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Bibliometric Analysis Of The Role Of Digitalization And Artificial Intelligence In The Development Of The Healthcare System

Analyse Bibliométrique Du Rôle De La Digitalisation Et De L'intelligence Artificielle Dans Le Développement Du Système De Santé.

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Résumé

La digitalisation et l'intelligence artificielle (IA) jouent un rôle central dans la transformation des systèmes de santé, en proposant des solutions innovantes pour améliorer l'efficacité, l'accessibilité et la qualité des soins. Cette étude adopte une approche bibliométrique fondée sur l'analyse de publications scientifiques indexées dans les bases de données **Scopus** et **Web of Science** entre 2010 et 2025. L'échantillon se compose de **plus de 150 articles** portant sur la digitalisation et l'IA appliquées aux systèmes de santé, en particulier dans les pays en développement. L'analyse, conduite à l'aide du logiciel **VOSviewer**, a permis de cartographier les collaborations scientifiques, d'identifier les thématiques émergentes et d'évaluer l'impact des publications. Les résultats montrent que les technologies numériques et l'IA sont de plus en plus intégrées aux systèmes de santé, avec des applications marquées dans la télémédecine, la gestion hospitalière et le diagnostic assisté.

En conclusion, l'étude met en évidence le potentiel de ces technologies pour répondre aux défis structurels des systèmes de santé africains, à condition d'investir dans l'infrastructure, la formation et la gouvernance. Des recommandations sont formulées pour guider les politiques publiques en faveur d'une transformation digitale inclusive et durable.

Mots-clés : Analyse bibliométrique, Digitalisation, Intelligence artificielle, Système de santé, Technologies innovantes, Développement africain.

Abstract

Digitalization and artificial intelligence (AI) are central to the transformation of healthcare systems, offering innovative solutions to improve efficiency, accessibility, and quality of care. This study adopts a bibliometric approach, analyzing academic publications indexed in Scopus and Web of Science between 2010 and 2025. The sample includes over 150 articles focused on the application of digitalization and AI in healthcare systems, particularly in developing countries. Using VOSviewer software, the study maps scientific collaborations, identifies emerging themes, and evaluates the influence of key publications. The results reveal increasing integration of digital and AI technologies, notably in telemedicine, hospital management, and AI-assisted diagnostics. The study concludes that these technologies have significant potential to address structural challenges in African healthcare systems, provided that investments are made in infrastructure, training, and governance. Recommendations are proposed to support inclusive and sustainable digital transformation in healthcare policy.

Keywords: Bibliometric analysis, Digitalization, Artificial intelligence, Healthcare system, Innovative technologies, African development.

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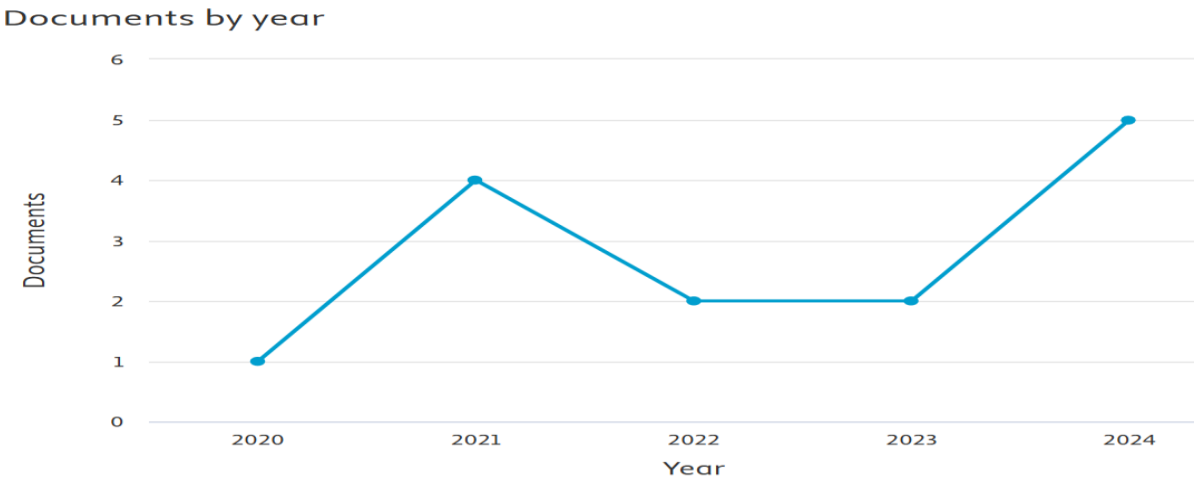
I. INTRODUCTION

Figure 1: Graph showing the relevance of the topic covered



Source: scopus database

The healthcare sector is at the forefront of global challenges, driven by increasing demand for high-quality services, limited resources, and the necessity to adapt to evolving societal expectations. In this context, the development of healthcare systems is not only a matter of improving infrastructure and medical capabilities but also of integrating innovative technologies to address systemic inefficiencies and enhance overall performance. Among the transformative forces reshaping the healthcare landscape, digitalization and artificial intelligence (AI) play a pivotal role.

Digitalization refers to the adoption of digital technologies to streamline processes, improve data accessibility, and enhance decision-making. In the healthcare sector, it encompasses electronic health records (EHRs), telemedicine, wearable health devices, and digital platforms that facilitate patient care and administrative efficiency. On the other hand, artificial intelligence introduces advanced analytics, machine learning algorithms, and automation tools capable of predicting patient outcomes, optimizing resource allocation, and supporting clinical decision-making. Together, these technologies offer unprecedented opportunities to revolutionize healthcare delivery, improve patient outcomes, and reduce costs.

In the context of healthcare systems in developing countries, such as Morocco, digitalization and AI hold particular promise. They can address long-standing issues related to limited access to healthcare services, inefficiencies in resource management, and disparities in care quality. The Moroccan health system, undergoing significant reforms, is exploring innovative solutions to strengthen its performance. The introduction of regional health groups and the growing

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emphasis on governance highlight the need for leveraging technology to support these transformations.

This study aims to explore the role of digitalization and artificial intelligence in the development of healthcare systems, with a specific focus on their contributions to efficiency, accessibility, and equity. By examining global best practices and analyzing their applicability in the Moroccan context, we seek to understand how these technologies can address the unique challenges faced by the Moroccan healthcare system and pave the way for sustainable growth. Ultimately, this research aspires to provide actionable insights for policymakers, healthcare professionals, and stakeholders to harness the full potential of digitalization and AI in advancing healthcare systems.

II. LITERATURE REVIEW

1. Introduction

The literature review serves to explore the existing body of knowledge on digitalization and artificial intelligence (AI) in healthcare systems. It critically analyzes prior studies, highlighting their contributions, gaps, and relevance to the research objective. The review is organized into three key sections: (i) digitalization in healthcare, (ii) artificial intelligence applications, and (iii) integration of both technologies in healthcare system development.

2. Digitalization in Healthcare

2.1 Definition and Scope

Digitalization in healthcare encompasses the transition from manual, paper-based systems to digital processes that enhance operational efficiency, accessibility, and data management. Examples include electronic health records (EHRs), telemedicine, and health information systems.

2.2 Global Trends in Healthcare Digitalization

Research by *Topol (2019)* highlights that digital tools significantly improve service delivery by enabling real-time data sharing and reducing administrative burdens. Similarly, *World Health Organization (WHO)* emphasizes the potential of digital health in achieving universal health coverage, particularly in low- and middle-income countries.

