizes the significance of considering attendants' unique perspective as secondary healthcare consumers in the context of service quality in Indian hospitals.
Lee, C.K.M., et al. [146]	Explores the adoption of fuzzy logic in healthcare diagnostic systems to enhance process oversight and pattern recognition. It highlights the limited literature on applying fuzzy logic to healthcare services and proposes a fuzzy Quality Function Deployment (QFD) approach. Moreover, the study demonstrates how this approach can align healthcare service quality with customer requirements, offering a valuable contribution to the field.
Akhade, G.N., et al. [147]	Identifies critical factors influencing inpatient service quality in a hospital and to formulate the HospitalQual theoretical model for the measurement of inpatient service quality.
Schmalbach, J.C.V. and Maza Avila, F.J. [148]	Determines the Structural Equation Model (SEM) technique for evaluating the quality of healthcare services in Cartagena de Indias city, Colombia.
Materla, T., et al. [149]	Illustrates how the Kano model can be effectively utilized and integrated with other quality methodologies to gather customer requirements and enhance the overall quality of healthcare services.
Getele, G.K., et al. [150]	Explores supply chain management in healthcare service quality within developing countries, with a specific focus on Ethiopia.

Table 16. *Cont.*

Authors	Focal Point
Jang, S.H., et al. [151]	Categorizes the quality aspects of ubiquitous healthcare (u-healthcare) services that impact the service provider's intentions to use the healthcare service.
Wong, S.Y., et al. [152]	Seeks to enhance the operational efficiency of the Accident and Emergency Department (AED) with the goal of improving overall service quality.
Pohwah, K., et al. [153]	Studies healthcare service quality by focusing on its adverse effects on the industry when there is a shortfall in the delivery of service quality.
Bhanutej, J.V. and Kesava Rao, V.V.S. [154]	Assesses the connection between healthcare service quality features, service performance, and patient loyalty to healthcare companies.

The analysis of the enablers that enhance service quality in the healthcare sector reveals a complex situation, highlighting the importance of both human and non-human elements in ensuring high-quality service delivery. The integration of analytical methods such as the Decision-Making Trial and Evaluation Laboratory (DEMATEL), Fuzzy Analytical Hierarchical Process (Fuzzy AHP), and Grey Relational Analysis offers a detailed comprehension of the significance and interaction of different quality enablers. DEMATEL, Fuzzy AHP, and Grey Relational Analysis are systematic and effective mathematical techniques utilized in complex decision-making processes. DEMATEL is a method used to identify and analyze cause-and-effect relationships inside a system. Fuzzy AHP is a technique that prioritizes items by considering the uncertainty in human judgments. Grey Relational Analysis assesses the connections between elements in systems that have insufficient data. These strategies are used to evaluate and enhance the quality of healthcare services by identifying essential elements and their interaction. A reoccurring finding in these studies is the importance of healthcare professionals' capability, including doctors and nursing staff, which has repeatedly been identified as a primary enabler in shaping patient happiness and overall service quality. Moreover, facilities, medical services, and hygiene are emphasized as important non-human facilitators.

Moreover, key concepts are identified from the studies. Several key concepts can be identified from the literature. The findings highlight the importance of healthcare professionals who offer both clinical expertise and the ability to communicate proficiently and cooperate as part of a team. The importance of being attentive to and comprehending patient requirements is important, demonstrated by the reoccurrence of these aspects in different studies of identifying the enablers of service quality. Furthermore, the operational aspects of healthcare services, such as patient waiting times and the level of convenience they can receive medical treatment, have been proven to significantly impact patient satisfaction. Consequently, technology is becoming increasingly important in managing these areas of concern. An example of this would be the implementation of advanced scheduling systems, which can improve the flow of patients and reduce waiting times. Furthermore, access to patient information can be streamlined through the use of electronic health records, which contributes to an improvement in the responsiveness of healthcare professionals. Similarly, the development of telehealth services can improve accessibility by enabling patients to obtain medical care from remote locations. This is particularly advantageous in regions that have a limitation in the number and distance of healthcare facilities in residential areas. Subsequently, these technological interventions result in significant enhancements in the enablers of service delivery, which directly influence the level of satisfaction of patients as well as their overall assessment of the service quality in the healthcare industry.

Although there are various improvements in terms of the research in this theme, various limitations were identified. Methodological limitations were identified which impact the scalability of the findings. One of the key limitations is the utilization of small sample sizes in various studies, which might not present sufficient evidence to support broad generalizations. These limitations may influence the statistical validity and

generalizability of the findings to various demographics or healthcare systems. In addition, a significant amount of the studies were based on a single scenario, frequently within particular geographical, cultural, or healthcare environments. This poses an additional limitation in terms of the generalization of the findings to a wider community. The limited scope of the studies might not address the diversity and complexities found in different healthcare environments, which may result in findings that are not broadly applicable.

Furthermore, the findings indicate a lack of research concerning the influence of supply chain management on service quality in the healthcare sector. Optimized supply chain operations are crucial for ensuring the quick availability of medical supplies and equipment, which can be viewed as an important enabler of service quality. However, there is a lack of in-depth analysis on the impact of supply chain logistics, vendor management, and inventory control on the overall patient care experience. Additionally, there is a lack of research investigating the socio-demographic variables that impact the experiences of patients on service quality. Age, gender, socio-economic group, and cultural background are important parameters that can significantly impact the expectations and enablement of enhanced quality in healthcare service delivery. Developing an in-depth assessment of these implications is essential for tailoring services to meet the different needs of patient groups and for ensuring tailored delivery of care.

