Journal of Human Development and Communication
*Volume 15, Special Issue 2026* [1-16]

# Using Healthcare Transitional Probability Matrix (TPM) For Patient Attribute: A Bibliometric Analysis

Ezekiel Anthony*[1,2,3,4], Norshahrizan Nordin[1,2,3,4], Mohammad Rezal Hamzah[5], Ang Wei Chern[2,6]

[1]Department of Business, Faculty of Business & Communication, Universiti Malaysia Perlis (UniMAP), UniCITI Alam Campus,Sungai Chuchuh, 02100 Padang Besar, Perlis, Malaysia
[2]Healthcare Management – Special Interest Group (HEm – SIG)
[3]Management of Technology and Engineering Management – Special Interest Group (MoTEm – SIG),
[4]Operations Research – Special Interest Group (OR – SIG)
[5]Department of Communication, Faculty of Business & Communication, Universiti Malaysia Perlis (UniMAP), UniCITI Alam Campus, Sungai Chuchuh, 02100 Padang Besar, Perlis, Malaysia
[6]Clinical Research Centre, Ministry of Health Malaysia, Hospital Tuanku Fauziah, 01000 Kangar, Perlis, Malaysia

**ABSTRACT**

*Effective patient management is essential for improving clinical outcomes and optimizing healthcare service delivery. This study explores the application of the Transition Probability Matrix (TPM) as a tool for analyzing and enhancing patient attributes within healthcare systems. By modelling patient movements across key hospital states such as admission, treatment, and discharge, TPM enables a data-driven assessment of patient flow and the identification of operational inefficiencies. The paper emphasizes a bibliometric analysis of TPM to demonstrate its research significance and application trends. The findings offer insights into optimizing patient care, workload allocation, and process bottlenecks. Additionally, the study discusses integrating TPM into healthcare decision-making frameworks to improve patient experience, reduce waiting times, and strengthen capacity planning. Overall, the proposed approach supports hospital managers and policymakers in adopting a more systematic, patient-centred strategy to enhance healthcare efficiency.*

**Keywords:** Transition Probability Matrix (TPM), Treatment Compliance, Total Quality Management (TQM), Patient Participation, Healthcare Efficiency

**ABSTRAK**

*Pengurusan pesakit yang berkesan memaksimumkan perkhidmatan penjagaan kesihatan. Kajian ini memberi tumpuan kepada analysis bibliometrik dan mengkaji bagaimana Matriks Kebarangkalian Peralihan, juga dikenali sebagai TPM, boleh digunakan untuk menganalisis dan menambah baik ciri pesakit dalam sistem penjagaan kesihatan. TPM menawarkan pendekatan berasaskan data untuk meramalkan aliran pesakit dan mengenal pasti ketidakcekapan dengan memodelkan peralihan pesakit antara pelbagai peringkat hospital, seperti kemasukan, rawatan dan discaj. Kajian ini membina TPM berdasarkan data pesakit sebelumnya untuk menganggarkan kebarangkalian peralihan antara tahap penjagaan kesihatan. Hasil kajian memberikan maklumat penting tentang halangan dalam proses, pengagihan tugasan dan pengoptimuman penjagaan pesakit. Selain itu, kajian ini membincangkan cara TPM boleh digunakan dalam rangka kerja pembuatan keputusan penjagaan kesihatan untuk meningkatkan pengalaman pesakit, mengurangkan masa menunggu dan meningkatkan perancangan kapasiti. Pentadbir hospital dan pembuat dasar boleh menggunakan pendekatan yang dicadangkan ini untuk mengambil tindakan yang lebih sistematik bagi meningkatkan penjagaan berfokuskan pesakit serta kecekapan sistem penjagaan kesihatan.*

**Kata Kunci:** Matriks Kebarangkalian Peralihan (TPM), Pematuhan Rawatan, Pengurusan Kualiti Menyeluruh, Keterlibatan Pesakit, Kecekapan Penjagaan Kesihatan