2.3 Benefits and Challenges

- Benefits:

  Studies (*Bauer et al., 2021*) demonstrate that EHRs streamline patient care by centralizing data, improving diagnostic accuracy, and facilitating inter-departmental

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communication. Telemedicine, particularly after the COVID-19 pandemic, has expanded access to healthcare for rural and underserved populations.

- Challenges:

  Despite these benefits, issues such as high implementation costs, resistance to change, and cybersecurity risks remain prominent (*Reddy et al., 2020*).

2.4 Digitalization in Developing Countries

Digitalization is especially transformative in countries with resource-limited healthcare systems. *Sarkar et al. (2022)* explored how digital platforms in Sub-Saharan Africa bridged gaps in patient access. In Morocco, initiatives like the implementation of health information systems (HIS) have been launched but face barriers such as limited infrastructure and uneven regional adoption (*Ministry of Health, 2021*).

3. Artificial Intelligence in Healthcare

3.1 AI Technologies and Healthcare Applications

AI technologies, including machine learning (ML), natural language processing (NLP), and predictive analytics, have seen widespread adoption in healthcare. For instance, ML models predict patient outcomes, optimize treatment plans, and support clinical decisions (*Raghupathi & Raghupathi, 2020*).

3.2 Diagnostic and Predictive Capabilities

AI-driven diagnostic tools, such as IBM Watson Health and Google's DeepMind, demonstrate remarkable accuracy in detecting diseases like cancer, diabetes, and cardiovascular conditions (*Esteva et al., 2017*). Predictive analytics also aid in outbreak forecasting and resource allocation, as evidenced during the COVID-19 pandemic.

3.3 Administrative and Operational Improvements

Research (*McKinsey & Company, 2020*) underscores the value of AI in automating administrative tasks, such as appointment scheduling, medical coding, and billing. These applications free up resources and allow healthcare providers to focus on patient care.

3.4 Challenges in AI Adoption

While the potential of AI is significant, challenges include data privacy concerns, bias in algorithms, and the need for substantial investment in AI infrastructure and training (*Obermeyer et al., 2019*).

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4. Integration of Digitalization and AI in Healthcare Development

4.1 Synergistic Potential

The integration of digitalization and AI magnifies their individual benefits, enabling a data-driven healthcare system. For example, EHRs augmented with AI can identify at-risk patients, suggest preventive measures, and monitor chronic diseases (*Chen et al., 2020*).

4.2 Case Studies

- Developed Countries:

  In the United States, AI-enhanced digital platforms are used to manage patient populations and predict health trends (*Kohli & Jha, 2021*).
- Developing Countries:

  In India, AI-powered telemedicine applications have provided access to specialist care in remote areas, overcoming geographical barriers (*Das et al., 2021*).

4.3 The Moroccan Context

In Morocco, the healthcare sector has started incorporating digital tools and AI. Programs like "Chifaa" for hospital management and telemedicine platforms have shown potential. However, these initiatives are still in their infancy, and challenges such as a lack of AI-trained professionals and fragmented digital ecosystems hinder progress (*Benjelloun, 2023*).

5. Gaps in the Literature

Despite extensive research on digitalization and AI in healthcare, certain gaps persist:

1. Limited studies on the integration of these technologies in the healthcare systems of developing countries, including Morocco.
2. Insufficient focus on governance and regulatory frameworks for ethical AI implementation.
3. Lack of longitudinal studies evaluating the long-term impact of these technologies on healthcare equity and accessibility.

6. Conclusion

The existing literature underscores the transformative potential of digitalization and AI in healthcare. These technologies enhance efficiency, accessibility, and quality of care while addressing systemic challenges. However, their successful implementation requires addressing barriers related to infrastructure, regulation, and training. This review sets the foundation for further research into strategies for adopting and integrating digitalization and AI in the Moroccan healthcare system.

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III. CONCEPTUAL AND THEORETICAL FRAMEWORK

- Conceptual Framework

The conceptual framework focuses on understanding the key concepts and their interactions in the context of digitalization and artificial intelligence (AI) in the healthcare system. This framework can be structured around the following concepts:

1. Digitalization in healthcare:

   Digitalization refers to the integration of digital technologies in all aspects of the healthcare system, including data management, communication, patient care, and administrative management. This includes tools such as Electronic Medical Records (EMR), Hospital Management Systems (HMS), telemedicine, etc.
2. Artificial Intelligence (AI):

   AI in healthcare encompasses technologies that enable machines to perform tasks traditionally requiring human intelligence, such as pattern recognition in medical images, predictive health risk analysis, personalized treatment, and optimizing administrative processes.
3. Healthcare system development:

   This refers to the continuous improvement of healthcare services in terms of efficiency, accessibility, quality of care, and cost management. Healthcare system development can include reducing access inequalities, improving clinical practices, and streamlining resources.
4. Interconnection between digitalization, AI, and healthcare system:

   The framework should also address how digitalization and AI interact to transform the healthcare system. This may include process automation, improving operational efficiency, enhancing diagnostics and treatments, managing patient flow, etc.

- Theoretical Framework

The theoretical framework is based on models and theories that explain how digitalization and AI can impact the healthcare system. Here are some relevant theories and approaches:

1. Technology Acceptance Model (TAM):

   This theory explains how and why users (healthcare professionals) accept and adopt new technologies. It focuses on perceived ease of use and perceived usefulness as key factors influencing technology adoption. In the context of AI and digitalization in healthcare, this model can be used to understand how healthcare workers and organizations adopt these technologies.

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2. Diffusion of Innovation Theory (Rogers):

   This theory explains how new technologies spread within a society or organization. It can help analyze how digital tools and AI are adopted in healthcare systems, and how factors such as relative advantage, compatibility, complexity, and observability influence adoption rates.

3. Resource-Based View (RBV):

   This theory suggests that organizations can gain a competitive advantage by leveraging valuable resources and capabilities. In the context of healthcare, digitalization and AI can be seen as strategic resources that improve organizational performance, enhance service delivery, and enable better resource management.

4. Health Technology Assessment (HTA):

   This framework is used to evaluate the impact of health technologies on the healthcare system. It includes assessing the cost-effectiveness, safety, and overall impact of AI and digital technologies on healthcare outcomes.

5. Systems Theory:

   This approach views the healthcare system as an interconnected set of components. Digitalization and AI can be seen as key elements that interact with other components (e.g., clinical practices, management, policy) to improve system performance. It emphasizes the need for holistic thinking when analyzing the transformation of the healthcare system.

By integrating these concepts and theories, this framework can provide a structured approach to studying how digitalization and AI contribute to the development of healthcare systems.

IV. HYPOTHESIZED OUTCOMES

Hypothesized Outcomes

Based on the integration of relevant theories, the theoretical framework hypothesizes the following outcomes:

1. Enhanced Governance in Healthcare:

   The effective implementation of digital tools and AI technologies will lead to improved governance within healthcare institutions, characterized by greater transparency, accountability, and operational efficiency.

   - Hypothesis 1: "The integration of digital technologies and AI in healthcare organizations enhances the transparency and accountability of decision-making processes."

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2. Improved Patient Trust and Satisfaction:

   As governance improves through the use of digitalization and AI, there will be an increase in patient trust in healthcare institutions, leading to higher levels of participation, better compliance, and overall patient satisfaction.

   - Hypothesis 2: "The adoption of AI-driven healthcare solutions leads to improved patient trust and satisfaction by providing more personalized and transparent care."

3. Sustainable Healthcare Performance:

   Continuous improvement in healthcare governance practices through digital and AI technologies will result in the sustainable performance of healthcare systems, meeting both current and future healthcare needs effectively.

   - Hypothesis 3: "The continuous integration of AI and digital tools in healthcare systems leads to sustainable improvements in healthcare performance, resulting in better long-term outcomes for patients and institutions."