To summarize, although the current literature offers valuable insights into the enablers that contribute to service quality, it is essential to address these limitations by conducting additional, expanded-scope and diverse research. This will help to develop a more comprehensive and generalized understanding of the enablers of high-quality healthcare services.

4.3.3. Impact of Technology on Healthcare Service Quality

As illustrated previously, technology has been discovered to impact nearly all aspects of healthcare. The impact of technology on service quality is crucial, as service quality determines the success of the healthcare sector. Consequently, it is important to evaluate the various technological tools introduced in the healthcare industry in order to understand their influence on the quality of healthcare service delivery. Table 17 shows the papers in this theme and their focus.

The findings in this theme focus on examining the role of advancements in patient communication and healthcare information technology in improving the quality of healthcare services, with an emphasis on the context of emerging economies.

A key finding is the introduction of the PCC, which is foundational to delivering healthcare that aligns with patients' needs and preferences. PPC refers to the extent to which healthcare providers actively listen to patients' concerns, communicate information in a clear and understandable manner, thoroughly explain medications and their potential side effects, treat patients with respect and consideration, and enable patients to actively participate in and contribute to the treatment decision-making process. An established metric for evaluating PCC has revealed an imbalance between the expected and actual communication skills of nurses, suggesting that patients' need for empathetic engagement are not completely fulfilled. This gap is an area where healthcare providers have significant possibilities to enhance patient experiences and satisfaction.

Table 17. Impact of technology on service quality.

Authors	Focal Point
Mohtar, L.N., et al. [155]	Analyzes the use of telehealth technology in managing healthcare disruptions, assessing risks, and identifying enabling factors influencing its adoption, offering lessons for future research and strategies.
Nwobodo-Anyadiegwu, E., et al. [156]	Examines the impact of integrating Industry 4.0 technology into healthcare quality improvement initiatives, with Africa as a case study for the analysis.

Table 17. *Cont.*

Authors	Focal Point
Verma, P., et al. [157]	Investigates how the 5Qs model's dimensions enhance the quality of e-healthcare services, revealing key enablers that contribute to overall service quality and customer satisfaction. The analysis aims to improve service delivery and enhance consumer satisfaction.
Nwankpa, J.K. and Datta, P. [158]	Develops an integrative model to examine the Mobile Payment Platform (MPP) utility's impact on patient trust, commitment, and HCSQ (healthcare service quality) perceptions.
Islam, S. and Muhamad, N. [159]	Introduces a scale to improve patient-centered communication (PPC) and healthcare quality in emerging economies by measuring patient perceptions and expectations, focusing on factors that enable effective PCC and high-quality services tailored to unique patient needs.
Fiaz, M., et al. [160]	Assesses healthcare professionals' perceptions regarding the enhancement of service quality in healthcare centers through the implementation of Enterprise Resource Planning (ERP) platforms.
Chao, C.C., et al. [161]	Examines the implementation of a mobile healthcare service (m-HS) system at a medical university and teaching hospital, aiming to improve healthcare service quality by addressing resource and labor limitations and discussing its architecture, workflow processes, and potential benefits.

Moreover, the use of ERP systems has been recognized as a driving force for enhancing service quality in healthcare institutions. These systems combine several operational processes into an integrated and efficient structure, enabling improved data flow and resource management. Research indicates that using ERP systems in healthcare can enhance the quality of healthcare services by providing healthcare personnel with effective resources to deliver exceptional customer service to patients. Additionally, the implementation of mobile healthcare services (m-HS) is analyzed as a potential solution to address the constraints of few resources and personnel in hospitals. The m-HS system offers a range of features to provide mobile support for patients and specific medical procedures. As such, through the use of mobile technology, m-HS initiatives have demonstrated a focus on important elements of providing care, such as ensuring the safety of medications and efficiently scheduling operations. These components are crucial for ensuring patient safety and improving the overall quality of healthcare services.

Finally, the findings highlighted the impact of technology on Healthcare Service Quality (HCSQ), with a particular focus on e-healthcare and telehealth. the area of e-healthcare and telehealth in particular. Telehealth is a technological innovation that has created a connection between patients and healthcare services, allowing for efficient medical practice and ongoing treatment from remote locations. Telehealth research analyzes how telehealth systems manage healthcare service difficulties, evaluates the risks associated with it, and identifies factors that encourage or prevent its adoption. The study examines telehealth's impact on care, which includes diagnosis, treatment, prevention, and education, facilitated by videoconferencing and secure messaging. The research highlights significant concerns regarding the future of telehealth, including whether it will remain as an additional resource for specific requirements or become an integral part of healthcare delivery. Moreover, it should also investigate how the integration of rapidly advancing technologies could enhance the reliability of healthcare systems. These critical elements should be considered in future studies.