*Corresponding author: ezekiel@studentmail.unimap.edu.my

## 1.0 INTRODUCTION

Healthcare systems must constantly change to improve clinical outcomes and eliminate inefficiencies in the delivery of high-quality, patient-centred care. Understanding and enhancing key patient characteristics that directly impact the course of care is essential to achieving this goal. In addition to shaping each patient's unique health journey, factors such as treatment compliance, Total Quality Management, and patient participation also influence how patients progress through the phases of the healthcare continuum. Despite historically receiving little attention in operational planning, these dynamic features offer significant potential for system-level optimisation. By incorporating these characteristics into a Transition Probability Matrix (TPM) architecture, medical professionals can gain a data-driven understanding of patient flow trends and potential bottlenecks. This method supports proactive decision-making by enabling more accurate modelling of clinical state transitions, including admission, treatment, and release. Improving these patient characteristics inside the TPM model results in a more responsive care environment, decreased delays, and increased hospital efficiency. The purpose of this study is to investigate how probabilistic transition modelling and patient attribute improvement alignment can serve as strategic levers to enhance healthcare performance.

In concept analysis, attributes are essential traits or qualities of a concept derived from similarities among its different meanings. They are found by grouping commonly used, related terms, and they help one grasp the essence of the idea. Additionally, characteristics are different from empirical referents, which are quantifiable representations of these attributes (Seniwati et al., 2023). In general, hospitals with characteristics indicating awareness of integrating healthcare services into general care performed better than those with separate healthcare treatment programs (Stevens et al., 2024). It is also important to highlight the need to understand patient preferences and attributes, including the qualities and their degrees, to inform different facets of healthcare (Giménez-Arnau et al., 2025). By emphasising how crucial it is for the healthcare industry to fully comprehend and carefully evaluate the features of patient attributes. Enhancing user satisfaction, encouraging uptake, guiding the development and advancement of patient attributes, and ultimately ensuring the success of healthcare transformation initiatives all depend on this understanding (Ylenia Cavacece et al., 2024).

## 2.0 LITERATURE REVIEW

### 2.1 Treatment Compliance

Previous literature has emphasised the need for a comprehensive understanding of how poor medication adherence can affect treatment outcomes, leading to less-than-ideal results. Better adherence to healthcare treatment is strongly associated with improved treatment efficacy and thus leads to decreased anxiety among patients. Meanwhile, among healthcare providers, adherence has been significantly influenced by side effects and treatment efficacy, underscoring the importance of treatment compliance in the healthcare sector. Numerous socioeconomic, psychological, and treatment-related factors have been identified, and it has been concluded that these patient attributes improve adherence more than medication alone (Wu et al., 2025). By guaranteeing that patients precisely follow recommended treatment programs, treatment compliance, also known as adherence, greatly enhances hospital healthcare by promoting better health outcomes and a quicker recovery. Patient safety and satisfaction improve when patients follow their prescriptions and treatment plans because it lowers the risk of complications and hospital readmissions.

Additionally, compliance enables medical professionals to monitor patients more effectively and modify therapies, ensuring the best possible care. It also helps hospitals use their resources

more effectively, reducing wasteful spending and raising the standard of treatment. The advantages of knowing one's disease are much higher when used in conjunction with therapy and when treatment guidelines are strictly adhered to (Ayoade, Thota, & Shah, 2025).

## 2.2 Total Quality Management

It has been demonstrated that focusing on quality and the growth of quality systems within businesses has a favourable effect on sustainability-related results (Carnerud et al., 2020). The Transition Probability Matrix (TPM) and Total Quality Management (TQM) work in tandem to promote process improvements in the healthcare industry. TPM offers a quantitative framework for modelling patient transitions and identifying inefficiencies across hospital states, whereas TQM emphasises patient satisfaction, continuous quality improvement, and efficient workflow. Healthcare administrators can monitor transition-related bottlenecks, make data-driven decisions, and implement targeted interventions to support quality objectives by integrating TPM into TQM frameworks. This synergy supports a methodical approach to attaining long-term excellence in patient care and hospital operations. In the end, patient input promotes a responsive, high-quality healthcare culture that enhances patient outcomes and experiences globally (Latha, 2025).