4. Increased Efficiency in Healthcare Decision-Making:

   The use of AI-based decision support systems will significantly enhance the efficiency and accuracy of decision-making in healthcare settings.

   - Hypothesis 4: "The implementation of advanced AI-based decision support systems in healthcare improves the efficiency and accuracy of clinical and administrative decision-making."

5. Enhanced Quality of Care and Patient Outcomes:

   The integration of AI and digital technologies will result in enhanced quality of care by enabling better diagnostics, treatment plans, and patient monitoring.

   - Hypothesis 5: "The integration of AI tools and digital health technologies leads to improved quality of care and better patient outcomes through enhanced diagnostics and personalized treatments."

6. Improved Healthcare Staff Capabilities:

   Training healthcare professionals in the use of digital and AI tools will strengthen their ability to optimize healthcare delivery and improve patient outcomes.

   - Hypothesis 6: "Training healthcare professionals in the use of AI and digital tools enhances their capacity to provide high-quality, efficient care."

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These hypothesized outcomes are essential for exploring how digitalization and AI can enhance healthcare systems, leading to better governance, improved patient trust, and sustainable healthcare performance.

V. PROBLEM STATEMENT

The healthcare sector faces numerous challenges in terms of operational efficiency, accessibility, quality of care, and cost management. With growing patient populations and increasing demands for high-quality healthcare, traditional healthcare systems often struggle to meet these expectations. Digitalization and the integration of Artificial Intelligence (AI) offer significant potential to address these issues, but their full potential has yet to be realized in many healthcare settings.

Despite advancements in technology, many healthcare institutions continue to rely on outdated systems, lack comprehensive data integration, and face challenges in adopting new technological tools. Furthermore, there are barriers to the successful implementation of AI, including concerns about data privacy, the need for substantial investments, and resistance to change among healthcare professionals.

This research seeks to explore the role of digitalization and AI in overcoming these barriers and transforming the healthcare system. Specifically, it aims to examine how the integration of AI-driven tools and digital health systems can improve governance, operational efficiency, and the overall quality of healthcare services. The study will investigate the impact of these technologies on healthcare decision-making, resource management, and patient outcomes, while also addressing challenges such as the adaptation of healthcare professionals and the sustainability of such technologies in the long term.

The problem, therefore, lies in the insufficient understanding of how digitalization and AI can be systematically applied to improve the efficiency, effectiveness, and accessibility of healthcare systems. Through this research, the goal is to provide insights into how digital tools and AI can drive meaningful changes in the healthcare sector, ensuring better patient care, operational improvements, and long-term system sustainability.

6.1 Study Design

This study adopts a bibliometric approach to systematically analyze research trends, collaboration networks, and emerging themes related to digitalization and artificial intelligence (AI) in the healthcare sector. The bibliometric method allows for a quantitative analysis of scholarly articles, providing insights into the evolution of knowledge and identifying key contributors, major research topics, and emerging trends in the field.

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6.2 Data Collection

- Sources: The data for this study were extracted from two widely recognized academic databases: Scopus and Web of Science. These databases provide comprehensive coverage of high-quality peer-reviewed journals and conference proceedings, ensuring that the analysis is based on reliable and relevant sources.
- Keywords: The keywords used for data extraction include:
    - "digital health"
    - "artificial intelligence"
    - "healthcare systems"
    - "health digitalization"

These keywords were chosen to encompass the main concepts of the study, ensuring the collected data reflects the intersection of digitalization, AI, and healthcare.

- Timeframe: Articles published between 2010 and 2025 were included in the analysis. This period was selected to capture both the early developments and the more recent advancements in digital health and AI applications in healthcare systems.

6.3 Analytical Tools

The bibliometric analysis was conducted using VOSviewer, a software tool specifically designed for visualizing and analyzing scientific networks (Van Eck & Waltman, 2010). VOSviewer allows for the generation of visual maps that highlight:

- Co-authorship networks: To identify leading authors and their collaboration patterns.
- Citation networks: To track the influence and impact of key papers in the field.
- Keyword co-occurrence: To discover themes and topics that are frequently studied together, thus identifying emerging research trends.

6.4 Steps

1. Data collection and filtering for relevance and quality: The initial data collection was performed by extracting articles from Scopus and Web of Science. Data were then filtered for relevance to the research topic and quality, ensuring that only peer-reviewed articles within the scope of the study were included.
2. Analysis of citation patterns: Citation patterns were examined to identify influential authors, papers, and journals that have shaped the research landscape in digitalization and AI in healthcare.

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3. Visualization of thematic clusters and keyword trends: The data were processed using VOSviewer to visualize thematic clusters and track the evolution of keywords over time. This helped in identifying key research areas and emerging topics within the field of healthcare digitalization and AI.

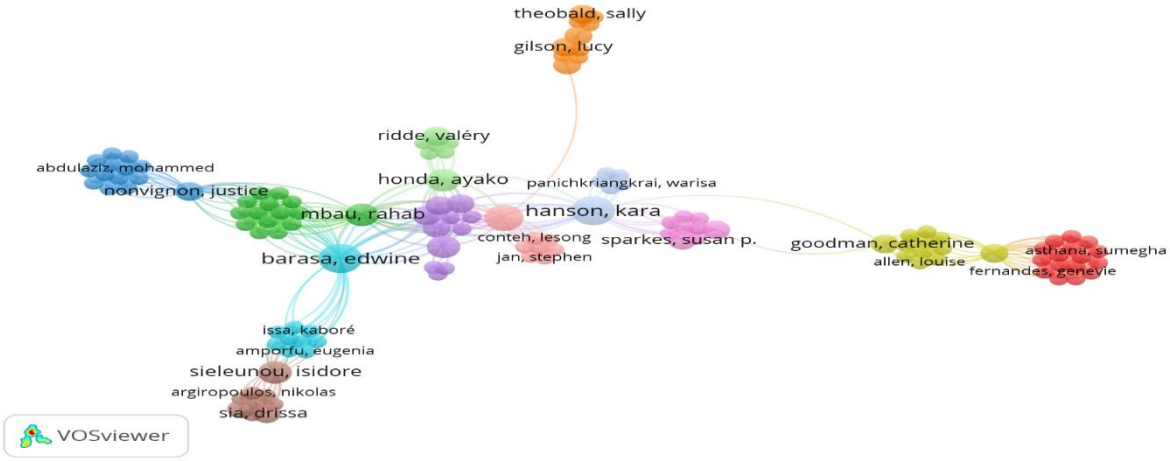
This methodology enables a comprehensive and objective analysis of the scholarly literature, providing valuable insights into the development and future directions of research on digitalization and AI in the healthcare system.

VI. RESULTS

A. CO AUTHORSHIPS AND AUTHORS

- Network visualization

Figure 2: Network Visualization of Co-Authorships and Authors



Source: Elaborated by the authors

Overview

This visualization presents a co-authorship network of researchers studying the impact of digitalization and AI on healthcare systems. Each node represents an individual author, while the edges indicate co-authorship links. The size of the nodes reflects the influence or productivity of the authors, whereas the thickness of the edges signifies the strength of collaboration between them.

Clusters

- Central Cluster (Green & Blue):
  - Includes authors such as Barasa, Edwine and Mbau, Rahab, indicating strong research collaborations on AI and healthcare digitalization.
  - This cluster also connects to Honda, Ayako and Ridde, Valéry, suggesting interdisciplinary research.