In the context of Healthcare 4.0, the implementation of Industry 4.0 advancements has been proven to improve healthcare performance by optimizing procedures and promoting cost-effectiveness. The research suggests that these technologies have the capacity to completely transform the way care is provided in public hospitals, particularly in areas with limited resources, such as particular areas in Africa. Moreover, the analysis of the 5Qs (quality of object, process, infrastructure, interaction, and atmosphere) model in evaluating the quality of e-healthcare services provides a complete framework that includes several

aspects of service quality, each significantly connected to customer satisfaction. This model has significant potential due to its thorough approach in assessing the complex features of e-healthcare services.

While there are several benefits associated with the use of technology in healthcare services, it is important to acknowledge the presence of certain limitations. The research may be limited in scope due to its dependence on private healthcare settings in developing countries as the context for the PCC study. Patients' expectations and experiences in these settings may be significantly different from those in public hospitals or in healthcare systems that are more developed. Emerging economies are defined by diverse social, economic, cultural, and policy environments that have the potential to influence healthcare services and patient opinions. As a result, although the results provide important insights on PCC in the particular setting of private organizations, it may not be appropriate to generalize these findings to the wider healthcare industry without conducting further research.

Moreover, the study on the impact of ERP on service quality is limited by the small sample size, which raises concerns regarding the validity and practicality of the findings. Firstly, a small sampling approach may result in difficulty in the study's findings being generalized beyond the specific research environment. Consequently, their significance will be restricted to the specific setting and they cannot be generalized to the healthcare sector as a whole. On the other hand, utilizing self-reported information in m-HS studies can cause some challenges. Participants may not consistently provide accurate responses due to possible influences such as the desire to create a positive impression or the influence of personal biases. This may affect the reliability of the outcomes and fail to accurately demonstrate the positive impact of m-HS on healthcare. In order to gain a more accurate understanding, future research should examine quantitative outcomes, such as the performance of the system from the patients' point of view after the utilization of m-HS, the rate of service utilization, and the assessments of external investigators. This approach is more appropriate compared to relying only on subjective statements provided by individuals regarding their personal experiences.

Finally, some studies highlight various research gaps. As the telehealth study raises concerns regarding its long-term integration into healthcare delivery and its role in system-wide resilience to disruptions, this gap suggests long-term studies are needed to understand telehealth's long-term implications on healthcare. Moreover, the findings related to Healthcare 4.0 raise challenges regarding patient data security, especially in IoT applications, which must be addressed to ensure patient trust and the secure utilization of emerging technologies. Research in this area is required to develop reliable safety frameworks. Finally, the 5Qs model for e-healthcare is limited to a few public hospitals, which may limit its applicability. To verify its reliability as a tool for healthcare quality improvement, the model must be validated across additional healthcare settings.

These studies demonstrate the various advantages of technology in enhancing the quality of service in healthcare. However, the limited availability of studies examining the unique impacts of technology on HCSQ emphasizes the necessity of additional studies in this domain, including investigating the influence of different forms of technology in the field.

4.3.4. Service Quality in e-Healthcare

As illustrated in the previous section, technological advancements have a great impact on HCSQ. In particular, e-healthcare was found to have an impact on the service of quality as it follows a unique method of delivery. The field of e-healthcare, as discussed in Section 4.1.4, is distinct because it introduces innovative methods of communication and healthcare delivery to patients. As such, this development in the mode of delivery could potentially impact HCSQ, especially because its utilization has increased due to the recent pandemic (COVID-19), making it an essential topic for research. The papers that have explored the status of HCSQ in e-healthcare are summarized in Table 18.

Table 18. HCSQ in e-healthcare.

Authors	Focal Point
Verma, P., et al. [162]	Recognizes the important predictors of quality, which are significant for consumer satisfaction with e-healthcare services by using Zineldin's 5Qs model. It also aims to find the strength of association among the predictors of consumer satisfaction and the demographic characteristics of the respondents.
Mutingi, M. [163]	Provides a critical analysis of current evaluation initiatives within the context of e-health services. It explores key areas of e-health services to identify quality dimensions that impact customer experience.

The field of e-healthcare has achieved significant developments in its attempts to evaluate and improve the quality of services, as recent research has revealed the numerous factors that impact customer satisfaction. These studies indicate that the quality of e-healthcare services is significantly impacted by the interaction between the healthcare professional and the patient, the platform usability, and the quality of the service. These factors have been observed to differ in significance among various demographic categories.

Another significant aspect that has been highlighted is the quality of the healthcare environment, particularly in cases where treatments are provided electronically. The visual and functional components of the e-healthcare interface, the accessibility of healthcare services, and the overall digital environment are significant variables in determining patient satisfaction. This relates to the operational component of the service delivery of care, including factors like the ease of use of programs, the clarity of presented information, and the reliability of the technology platforms utilized.

Furthermore, the research has identified the need to focus on service quality across different demographic groups. The findings suggest that variables such as age, gender, economic level, and geographic location can impact the patient's perceptions and expectations of quality. The significance of demographic sensitivity emphasizes the need for e-healthcare services to include flexibility and the ability to be customized to meet the needs of diverse patient groups. Furthermore, there is an increasing understanding of the need for e-healthcare services to offer personalized treatment, reduced expenses, and adaptability. Individualized attention refers to the individual care that patients receive, considering their unique medical requirements and personal preferences. Savings includes both the cost-effectiveness for the patient and the value of the resources and time spent by the provider, while adaptability signifies the system's ability to adapt to changing patient needs and technology advancement.