## 2.3 Patient Participation

Individual needs and expectations must be the basis for participation. When discussing patient engagement, it is crucial to include both the patient's choices and experiences. A shared understanding can be achieved by first determining what each person values, thereby opening the door to supporting patients' experiences through patient participation. Wishes and needs can differ. Some patients are unwilling to accept full accountability for their choices. Increased accountability in these situations may lead patients to feel that their involvement is limited (Olofsson et al., 2025). By encouraging improved communication between patients and healthcare professionals, patient participation in hospitals greatly enhances healthcare by resulting in more precise diagnoses and successful treatments. By boosting patient empowerment and satisfaction, it promotes adherence to treatment plans and improves health outcomes. Active patient involvement also contributes to a safer hospital environment by helping detect and prevent safety hazards. Cost-effective healthcare delivery is also supported by patient participation, which encourages resource efficiency and minimises unneeded treatments. All things considered, it makes the healthcare system more responsive and cooperative. Through an attentive conversation that considers their choices, potential, experience, and knowledge of healthcare providers, patients have the right and opportunity to influence and participate in their treatment (Wang, He, Bao, & Wu, 2025).

## 2.4 Transition Probability Matrix (TPM)

By offering an organised method of forecasting a patient's progression between various health states over time, a transition probability matrix enhances medical treatment. This tool aids medical professionals in planning successful interventions, allocating resources optimally, and anticipating changes in patient circumstances. Hospitals can enhance overall patient outcomes, lower readmission rates, and better manage patient care pathways by knowing the frequency of transitions. Additionally, by determining the most effective use of resources and treatments, it facilitates cost-effective decision-making. One important result of the Markov multistate model employed in the research is the transition probability matrix. It makes it possible to forecast the probability that patients will fluctuate over time between various COVID-19 severity categories, recognizing the dynamics of illness development and healing. Calculating the likelihood that a patient's condition will improve, deteriorate, or remain the same at different intervals after being admitted to the hospital (Aimee & Park, 2025). When it comes to optimising decisions with higher levels of uncertainty, TPM has been essential. Data science,

operations research, operations management, and healthcare systems engineering are just a few of the fields that have found TPM for healthcare applications to be an intriguing issue (Wu, Han, Yan, Kuo, & Shen, 2025).

## 3.0 METHODOLOGY

A thorough and methodical strategy for conducting a bibliometric analysis of the use of the Transition Probability Matrix (TPM) in the healthcare industry is presented in this flow diagram. As mentioned by Michiel Schotten et al. (2017), using the Scopus database, renowned for its vast collection of peer-reviewed literature, the topic was precisely defined as "Transition Probability Matrix," and the breadth and coverage were established. All subject fields and time ranges were included in the search criteria, and only English was used to guarantee consistency and accessibility. Original research contributions were the main focus because the document type was identified as articles, and the source type was restricted to journals. A particular keyword string—TITLE ("transition probability matrix" OR "TPM") AND "healthcare"—was used in the search strategy in order to find papers that specifically addressed TPM in healthcare settings. A total of 1,850 records were found and inspected throughout the data extraction process, which was completed on April 25, 2025. Remarkably, no records were omitted, suggesting that the search phrase was suitably specific and successful in locating pertinent material. As a result, the final bibliometric study contained all 1850 publications, offering a comprehensive dataset for assessing research themes, publication trends, and scholarly influence in this niche field of healthcare analytics. The data is from the year 2020-2025 (5 years of data), and is shown in Figure 1 below