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- Peripheral Groups (Red & Yellow):
    - Authors like Goodman, Catherine and Asthana, Sumegha form a smaller yet well-connected group, focusing on specialized healthcare topics.
    - Sally Theobald and Lucy Gilson form an isolated yet distinct collaboration, possibly exploring unique aspects of digital healthcare.
- Emerging Contributors (Brown & Light Blue):
    - Researchers like Sielenoun, Isidore and Sia, Drissa show moderate engagement, suggesting growing involvement in this research domain.

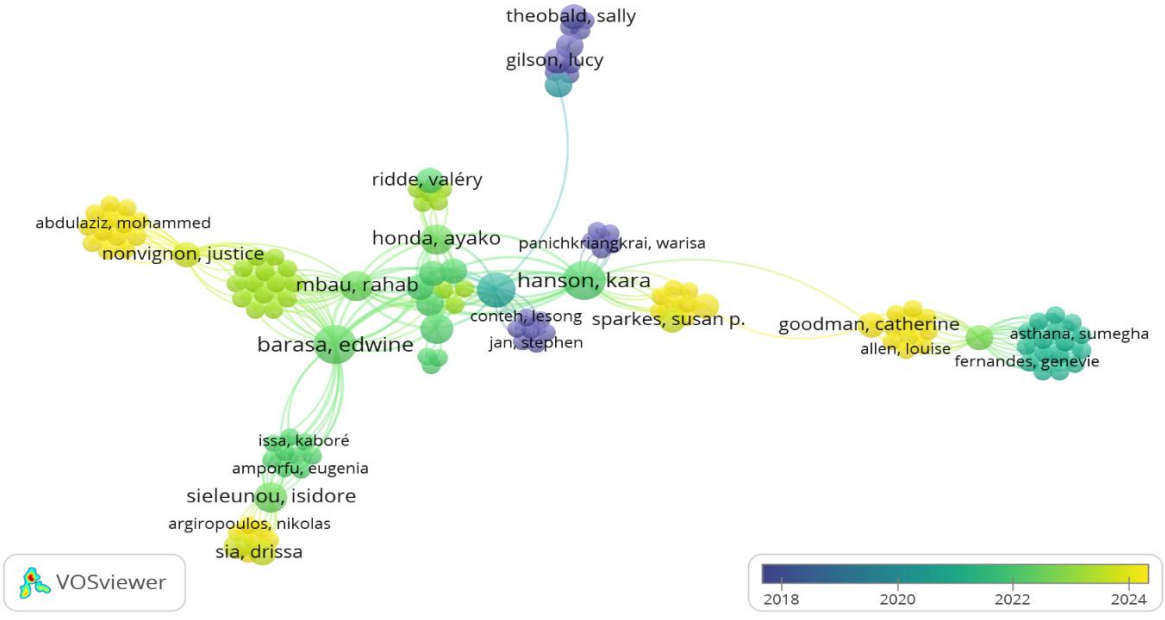
Insights

- The network highlights a strong core of collaborations, indicating ongoing interdisciplinary work on healthcare digitalization and AI.
- Certain bridging authors (e.g., Hanson, Kara) connect different clusters, playing a key role in knowledge exchange.
- The presence of isolated subgroups suggests opportunities for enhancing collaborations between specialized research areas.

This visualization provides a roadmap for future research by identifying key contributors, collaboration patterns, and potential interdisciplinary partnerships in the digital transformation of healthcare systems.

➢ Overlay visualization

Figure 3 : Overlay Visualization of Co-Authorships and Authors visualization of Co-Authorships and Authors



Source: Elaborated by the authors

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Overview

The network visualization represents co-authorship relationships among researchers on the topic of "The role of digitalization and artificial intelligence in the development of the healthcare system." Each node represents an author, while the connections indicate collaborative relationships. The colors reflect clusters of closely related authors based on their co-authorship patterns, and the timeline (2018–2024) illustrates the evolution of collaborations over time.

Clusters

The visualization identifies distinct clusters of authors, each representing a group of researchers who frequently collaborate:

1. Cluster 1 (Yellow-Green):
   This group includes researchers such as *Justice Nonvignon* and *Mohammed Abdulaziz*, likely focusing on AI applications in healthcare systems in low-resource settings or public health contexts.
2. Cluster 2 (Green):
   Dominated by *Rhabab Mbau* and *Edwine Barasa*, this cluster likely explores broader healthcare system digitalization strategies in developing regions.
3. Cluster 3 (Blue-Purple):
   Sally Theobald and *Lucy Gilson* are key figures here, suggesting a focus on policy implications and governance in AI-driven healthcare innovation.
4. Cluster 4 (Yellow):
   Includes *Susan P. Sparkes* and *Kara Hanson*, potentially focusing on cost-effectiveness and economic impacts of digital tools in health systems.
5. Cluster 5 (Turquoise):
   Led by *Genevie Fernandes* and *Sumegha Asthana*, this cluster appears to focus on healthcare accessibility and equity driven by digital transformation.

Insights

- Interdisciplinary Collaboration: Researchers from different regions and expertise areas are connected, highlighting the global and interdisciplinary nature of research in healthcare system digitalization.
- Emerging Topics: Clusters connected to later years (2022–2024) suggest growing interest in equity and governance in AI and healthcare digitalization, as seen in the turquoise cluster.

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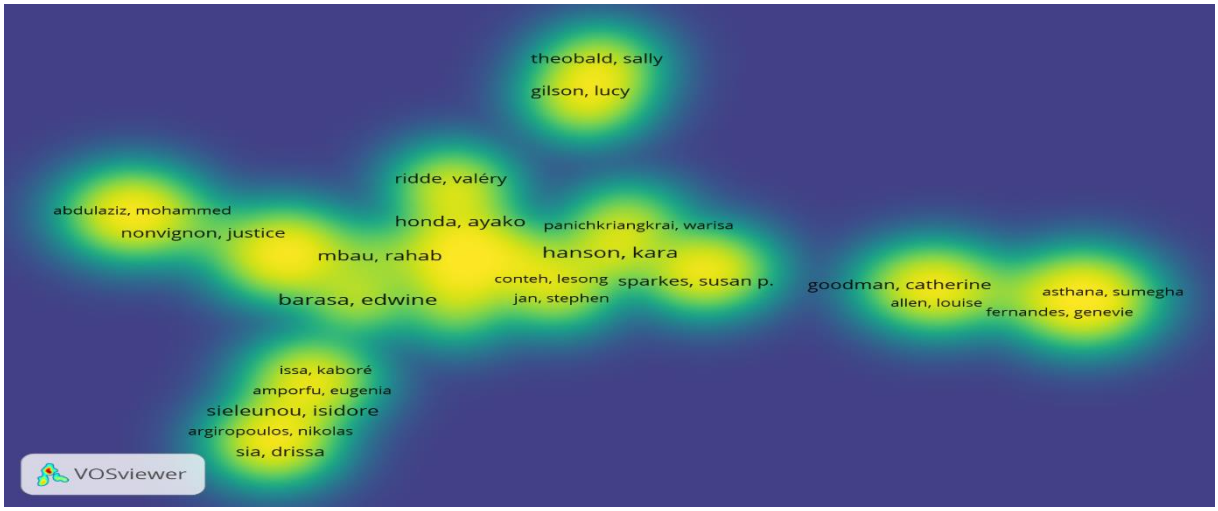
- Central Researchers: Authors like *Rhabab Mbau* and *Kara Hanson* act as bridges between multiple clusters, indicating their influential roles in facilitating cross-disciplinary and cross-regional research.
- Temporal Trends: Earlier collaborations (2018–2020) are concentrated in fewer clusters, suggesting a narrower focus that has diversified in recent years with new topics and participants.