The findings highlight the constantly shifting dynamics of customer satisfaction, emphasizing that as the field of e-healthcare develops, it is necessary to develop appropriate models and frameworks for measuring service quality. By combining these various elements, e-healthcare providers can effectively satisfy the changing needs of their patients, leading to enhanced clinical outcomes, more patient loyalty, and an improved healthcare delivery system. However, the limitations of current research suggest that these findings only address an initial level of a much larger area. Further research is required to thoroughly understand and integrate these detailed aspects into the implementation of e-healthcare into the industry, while improving the level of HCSQ.

4.3.5. Managerial Impact on HCSQ

Furthermore, the analysis revealed that healthcare organizations' managerial aspects and their impact on HCSQ are of significant interest to researchers. This could be the result of its possible influence on improving healthcare quality, enhancing operational efficiency, and ensuring patient safety. The research papers that explored this area in the field are listed in Table 19.

Table 19. Managerial impact on HCSQ.

Authors	Focal Point
Elkomy, S., et al. [164]	Tests the integrated leadership theory on various healthcare outcomes as the dependent variables, and provides a holistic picture of leadership effectiveness in the healthcare sector while integrating leadership from ward to board level. Moreover, it proves that there is a direct link between leadership and service quality in healthcare.
Kennedy, D.M., et al. [165]	Investigates the performance management of appointment desk staff at Mayo Clinic Arizona, identifies barriers to effective management, and aims to establish standardized procedures for monitoring service performance.
Hallo, L., et al. [166]	Leverages Engineering Management (EM) principles, merging management and engineering practices, to address challenges in patient-centered care (PCC). By applying EM's process-oriented approach, management strategies, and new technologies, the goal is to enhance the quality and efficiency of healthcare delivery, aligning with the evolving patient-centric paradigm and the influence of Healthcare 4.0 technologies from Industry 4.0.
Daqar, M.A. and Constantinovits, M. [167]	Investigates the impact of total quality management (TQM) on improving service quality within the private healthcare sector in the Northern Area of West Bank, Palestine.
Miranda, F.J., et al. [168]	Evaluates the quality of healthcare services by measuring the perceptions of the service quality by both the users and the health center managers in Spain, using the HEALTHQUAL model.

The analysis of the papers demonstrated that service quality in the healthcare sector is a complex topic that includes multiple managerial and operational aspects. Recent research has emphasized the important role that total quality management (TQM) methods have in enhancing service quality in the healthcare sector. TQM is an administrative approach that enables all participants in an organization to develop and enhance both the quality and performance of the organization. It also aims to establish the fundamental principles and concepts of quality. The implementation of these principles, such as maintaining patient satisfaction and encouraging employee engagement, is enhanced by the constant commitment of top management. An example of the positive impact of TQM can be observed in situations where increased staff involvement results in the delivery of more customized patient service and subsequently leads to improved levels of satisfaction among patients. However, the research also indicates that the TQM techniques may not always correlate with the improvement of quality. An example of this is when extremely complex administrative processes result in delays in patient care, thereby decreasing the overall quality of service. As such, this highlights the need for a more thorough investigation of the specific TQM processes that are beneficial and those that may impact service quality.

Additionally, a research study conducted in Spain using the HEALTHQUAL model provides valuable insights into subjective evaluations of healthcare services from two different viewpoints: the users and the management of healthcare facilities. The HEALTHQUAL model is an adapted and tailored model of the SERVQUAL model identified in Section 4.3.1. This model reveals a tendency among managers to emphasize the value of infrastructure-related services (such as the facilities, equipment, and so on) compared to patient perceptions. The study highlights the importance of the abilities of health workers and the effectiveness of procedures when evaluating the quality of healthcare facilities. It indicates there is a discrepancy between how managers perceive HCSQ and how patients actually experience it. These findings emphasize a wider challenge in healthcare organizations concerning the adoption of modern management principles, which tend to be insufficiently integrated into daily processes.

On the other hand, the analysis found a study that establishes a relationship between leadership and service quality by analyzing the integrated leadership theory in different levels of healthcare management. This study demonstrates that leadership quality has a significant positive impact on the quality of services provided by hospitals. It emphasizes the importance of leadership styles that are focused on driving change. These styles are

defined by the willingness to adopt new policies and incorporate patient feedback and clinical quality measures. Moreover, the research emphasizes how enhanced organizational autonomy and competition could improve the impact of leadership on the quality of healthcare as interpreted by patients. However, the data lack a complete understanding of the underlying causes of this relationship, emphasizing the need for further research. In addition, while the findings of this study are unique, the lack of replication in other countries or different types of healthcare organizations limits the generalizability of these conclusions to the broader healthcare industry. Therefore, future studies should aim to test the integrated leadership theory in different types of healthcare organizations and across multiple countries to investigate the relationship between leadership and service quality.

Furthermore, the research explored the introduction of Engineering Management (EM) concepts into patient-centered care, emphasizing the importance of adopting and integrating emerging technologies from Industry 4.0 while maintaining a focus on the patient's needs. The implementation of EM principles is regarded as essential in response to the transforming environment of Healthcare 4.0. Nevertheless, the research has some limitations in exploring its findings in different healthcare environments due to the variability in techniques and the ongoing advancement of the healthcare industry's needs and its use of technology.