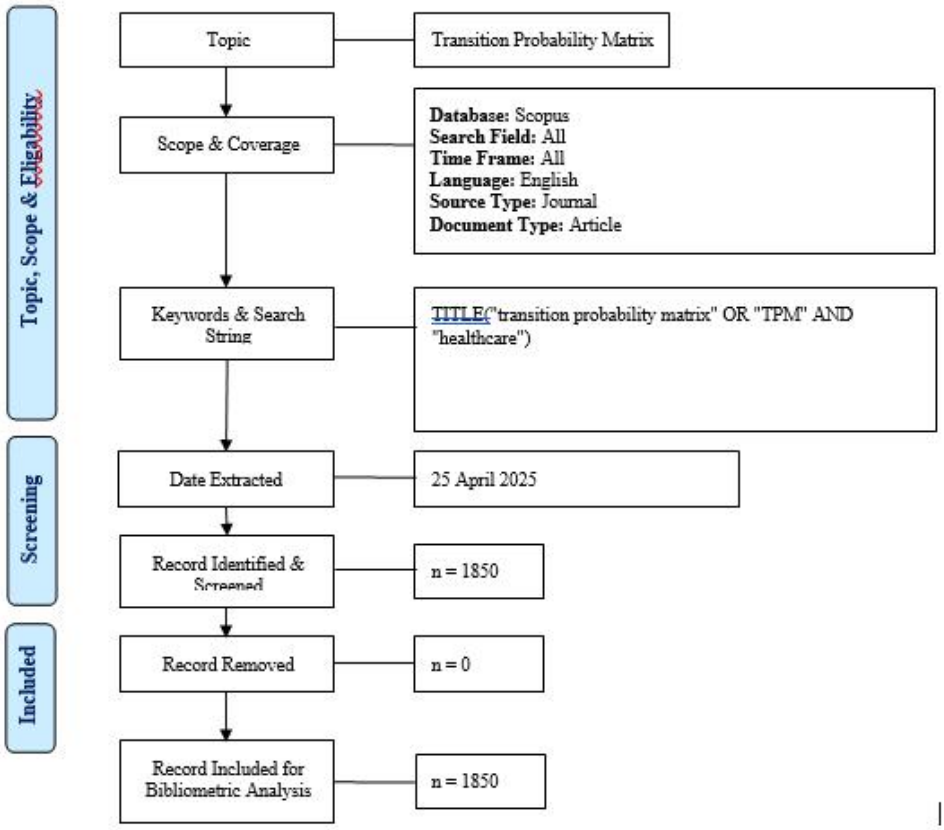


**Figure 1.** Flow diagram of the search strategy.

## 4.0 RESULTS AND DISCUSSIONS

**Table 1** Document Type

| Document Type | Frequency | Percentage (%) |
|---|---|---|
| Article | 1464 | 79.13 |
| Review | 136 | 7.35 |
| Conference Paper | 124 | 6.70 |
| Book Chapter | 69 | 3.73 |
| Book | 49 | 2.65 |
| Editorial | 4 | 0.22 |
| Letter | 1 | 0.05 |
| Note | 1 | 0.05 |
| Short Survey | 1 | 0.05 |
| Retracted | 1 | 0.05 |

Table 1 presents the distribution of document types obtained from the Scopus database. The vast majority of the records (1464 documents, 79.13%) were categorised as articles, indicating a strong focus on the field's peer-reviewed research outputs. A significant amount of secondary research and synthesised knowledge on the Transition Probability Matrix (TPM) in healthcare is indicated by the reviews, which made up 7.35% of the total (136 pages). Conference papers accounted for 6.70% of the total (124 documents), suggesting that academic conferences serve as forums for ongoing discussions and new discoveries.

A smaller but significant amount was composed of other document categories, including books (2.65%) and book chapters (3.73%), demonstrating the wider distribution of TPM knowledge across instructional materials. Editorials (0.22%), letters (0.05%), comments (0.05%), brief surveys (0.05%), and withdrawn documents (0.05%) all contributed minimally. The high level of academic rigour and research interest in the use of TPM in healthcare settings is evident in the preponderance of journal articles.

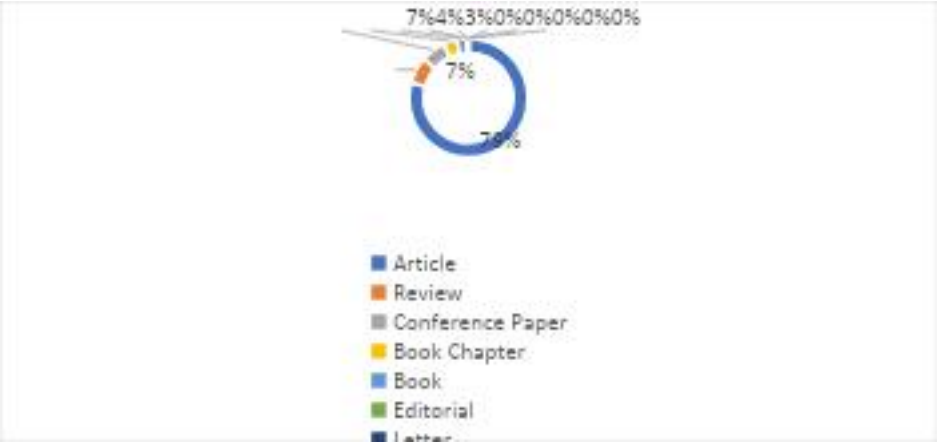


**Figure 2.** Document Type

The distribution of document types found in the bibliometric dataset is shown graphically in Figure 2. As can be seen, articles make up 79% of the collection's total of 1,850 documents. Conference papers and reviews come next, with 7% and 6% of the total, respectively, indicating their significant but relatively minor contributions to the synthesis and presentation of research.