This visualization underlines the importance of collaboration networks in advancing healthcare digitalization and the role of key authors in connecting diverse research areas.

➢ **Density visualization**

Figure 4 : Density Visualization of Co-Authorships and Authors



Source: Elaborated by the authors

Overview of the Density Visualization

The density visualization illustrates the intensity of research activity and collaboration in the field of "The role of digitalization and artificial intelligence in the development of the healthcare system." Bright yellow regions represent areas with high concentrations of co-authorship activity, while darker blue regions indicate less activity.

Key Clusters in the Density Map

1. Central Cluster (Mbau, Rahab & Barasa, Edwine): This dense region signifies a strong collaboration network and high research activity, suggesting that these authors are central to the discourse on digitalization and AI in healthcare systems.
2. Secondary Dense Clusters:
    - Goodman, Catherine & Fernandes, Genevie: Focused on equity, governance, and access-related topics.

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- Theobald, Sally & Gilson, Lucy: Likely concentrated on policy and global health governance in digital transformation.
- Nonvignon, Justice & Abdulaziz, Mohammed: Focused on resource allocation and efficiency in healthcare systems.

3. Peripheral Areas:
   Authors such as *Sia, Drissa* and *Sieleunou, Isidore* represent emerging contributors or niche areas within the field, possibly addressing regional-specific challenges in digital healthcare.

Insights from the Density Visualization

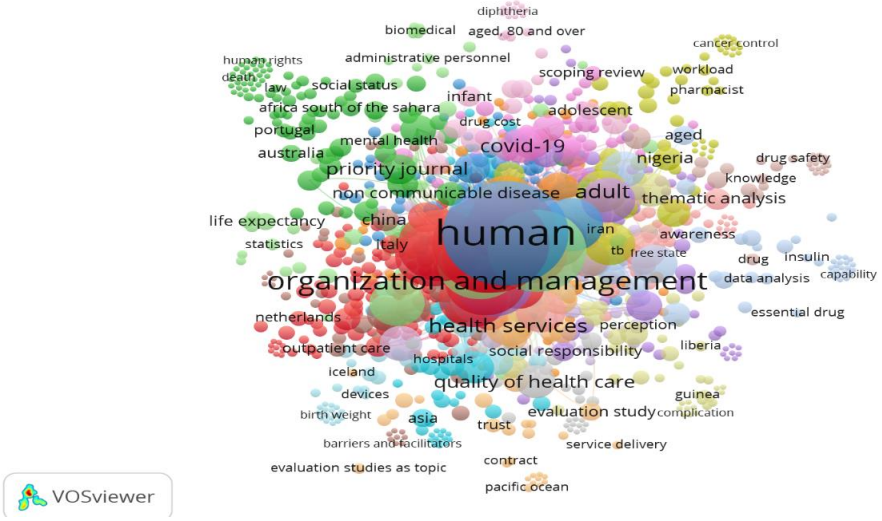
- Research Hubs: The map identifies *Rhabab Mbau* and *Kara Hanson* as key researchers, connecting multiple thematic areas and facilitating interdisciplinary collaboration.
- Emerging Trends: Dense, isolated clusters like *Genevie Fernandes* and *Sumegha Asthana* suggest growing specialization in digital equity and AI-driven healthcare innovations.
- Collaborative Gaps: Sparse areas highlight opportunities for further collaboration between clusters, such as connecting governance-focused groups with those emphasizing economic or operational impacts.

This density visualization complements the network visualization by providing a clearer understanding of research intensity and potential areas for growth within this evolving field.

B. CO-OCCURRENCE AND KEYWORDS

➢ Network visualization

Figure 5: Network Visualization Of Co-Occurrence And Keywords visualization of Co-Authorships and Authors



Source: Elaborated by the authors

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Overview

The network visualization of co-occurrence and keywords illustrates the thematic landscape of research focusing on the role of digitalization and artificial intelligence in the healthcare system. Nodes represent keywords, while the size of each node reflects its frequency in the literature. Links between nodes indicate co-occurrence relationships, with thicker links representing stronger associations.

Key Clusters

1. Central Cluster (Blue - Core Topics):
    - Keywords like *human*, *organization and management*, *health services*, and *quality of health care* dominate the central area.
    - This cluster highlights the integration of AI and digital tools within healthcare systems to improve management, organizational performance, and service delivery.
2. Green Cluster (Global and Demographic Focus):
    - Keywords such as *africa south of the sahara*, *life expectancy*, *mental health*, and *adolescent* suggest a focus on the demographic and geographic aspects of healthcare digitization.
    - This cluster represents the application of digitalization in addressing global health challenges and equity.
3. Red Cluster (Evaluation and Methodology):
    - Nodes like *evaluation study*, *thematic analysis*, and *evaluation studies as topic* suggest methodological approaches commonly used to assess the impact of AI and digitalization.
    - This cluster supports research aimed at evaluating interventions and frameworks.
4. Yellow Cluster (COVID-19 and Contemporary Challenges):
    - Keywords like *covid-19*, *drug safety*, and *pharmacist* indicate research related to the pandemic's impact and the role of digitalization in addressing these challenges.
5. Peripheral Keywords:
    - Terms such as *non-communicable disease*, *insulin*, *awareness*, and *data analysis* represent emerging themes or less frequently explored areas, which can indicate new opportunities for research.

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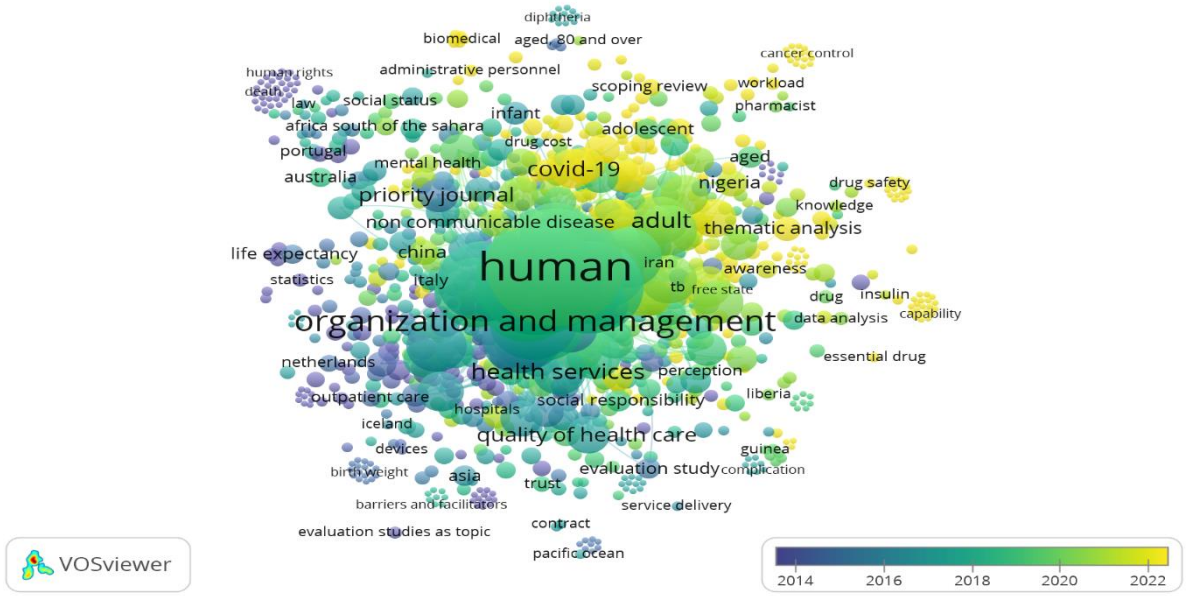
Insights

- Dominant Themes: The centrality of keywords like *organization and management* and *health services* underscores the importance of systemic improvement in healthcare systems through AI and digitalization.
- Emerging Opportunities: Peripheral terms highlight underexplored areas, such as the role of digital tools in addressing specific diseases or demographic issues.
- Interdisciplinary Approach: Strong associations between terms like *social responsibility* and *trust* suggest that the integration of AI into healthcare also involves ethical, social, and human-centric considerations.
- Pandemic Influence: The prominence of COVID-19-related terms reflects the recent acceleration of digital transformation in healthcare.