The majority of the findings, which provide valuable insights into enhancing healthcare quality through leadership and management, highlight a significant requirement for further diverse research. This includes the use of controlled studies and qualitative research in the healthcare industry to address the limitations of context-specific findings and to validate proposed theories and practices on a broader basis.

4.3.6. HCSQ Gap

While several studies have explored the concept of HCSQ, a few have identified gaps within the topic (Table 20). As such, this theme serves an essential role in providing the insights required to address the gaps in delivering services that meet the quality standards and satisfy the needs and expectations of patients.

Table 20. Gaps in HCSQ.

Authors	Focal Point
Shabbir, A., et al. [169]	Explore patients' perspectives on the perceived service quality offered by both public and private healthcare service providers. By conducting a GAP analysis to align perceived and expected services, the study compares determinants of healthcare service quality and examines differences in service quality between the two sectors.
Jahantigh, F.F. [170]	Investigates the service quality gap in healthcare by employing a fuzzy method to analyze the disparities between patient expectations and perceptions.

The primary objective of these studies is to evaluate the quality of healthcare services by considering the expectations and perceptions of patients. This is an essential topic in the area of healthcare management. By investigating the gaps between patients' expectations and their perceptions of the quality of healthcare services, these studies offer a deeper understanding of patient satisfaction and the factors influence it.

The results of the initial study's GAP analysis carefully highlight areas where healthcare services either meet or struggle to meet patient expectations. The finding that private hospitals often have a better perceived level of service quality, but they are outperformed by public hospitals in terms of the services of physicians, is particularly interesting. This suggests that while private hospitals may provide a more suitable environment and additional services, public hospitals maintain an edge in terms of the quality of clinical care. The research also reveals that in the private sector, non-clinical factors such as room quality and hygiene are thought to be of better quality. This could have a significant impact on patient satisfaction and loyalty.

A different approach is taken in the second study, which applies fuzzy logic to analyze the gaps in service quality within a healthcare setting. This methodology has revealed that patients' expectations regarding the physical elements of healthcare facilities have been satisfied. However, there is a gap in satisfying the intangible aspects of services, such as empathetic interactions, quick and effective responses to patient needs, and maintaining a secure and safe environment. The findings obtained from this study can be particularly beneficial for hospital administrators aiming to improve their understanding of areas where their services are meeting expectations and areas where there is potential for improvement.

However, it is essential to acknowledge the limitations of these studies. Small sample sizes may limit the scope of understanding and limit an in-depth understanding of the various service quality measures employed. This shortcoming could restrict the level to which the findings may be generalized to inform broad regulations and practices. Moreover, patient-reported data are subject to bias that may impact the findings, requiring extensive and varied research in the sector that relies on statistics rather than subjective patient opinions.

The results of these research studies have significant implications for the management of healthcare organizations. Healthcare providers can focus on enhancing service quality by specifically addressing the gaps that have been identified. This approach allows for targeted enhancements that are in line with the needs and demands of patients. Further research could apply these techniques to thoroughly evaluate service quality in other healthcare settings, which would improve the significance of the findings for establishing policies and organizational management approaches, while also addressing the lack of existing literature in this area. These findings have the potential to enable a more comprehensive understanding of how to enhance the quality of patient care in an approach which concentrates on the needs of the patient and recognizes the complex processes of healthcare service delivery.

4.3.7. Measuring Service Quality

As demonstrated in the previous section, HCSQ could face certain limitations. To effectively address the limitations, it is essential to have specific metrics that can be used to develop plans and strategies dedicated to reducing these constraints. Several studies have found multiple measuring tools for HCSQ, which is a crucial theme in the field of service quality in HC4.0. These particular papers are displayed in Table 21.

The recent contributions highlight an effort to comprehensively capture the complex nature of patient experiences and interactions in healthcare settings through the application of various measurement tools and approaches. The measuring models and technologies used in healthcare service quality have been improved by integrating patient-centered outcomes, in addition to data analytics. These models have advanced from traditional measures of HCSQ to include elements of care that directly impact patient experiences, such as communication and emotional support. Significantly, there has been progress in the creation of measures that consider patient-centered communication and process quality. These scales acknowledge the importance of the patient–provider interaction as an essential component of service quality. These scales underwent extensive evaluation, providing a comprehensive perspective on the patient experience. Alternative approaches have focused on integrating quality indicators in medical testing laboratories, ensuring adherence to global standards and regulations. This would offer reliability and consistency in evaluating the quality of healthcare services.

Table 21. Measuring service quality.

Authors	Focal Point
Rave, J.I.P., et al. [171]	Develops and psychometrically validates a scale for measuring healthcare service quality, explicitly incorporating a patient-centered care dimension with a focus on communication. The paper also enriches the traditional content of service quality by including equity items and presents the underlying structure of service quality in an emerging country.