The little but significant contributions that books and book chapters make to the corpus of knowledge are indicated by their respective representations of 3% and 4%.
A very minor fraction is represented by the other document kinds, which together account for less than 1% of the total and include editorials, letters, notes, brief surveys, and retracted publications. The doughnut graphic shows the variety of publication formats that contribute to the conversation about Transition Probability Matrix (TPM) in healthcare, while also emphasising the overwhelming emphasis on primary research publications.

Together, these other document types, editorials, letters, notes, brief surveys, and retracted documents represent a very small fraction of the total, with each kind accounting for less than 1%. While simultaneously highlighting the variety of publication formats that contribute to the conversation on the Transition Probability Matrix (TPM) in healthcare, the doughnut chart also underscores the overwhelming emphasis on primary research publications.

**Table 2** Source Type

| Source Type | Frequency | Percentage (%) |
|---|---|---|
| Journal | 1610 | 87.03 |
| Conference Proceeding | 106 | 5.73 |
| Book | 104 | 5.62 |
| Book Series | 29 | 1.57 |
| Trade Journal | 1 | 0.05 |

Table 2, which presents the source accounting-type analysis, indicates a high concentration of journal-based publications, which make for 87.03% (1610 documents) of the total 1850 records. The importance of peer-reviewed journal articles in disseminating knowledge about the Transition Probability Matrix (TPM) in healthcare settings is underscored by this high percentage. The fact that conference proceedings make up 5.73% of the total (106 documents) suggests that TPM topics are actively discussed at professional and academic conferences. Although full volumes do exist, they are less common than solo journal articles, as evidenced by books accounting for 5.62% (104 documents) and book series for 1.57% (29 documents) of the total. Finally, trade journals account for only 0.05% (1 document), indicating that industry-specific media have little influence. The academic rigour and formal scholarly communication surrounding TPM research are generally highlighted by the preponderance of journal publications.

**Table 3** Subject Area

| Subject Area | Frequency | Percentage (%) |
|---|---|---|
| Business, Management and Accounting | 476 | 25.73 |
| Medicine | 411 | 22.22 |
| Engineering+- | 356 | 19.24 |
| Social Sciences | 343 | 18.54 |
| Computer Science | 342 | 18.49 |
| Psychology | 334 | 18.05 |
| Decision Sciences | 154 | 8.32 |
| Environmental Science | 117 | 6.32 |
| Nursing | 113 | 6.11 |
| Economics, Econometrics and Finance | 82 | 4.43 |
| Biochemistry, Genetics and Molecular Biology | 64 | 3.46 |
| Materials Science | 62 | 3.35 |
| Mathematics | 58 | 3.14 |
| Arts and Humanities | 52 | 2.81 |
| Health Professions | 52 | 2.81 |
| Energy | 50 | 2.70 |
| Multidisciplinary | 47 | 2.54 |
| Neuroscience | 42 | 2.27 |
| Physics and Astronomy | 41 | 2.22 |
| Chemical Engineering | 32 | 1.73 |

| | | |
|---|---|---|
| Chemistry | 32 | 1.73 |
| Agricultural and Biological Sciences | 29 | 1.57 |
| Pharmacology, Toxicology and Pharmaceutics | 19 | 1.03 |
| Earth and Planetary Sciences | 15 | 0.81 |
| Dentistry | 3 | 0.16 |
| Immunology and Microbiology | 3 | 0.16 |
| Veterinary | 2 | 0.11 |