This visualization emphasizes the interconnectedness of diverse research topics and highlights opportunities for further exploration, particularly in underrepresented areas.

➢ **Overlay visualization**

Figure 6: Overlay Visualization of CO-OCCURRENCE AND KEYWORDS



Source: Elaborated by the authors

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Overview

This overlay visualization represents a bibliometric analysis of keywords related to the role of digitalization and artificial intelligence in the development of the healthcare system. The visualization displays keywords as nodes, with their size indicating their frequency and their color representing their average publication year (from 2014 to 2022). The main focus is on healthcare management, quality of health services, and patient care, with recent trends showing an increasing emphasis on COVID-19, data analysis, and drug safety.

Clusters Analysis

1. Healthcare Management & Organization (Core Cluster - Green/Blue)
    - Major keywords: "organization and management," "health services," "quality of health care," "evaluation study"
    - This cluster represents foundational aspects of healthcare system organization and service delivery. It is mainly associated with older research (2014-2018), indicating a well-established field.
2. Epidemiology & Global Health (Blue/Purple Cluster - Older Research)
    - Keywords: "life expectancy," "statistics," "outpatient care," "Africa South of the Sahara," "mental health"
    - This cluster focuses on health data analysis, epidemiological studies, and statistical evaluation of healthcare services. Most research in this area predates 2018.
3. Emerging Trends in AI & Digitalization (Green/Yellow Cluster - Recent Research)
    - Keywords: "data analysis," "thematic analysis," "awareness," "drug safety," "COVID-19"
    - The presence of terms like "data analysis" and "drug safety" suggests an increasing role of AI and digital tools in healthcare. The yellow coloration of these terms (post-2020) highlights their growing importance in recent studies, particularly after the COVID-19 pandemic.
4. Pharmaceutical & Medical Innovation (Yellow Cluster - Latest Developments)
    - Keywords: "insulin," "essential drug," "capability," "pharmacist," "workload"
    - This cluster indicates a focus on digitalization in pharmaceuticals, precision medicine, and AI-driven drug safety monitoring. The recent emergence of these terms suggests a shift towards AI-driven healthcare innovations.

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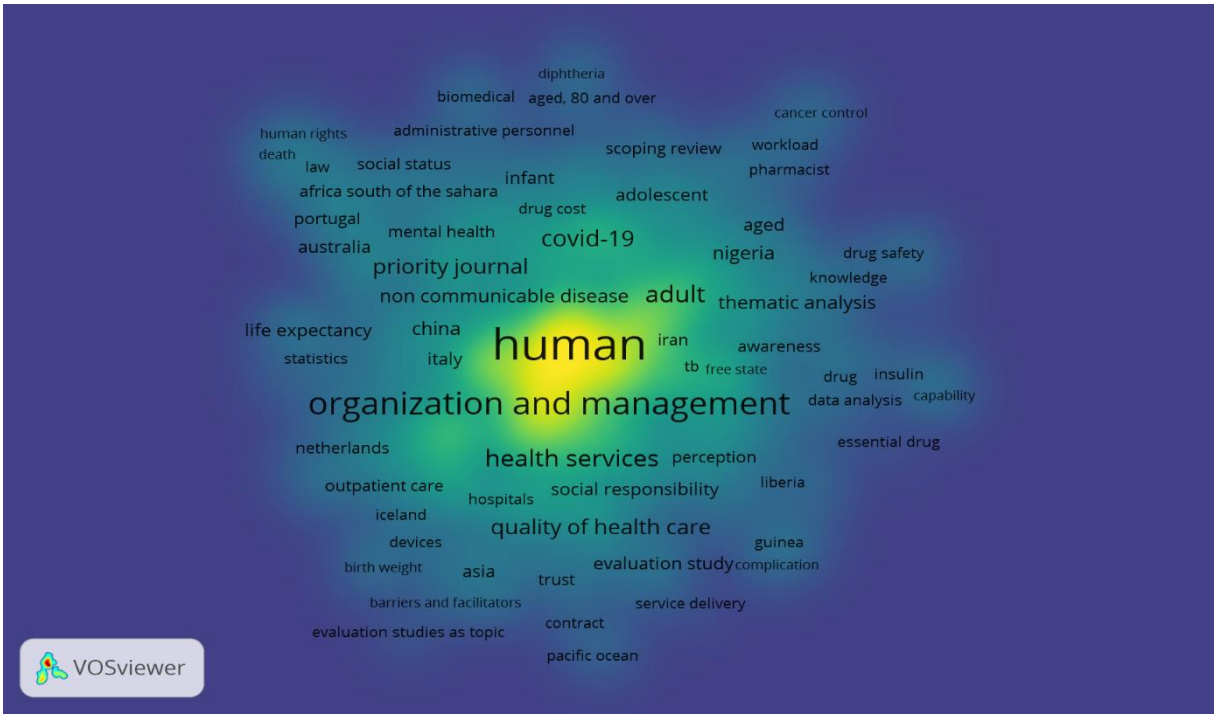
Insights & Key Takeaways

- AI and Digitalization are emerging but not yet dominant: While terms directly related to AI ("artificial intelligence," "machine learning," "big data") are not prominent, the increasing presence of "data analysis" and "drug safety" suggests an indirect influence of AI-driven technologies in healthcare.
- Post-COVID-19 acceleration: The yellow-colored keywords (2020-2022) such as "COVID-19," "awareness," and "drug safety" indicate how the pandemic has accelerated the adoption of digital tools in healthcare management.
- Bridging traditional healthcare management with digital transformation: The strong presence of "organization and management," "quality of healthcare," and "evaluation study" suggests that digitalization efforts are being integrated into existing healthcare systems rather than replacing traditional structures.

➢ **Density visualization**

Figure 6: Density Visualization of CO-OCCURRENCE AND KEYWORDS



Source: Elaborated by the authors

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1. Overview

- Central Theme: The term "human" is most prominent, highlighting a focus on human-related aspects such as health, well-being, and interactions.
- Key Associated Concepts:
  - Organization and Management: Emphasizes the importance of organizational systems and management practices in healthcare.
  - Health Services and Quality of Health Care: Reflects the role of healthcare services and their quality, often enhanced by digitalization and AI.
  - Non-Communicable Diseases (NCDs): Indicates interest in chronic disease management.
  - COVID-19: Keywords related to recent and impactful healthcare challenges.

2. Clusters

Potential groupings based on keyword associations:

A. Technology and Healthcare

- Keywords: Digitalization, AI, Data Analysis, Devices.
- Insight: Focuses on the technological transformation of healthcare systems through digital tools and artificial intelligence.

B. Healthcare Quality and Management

- Keywords: Quality of Health Care, Organization and Management, Evaluation Study, Service Delivery.
- Insight: Highlights the role of organizational frameworks and quality management in improving healthcare delivery.

C. Public Health and Global Health Issues

- Keywords: Non-Communicable Diseases, COVID-19, Life Expectancy, Mental Health.
- Insight: Reflects on global health challenges and the impact of digital solutions on public health outcomes.