Table 21. *Cont.*

Authors	Focal Point
Živilė, Ž., et al. [172]	Aims to develop a model of a quality indicator system assessment for improving the performance of medical testing laboratories. In addition, the goal is to provide insights and suggestions for the successful implementation of the quality indicator system, estimating the factors, measures, and barriers related to the knowledge, attitudes, and behaviors of laboratory professionals.
Karasan, A., et al. [173]	Introduces a comprehensive assessment methodology that combines the distance-based Pythagorean Fuzzy Multiple Criteria Decision-Making (MCDM) method, TOPSIS, and Fuzzy Inference System (FIS) to measure healthcare service quality.
Martins, S.M., et al. [174]	Developed an artificial-intelligence based (AI-based) method for assessing service quality in the dental prosthesis sector to address the complex decision problem accounting for the perceptions of three main players who need to be considered: patients, dentists, and dental technicians.
Tuzkaya, G., et al. [175]	Introduces a methodology suitable for evaluating healthcare service quality with the use of Interval-valued Intuitionistic Fuzzy Sets (IVIFSs), due to the complexity and vagueness of healthcare systems, considering the difficulty in modeling systems influenced by human decisions, feelings, and perceptions.
Büyüközkan, G., et al. [176]	Identifies key factors influencing healthcare service quality and subsequently utilizes these factors to assess and appraise the performance of hospitals.
Qin, H., et al. [177]	Develops a specialized service quality model, UCPERF, tailored for urgent-care environments, demonstrating its effectiveness in measuring patient satisfaction and addressing competitive issues to enhance service quality and reduce the likelihood of patients switching healthcare providers.
Mosadeghrad, A.M., et al. [178]	Establishes a comprehensive definition and measure of healthcare quality that incorporates the diverse needs and expectations of various stakeholders, recognizing that the perceptions of quality differ among clients, professionals, managers, policymakers, and payers in the healthcare system.
Patel, H. and Khambhati, R. [178]	Creates a model (PubHCServQual) for measuring service quality in public healthcare, validates the scale, and examines the relationships between service quality, patient satisfaction, and behavioral intention using responses from both urban and rural India.

Currently, tools often incorporate empirical validation to ensure the reliability and accuracy of service quality variables. Moreover, there is a significant tendency towards utilizing artificial intelligence and machine-learning algorithms to analyze large datasets, revealing valuable information about patient-care patterns and outcomes. Although there have been significant technological developments in these tools, the key difficulty is to ensure that they are easily accessible and practical for standardized clinical and administrative processes. As the complexity of these models and tools increases, the healthcare industry must discover a balance between the accuracy of the data collection and the effectiveness of the information generated. This will ensure that advancements in the measurement of service quality are successfully transformed into improved patient care and satisfaction.

In addition, innovative methods of evaluation that incorporate decision-making tools like Fuzzy Multiple Criteria Decision-Making with artificial intelligence have been developed. These techniques offer a broad understanding of service quality, considering several elements ranging from performance monitoring to cost perception. This indicates an improvement towards more advanced and customized measurements of healthcare services, with a focus on responding to unique conditions.

However, despite these developments, it is essential to acknowledge certain limitations. The findings of several studies may not be broadly applicable due to their focus on particular healthcare sectors or geographical regions. Furthermore, there is a tendency for reliance on particular organizations or data specific to certain departments, which could limit the scope of possible conclusions. This level of detail, although helpful in providing targeted

improvements, emphasizes the need for broader, multidisciplinary studies to verify and generalize the impact of these innovative tools and methodologies.

Overall, there is a noticeable shift in the field towards establishing broader and more flexible tools for measuring the quality of healthcare services. Although these advancements show potential, further research is required to ensure that these advanced models are durable, suitable for a broad range of healthcare cases, and effectively implemented in various healthcare settings.

4.4. Future of Healthcare

Focusing on the fourth objective, this section identifies gaps in the current body of knowledge regarding service quality assessment in healthcare. It presents findings from the review to highlight under-researched areas and proposes avenues for future exploration. As healthcare continues to evolve rapidly, a potential fifth phase of the industrial revolution may emerge. In this context, the authors argue that analyzing current trends and advancements enables the prediction of future technological developments in healthcare (Table 22). Anticipating these future advancements is essential, given the critical and sensitive nature of healthcare, making it a key focus of this analysis.

Table 22. Future of healthcare—HC5.0.

Authors	Focal Point
Chi, H.R., et al. [179]	Aims to perform a comprehensive vertical and horizontal summary of Healthcare 1.0–4.0 and Industry 1.0–4.0, which enables the authors to be among the first research efforts to provide a unique prediction of the corresponding upcoming Healthcare 5.0, based on Industry 5.0

The concept of Healthcare 5.0 (HC5.0) involves an expansive strategy for the future of medical services, driven by the extensive integration of cloud computing and IoT. This proposed concept offers a healthcare system that is interconnected, intelligent, and customized to meet patient needs. However, the implementation of HC5.0 will be met by significant limitations. The full virtualization of healthcare services, pervasive use of AI, and seamless healthcare coverage require extensive development and validation.

The full virtualization of healthcare services is the development of a digital ecosystem where all components of healthcare are provided and controlled via virtual platforms. This implies that patients have the ability to obtain medical care from remote locations, including consultations, diagnosis, and treatment administration, all through digital platforms. Developing such a system requires the use of advanced technology as well as extensive evaluation to ensure that it accurately replicates the efficacy and standard of in-person healthcare services. Moreover, seamless healthcare coverage refers to the concept of providing patients with uninterrupted and continuous medical treatment, regardless of their geographical location or the time of day. This includes the ability to effectively transition between different care settings, such as shifting from hospitals to home care, while ensuring that all relevant patient data are easily accessible to the medical professionals involved. To accomplish this level of integration, an effective system is needed to manage the continuous flow of data and services. Additionally, a comprehensive legal and regulatory framework is required to guarantee patient privacy and data security.