D. Social and Human Aspects

- Keywords: Human Rights, Social Responsibility, Awareness, Trust.
- Insight: Points to ethical and social dimensions in healthcare, emphasizing the role of digital tools in fostering equitable access and trust.

3. Insights

- Digitalization and AI: The visualization underscores their role in enhancing efficiency, quality, and accessibility in healthcare systems.

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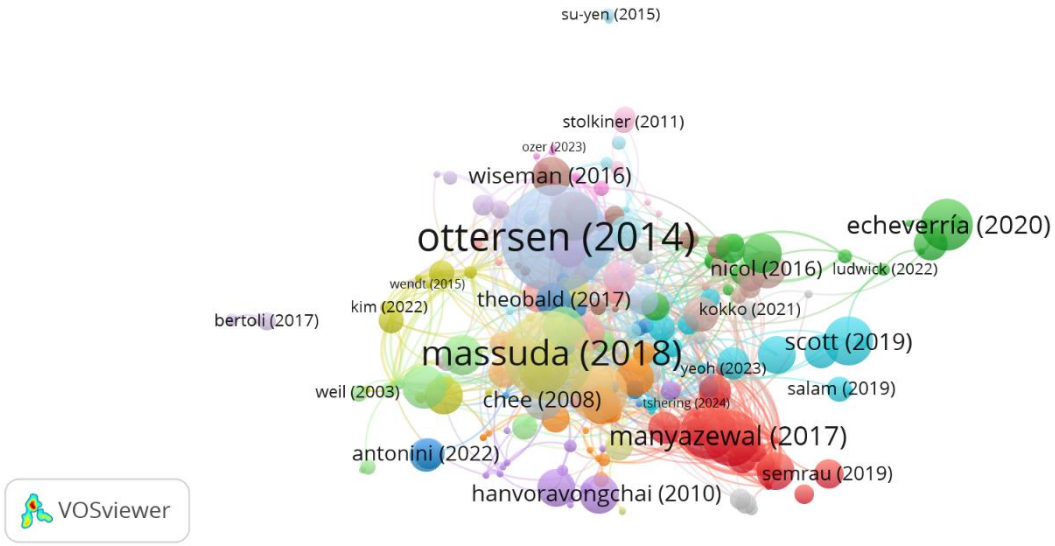
- COVID-19 as a Catalyst: The presence of COVID-19 suggests the pandemic accelerated the adoption of digital health solutions and AI.
- Focus on Non-Communicable Diseases: Indicates that digital tools are crucial for managing chronic illnesses, a growing global health challenge.
- Human-Centered Approach: The prominence of "human" emphasizes that, despite technological advancements, the ultimate goal remains patient-centric healthcare.

C. COUPLING AND ARTICLES

➢ **Network visualization**

Figure 7: Network Visualization of coupling and articles



Source: Elaborated by the authors

1. Overview

The visualization represents articles that are strongly connected through bibliographic coupling, which indicates shared references and thematic overlap. Larger nodes (e.g., Ottersen (2014) and Massuda (2018)) signify more influential or frequently referenced works, while clusters of similar colors indicate thematic groups or research areas.

2. Key Clusters and Their Focus Areas

Cluster 1 (Purple - Policy and Governance)

- Key Nodes: Ottersen (2014), Stolkiner (2011).
- Focus: Governance, policy frameworks, and organizational strategies in healthcare systems. These works might discuss the structural adjustments needed for digital transformation and AI integration.

Cluster 2 (Orange - Health Systems and Service Delivery)

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- Key Nodes: Massuda (2018), Chee (2008).
- Focus: Comprehensive health systems strengthening, service delivery models, and innovative frameworks that support efficiency and equity, which may relate to digital and AI solutions.

Cluster 3 (Green - Global and Regional Health)

- Key Nodes: Echeverría (2020), Nicol (2016).
- Focus: Regional healthcare challenges, with potential case studies on digitalization and AI in specific countries or regions.

Cluster 4 (Red - AI, Digital Tools, and Healthcare Quality)

- Key Nodes: Manyazewal (2017), Semrau (2019).
- Focus: The integration of AI and digital technologies to improve healthcare quality and reduce inefficiencies, including hidden costs.

Cluster 5 (Yellow - Methodological Approaches)

- Key Nodes: Kim (2022), Weil (2003).
- Focus: Methodologies for evaluating the impact of AI and digitalization on healthcare, including cost-effectiveness and performance metrics.

3. Insights

- Influential Articles: Ottersen (2014) and Massuda (2018) appear to be central to multiple clusters, suggesting they provide foundational frameworks or widely applicable insights for digitalization in healthcare.
- Emerging Trends: Articles from recent years (e.g., Kim (2022), Yeoh (2023)) indicate an ongoing focus on AI and its implementation, reflecting the rapid evolution of technology in healthcare.
- Thematic Overlap: The dense interconnections among nodes highlight the interdisciplinary nature of the topic, combining policy, technology, and healthcare delivery.

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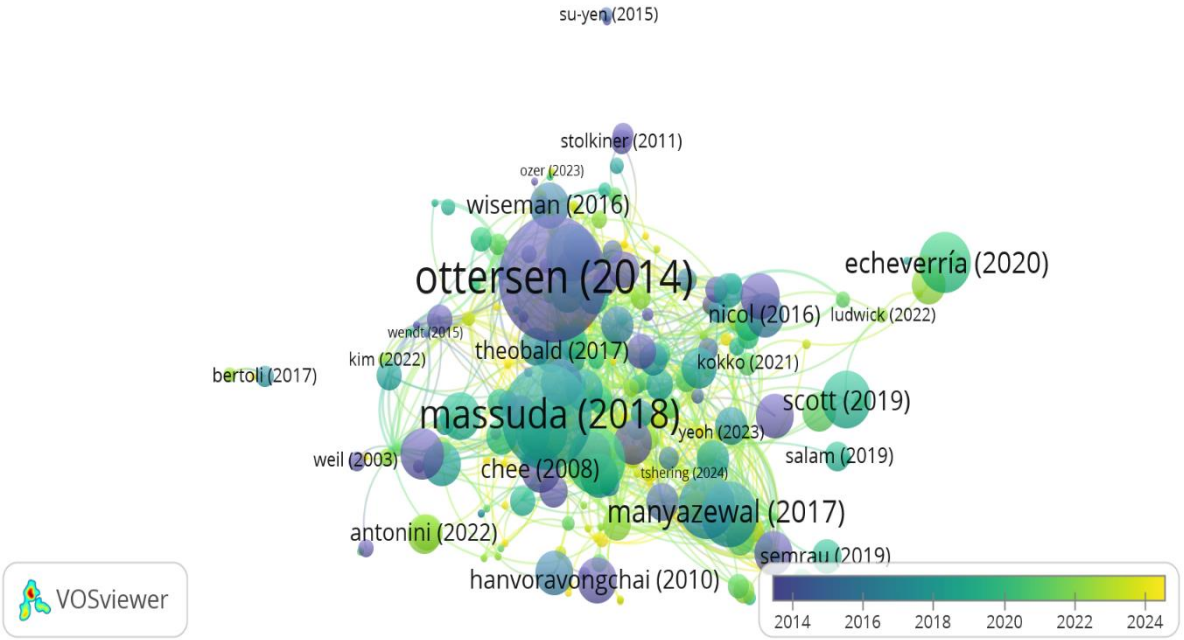
➢ **Overlay visualization**

Figure 8: Overlay Visualization Of coupling and articles



Source: Elaborated by the authors

1. Overview

The Overlay Visualization shows the same bibliographic coupling network as the earlier network graph, but with an added temporal dimension. The node colors correspond to the average publication year of the articles, as shown in the gradient bar below the graph (darker shades represent earlier years, while lighter shades represent more recent years).

2. Key Observations

Temporal Trends:

- Older Foundational Works:
  - Articles such as Chee (2008) and Hanvoravongchai (2010) are darker in color, indicating their role as foundational works. They likely address early challenges and strategies in healthcare systems.
  - Weil (2003) is one of the oldest contributions and may focus on initial explorations of healthcare system development.
- Recent Contributions:
  - Nodes like Ozer (2023), Yeoh (2023), and Tshering (2024) are bright yellow, representing cutting-edge or emerging research. These works likely focus on current advancements in digitalization and AI in healthcare.

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- Recent studies reflect the growing emphasis on real-world applications, such as AI-based diagnostics, process automation, and cost management.

Central Articles Across Time:

- Ottersen (2014) and Massuda (2018) remain central nodes despite their mid-range publication years, highlighting their continued relevance in connecting past and current research.
- Echeverría (2020) and Scott (2019) bridge mid-range to more recent studies, signaling their thematic overlap with newer AI and digitalization trends.

3. Key Clusters

- Foundational Research Cluster: Articles published earlier (e.g., Chee (2008)) focus on conceptual frameworks for healthcare improvements.
- Innovation and Technology Cluster: Recent works (Kim (2022), Yeoh (2023), Ozer (2023)) highlight the integration of digital tools and AI.
- Transitional Nodes: Articles from 2016-2020 (e.g., Nicol (2016), Scott (2019)) bridge foundational theories with emerging trends.

4. Insights

- Recent Focus: Leveraging insights from the newer articles (2022–2024) will help position your research within the latest advancements.
- Bridge Contributions: Mid-range articles (2014–2020) can serve as a theoretical base, offering frameworks or methodologies that link traditional healthcare models with digital transformations.
- Future Trends: Incorporating recent technologies (e.g., machine learning, IoT in hospitals) addressed by the yellow nodes will ensure your work remains forward-looking.

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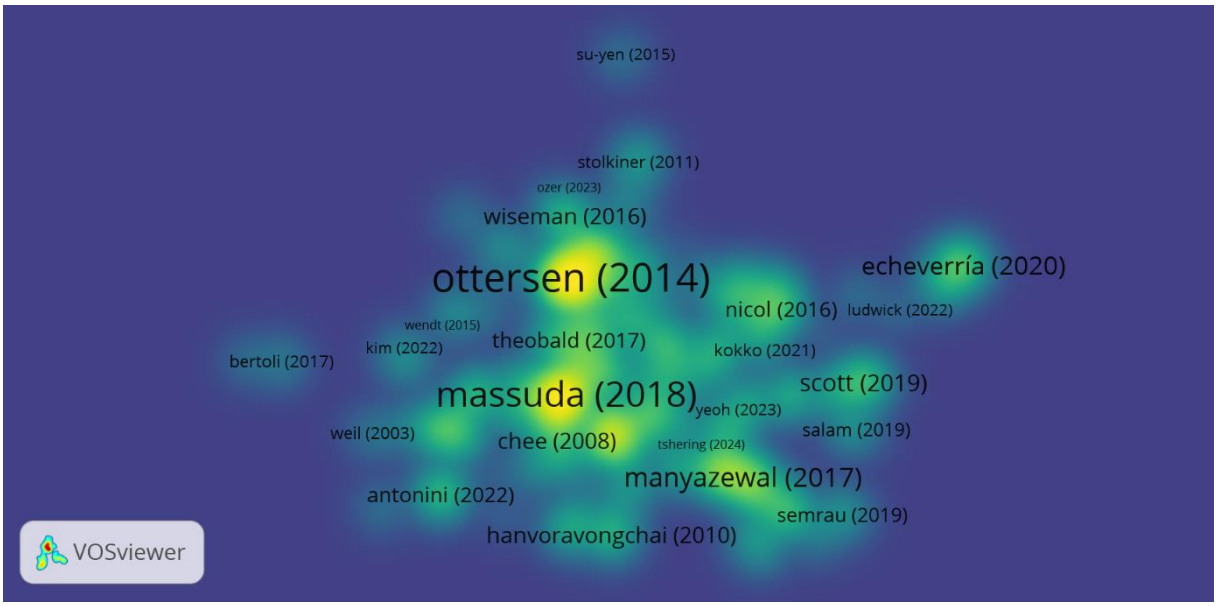
➢ **Density visualization**

Figure 9: Density Visualization of coupling and articles



Source: Elaborated by the authors

Overview

- The color gradient represents density of coupling, with yellow indicating the highest concentration of influential references, followed by green and blue as the intensity decreases.
- The most prominent articles, based on citation connectivity, include:
  - Ottersen (2014)
  - Massuda (2018)
  - Manyazewal (2017)
  - Scott (2019)
  - Echeverría (2020)

These authors represent key studies that are widely referenced and interconnected in research focusing on healthcare transformation, management, and innovation.

Key Clusters & Observations

1. Core Influential Articles (High-Density Areas - Yellow/Green)

- Ottersen (2014) and Massuda (2018) are the most frequently cited works, indicating they serve as foundational references.
- Massuda (2018) likely contributes key insights on healthcare systems and digitalization.
- Manyazewal (2017) appears to have an emerging influence, possibly focusing on healthcare quality and efficiency through technology.

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2. Emerging and Supporting Studies (Green Areas - Moderate Density)

- Scott (2019), Echeverría (2020), and Kim (2022) show moderate influence and are likely discussing recent developments in AI-driven healthcare solutions.
- The presence of authors from various years (2010-2024) suggests a growing and evolving research field.

3. Peripheral and Specialized Articles (Blue Areas - Lower Density)

- Articles such as Bertoli (2017), Chee (2008), and Weil (2003) are referenced less frequently in recent studies.
- These might focus on earlier healthcare reforms or policy-driven approaches, which have influenced but not dominated current discussions on digitalization.

Insights & Key Takeaways

✓ Ottersen (2014) and Massuda (2018) are foundational – Their high-density placement indicates they strongly influence digital healthcare research.

✓ AI and digital transformation are emerging themes – More recent works (e.g., Kim (2022), Yeoh (2023), Tshiring (2024)) suggest increased interest in technology-driven healthcare advancements.

✓ Future Research Directions

🔷 Further integration of AI-driven healthcare management – Recent works should explore how machine learning, big data, and automation can enhance patient care.

🔷 Bridging traditional and digital healthcare research – Older healthcare management frameworks can be updated with modern digital solutions.

VII. DISCUSSION

The results underscore the transformative role of digitalization and AI in healthcare, particularly in addressing challenges like cost management, quality improvement, and accessibility. However, disparities in technological adoption, ethical considerations, and data governance remain pressing issues. Future research should focus on developing equitable policies and frameworks to ensure the sustainable integration of these technologies.

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VIII. CONCLUSION AND PRACTICAL RECOMMENDATIONS

Digitalization and AI represent powerful tools for modernizing healthcare systems and addressing critical challenges. Based on the findings, the following recommendations are proposed:

- Policy Development: Governments should establish robust policies to address data privacy and ethical concerns.
- Investment in Infrastructure: Increased funding for digital health infrastructure is essential to bridge technological gaps.
- Capacity Building: Training healthcare professionals to adopt and utilize digital and AI tools effectively.
- Interdisciplinary Research: Promoting collaboration between technologists, clinicians, and policymakers to ensure holistic solutions.

This study provides a foundation for understanding the evolving role of digitalization and AI in healthcare and highlights opportunities for future innovation and research.

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