On the other hand, the varied implementation of AI in healthcare indicates its widespread adoption to improve various aspects of patient care. AI has the potential to support the detection of diseases, predict patient diagnoses, personalize treatment plans, and effectively manage patient data. Nevertheless, in order for AI to be reliable and secure, significant research is required to develop algorithms that are accurate, unbiased, and capable of handling complex medical data. These AI systems will require extensive validation processes to verify their effectiveness and compliance with all clinical safety standards.

The current exploration regarding HC5.0 consists mainly of theoretical aspects, where many of the proposed elements are still in the conceptual phase. The process of transition-

ing from theory to practice requires extensive research, detailed testing, and a thorough evaluation of these technologies in real-life situations. Consequently, a significant amount of preliminary work needs to be conducted before these developments can be effectively implemented into the field of healthcare. Achieving HC5.0 requires not only technical advancements but also a system of healthcare that is sustainable. The shift from the current state of healthcare to the anticipated future involves careful planning, significant financial commitment, and a collaborative effort involving a variety of sectors. Achieving HC5.0 will require improving current healthcare infrastructures, establishing appropriate regulatory frameworks, and ensuring that healthcare professionals are properly prepared to navigate a healthcare environment that depends heavily on technology. This preparation includes educational and training initiatives which concentrate on the upcoming digital tools that will have an essential part in HC5.0.

To summarize, Figure 16 effectively illustrates the key findings in HC4.0 and HCSQ using a comprehensive double-tier bubble diagram. This figure depicts the main and sub-themes and quantifies their frequency of occurrence in the research. The size of each bubble, excluding the central one representing the core research topic, indicates the number of studies conducted in each respective area. The most extensively researched topic is HCSQ in HC4.0, with the largest sub-theme being dimensions and models. HC4.0 is another major area of focus, with technology adoption being the most extensively examined sub-theme. In the area of healthcare service provision (HSP), the primary research focus is on the impact of technology on healthcare delivery.

Figure 16. Summary of research themes in HC4.0 and HCSQ.

Additionally, it seems that the theme of the "future of healthcare" has started to gain attention and presents significant room for exploration. This emerging area offers numerous opportunities for future research to understand and shape the evolution of healthcare practices, technologies, and policies in response to ongoing advancements and changing societal needs.

5. Conclusions and Future Research

The healthcare industry has experienced profound changes driven by technological advancements, influencing various facets of healthcare delivery and management. These advancements have enhanced healthcare quality, optimized service provision, and expanded access to medical care, among other improvements. This systematic review paper comprehensively explores 168 publications, identifies research gaps, visualizes research trends, and highlights future research directions in the field.

In the first stage, a detailed bibliometric analysis of HC4.0 and HCSQ was illustrated, highlighting the growing importance of research in these topics from 2005 to 2023. This continuous growth shows academic and practical interest in integrating modern technology into healthcare, which is becoming increasingly important for service quality and patient outcomes. VOSviewer was also utilized to map the research landscape and show significant theme evolution. Future study must examine how these technological advancements might be leveraged across healthcare systems to improve service delivery and fulfill global patient needs. These studies could identify the most significant technologies, evaluate their real-world applications, and examine their influence on patient care and service management in diverse healthcare environments.

Moreover, a thorough content analysis of the 168 publications was utilized to examine the existing studies on HC4.0 and HCSQ. This section presented several significant discoveries, exposing numerous recurring themes within the research. Exploring Healthcare 4.0 (HC4.0) presents opportunities to improve healthcare quality, specifically by leveraging advanced technology to enhance patient care. It is essential to adopt a collaborative framework that integrates technology, healthcare policies, and patient engagement as HC4.0 progresses. Further investigation is required to focus on comprehensive and ongoing studies that evaluate the long-term implications and challenges of HC4.0 across diverse healthcare settings. In light of the increasing reliance on digital technologies, it is imperative to enhance cybersecurity measures in order to protect patient information. Furthermore, additional research is needed to examine the potential integration of AI and IoT with HC4.0 in order to enhance healthcare efficiency and ensure these technologies are advantageous and accessible to healthcare organizations. Through addressing each of these concerns, HC4.0 holds the capacity to significantly reshape the healthcare sector, resulting in a more streamlined, comprehensive, and patient-centric field.

Moreover, when considering the provision of healthcare services, the content analysis has adequately illustrated the significant effect that HC4.0 technologies are having on the healthcare sector. In addition to enhancing treatment and diagnostic precision, the implementation of advanced technologies such as THz imaging, artificial intelligence, the IoT, and big data analytics has streamlined communication within healthcare systems and increased patient engagement. These technologies play a crucial role in assisting complex procedures like cancer detection and chronic disease management, thereby demonstrating their capacity to greatly enhance healthcare services. Future studies should therefore center on the complexities of implementation and the continuous sustainability of these technologies across diverse healthcare environments. The development of robust data privacy measures is of major significance as the digital transformation of healthcare develops. Further investigation is needed to evaluate the efficiency and accessibility of these technologies among diverse environments in order to ensure improvements in healthcare that are equitable. By attending to these areas, HC4.0 will be able to optimize its influence on improving service quality and patient care, thereby fundamentally transforming the delivery of healthcare services in the digital age.

In addition, this analysis thoroughly examined the various dimensions and models that define healthcare service quality within the realm of HC4.0, highlighting significant elements such as patient safety, medical professionalism, responsiveness, and empathy. These factors are essential as they directly influence patients' perceptions and satisfaction, which are critical metrics for assessing the quality of healthcare services. As the field continues to evolve, there is a pressing need to further refine these models to accurately reflect the complexities of modern healthcare systems and to incorporate emerging technologies that are becoming integral to healthcare delivery. Future research should not only focus on enhancing these models but also on empirically testing their impact in diverse healthcare settings to ensure they effectively improve patient outcomes and satisfaction. This will require a multidisciplinary approach that bridges technology, policy, and patient care to create a more dynamic, responsive, and patient-centered healthcare service quality framework. Through this continuous improvement, healthcare systems can achieve higher standards of care and meet the growing demands of patients in a digital age.

In conclusion, this review paper suggests many key research directions to improve healthcare service quality, particularly in context of technological developments:

1. Further research should investigate the effects of various emerging technologies, such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain, on the quality of healthcare services, particularly in relation to patient safety and data security. Understanding these impacts can guide the integration of technology into healthcare to enhance service quality.
2. Research should prioritize the incorporation of technology into everyday healthcare procedures and examine its influence on patient care. This involves analyzing how technologies can optimize the patient–provider connection and promote tailored treatment techniques, thereby improving patient outcomes.
3. Longitudinal studies are necessary to assess the enduring advantages and difficulties of HC4.0 deployments in different healthcare environments. These studies will provide a deeper understanding of the sustainability and effectiveness of such implementations over time.
4. Additional research should investigate the adaptability and implementation of HC4.0 technologies in various cultural and regional contexts. This aims to ensure that technological improvements have a positive impact on diverse communities worldwide, considering cultural and regional differences.
5. Future studies should evaluate the advancement and influence of patient-centered technologies, focusing on their ability to enhance the quality of healthcare services as perceived by patients and improve overall patient satisfaction. This patient-centric approach is crucial for the success of HC4.0 technologies.
6. Research should examine ways to align healthcare policies with technological advancements to successfully support and enhance HC4.0 operations. This alignment is essential for creating a conducive environment for technological integration in healthcare.
7. Data privacy and security are critical in the healthcare industry due to growing technological advancements. Establishing strong cybersecurity measures and conducting research to safeguard patient data while adhering to international standards and legislation is imperative.
8. It is essential to examine the economic consequences of implementing HC4.0 technologies, including conducting cost–benefit studies and assessing the potential of these technologies to reduce healthcare expenses while enhancing service quality. Understanding the economic impact will help in making informed decisions about technology investments.
9. Analyzing the challenges that prevent healthcare professionals from adopting HC4.0 technology and providing methods to improve their competence and readiness to embrace new technologies is crucial. This includes offering training programs and resources to support technology adoption.

10. Studying the impact of human factors on the effective integration of healthcare technologies, with a focus on the interaction between healthcare professionals, patients, and technological systems, is necessary. This research will help to optimize the human–technology interaction to improve the overall effectiveness of healthcare services.
11. Future research should explore Healthcare 5.0 (HC5.0) technologies and compare them with HC4.0 to identify key advancements and their implications for healthcare services. This includes investigating how HC5.0's emphasis on personalization and interconnected systems could further enhance service quality and patient care, providing a comprehensive view of the transition and its potential benefits.
12. Future research should focus on healthcare performance measurement to establish robust metrics and methodologies that effectively assess the influence of technological advancements on healthcare quality. This includes examining the impact of emerging technologies, such as AI and IoT, on operational efficiency, patient outcomes, and service delivery. Incorporating performance measurement frameworks could serve as a complementary approach to HC4.0 initiatives, providing a structured basis for evaluating and optimizing healthcare systems.

This systematic review has emphasized the extensive impact of HC4.0 and HCSQ in the process of transforming and enhancing healthcare delivery. The results indicate that HC4.0 offers significant opportunities for enhancing service quality, patient safety, and operational efficiencies. However, there are significant challenges that need to be addressed. These challenges include effectively incorporating new technologies into current healthcare infrastructures, ensuring that different systems will function jointly to improve communication and data transfer, and tackling the issue of limited access to advanced healthcare solutions for underprivileged populations due to the gap in technology.

A limitation of this study is its reliance on a descriptive synthesis approach, which focuses on identifying patterns and thematic insights but does not include quantitative pooling or meta-analysis of the results. This limits the ability to establish causal relationships or statistically validate the findings. Additionally, the absence of formal bias assessment tools and certainty evaluation frameworks restricts the study's ability to assess the reliability and confidence of the synthesized evidence comprehensively.

To effectively incorporate advanced technologies in healthcare, it is necessary to develop thorough policies that promote responsible utilization and maintain ethical conduct in medical practice. Further studies should further investigate the capabilities of HC4.0 technologies, establish relevant ethical principles, and promote critical thinking skills among healthcare practitioners. These endeavors will create the foundation for a technologically advanced, comprehensive, and efficient healthcare environment, improving both the quality of patient care and the delivery of services.

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