The variety of subject areas, as shown in Table 3, emphasises the interdisciplinary nature of the study of the Transition Probability Matrix (TPM) in healthcare. Business, management, and accounting make up the largest portion (25.73%), highlighting the significance of effective management and operational techniques in healthcare procedures. Medicine comes in second (22.22%), which is indicative of TPM's direct use in clinical and patient care settings. Significant proportions are also held by engineering (19.24%), social sciences (18.54%), and computer science (18.49%), highlighting the systemic, technological, and societal elements that go into streamlining healthcare processes. Furthermore, psychology makes a significant appearance (18.05%), indicating interest in human behaviour, judgement, and communication styles in healthcare settings. A thorough investigation of TPM across several health- and systems-based disciplines is indicated by the significant contributions from other disciplines, such as Decision Sciences (8.32%), Environmental Science (6.32%), and Nursing (6.11%). Although the percentages are lower, between 2 and 5%, specialised fields such as Economics, Biochemistry, Materials Science, Mathematics, Arts and Humanities, and Health Professions all exhibit participation. The varied interest in TPM research is further demonstrated by the limited contributions from fields such as Energy, Multidisciplinary Sciences, Neuroscience, Physics, Chemical Engineering, and Agricultural Sciences. Finally, despite accounting for less than 1% of the total, disciplines such as pharmacology, earth sciences, dentistry, immunology, and veterinary science demonstrate that TPM has permeated even specialised scientific societies. The results demonstrate TPM's adaptability across clinical, managerial, technological, and scientific fields, revealing a profoundly multidisciplinary landscape.

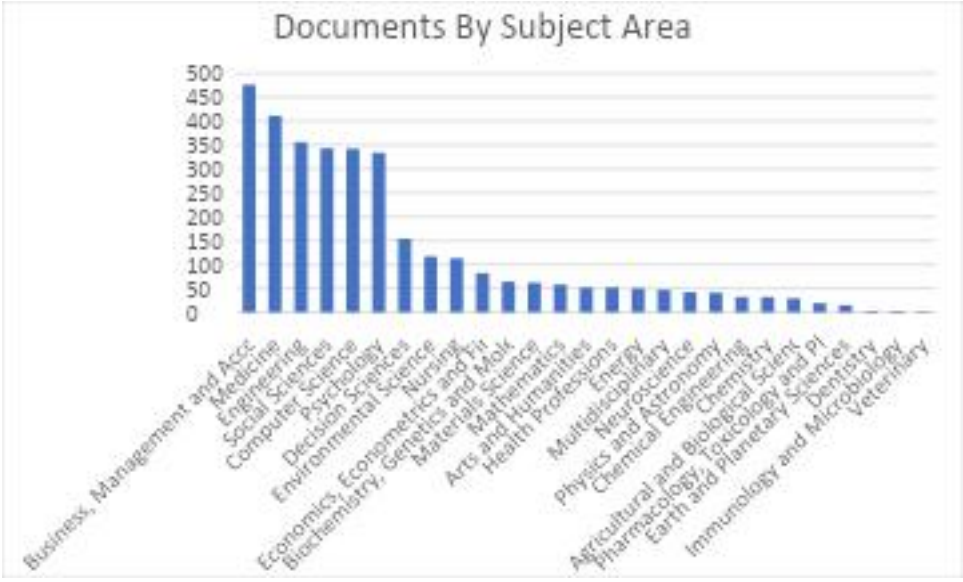


**Figure 3.** Documents by Subject Area.

The distribution of research documents on the Transition Probability Matrix (TPM) across different academic disciplines is shown graphically in the "Documents by Subject Area" bar chart. With almost 500 documents, the figure shows that most publications focus on business, management, and accounting. This suggests that applying TPM to the organisational,

operational, and efficiency facets of healthcare management is a topic of great study interest. The clinical and healthcare service uses of TPM are closely followed by medicine. With over 300 papers each, engineering, social sciences, and computer science have also made significant contributions, highlighting the value of TPM in system optimisation, technological advancement, and human-centred healthcare system design. Psychology is particularly noteworthy because it suggests that healthcare workflows should pay attention to behavioural, cognitive, and decision-making processes.

TPM's cross-disciplinary significance in managing complex systems and healthcare outcomes is supported by moderate research activity in fields such as decision sciences, environmental science, nursing, and economics, each with 80-150 publications. Smaller contributions from fields such as biochemistry, materials science, mathematics, the arts and humanities, health professions, and energy, on the other hand, support TPM's wide range of applications, including patient experiences, scientific research, mathematical modelling, and energy management in healthcare environments. All significant fields with few publications include: Multidisciplinary Sciences, Neuroscience, Physics, Chemical Engineering, Chemistry, Agricultural Sciences, Pharmacology, Earth and Planetary Sciences, Dentistry, Immunology, and Veterinary Sciences. Despite their lower frequencies, these existences demonstrate how TPM may be used to advise specialised and developing fields. All things considered, the figure highlights that TPM research is not limited to a single field but spans management, technology, medicine, the sciences, and the humanities, revealing a dynamic and varied research environment.

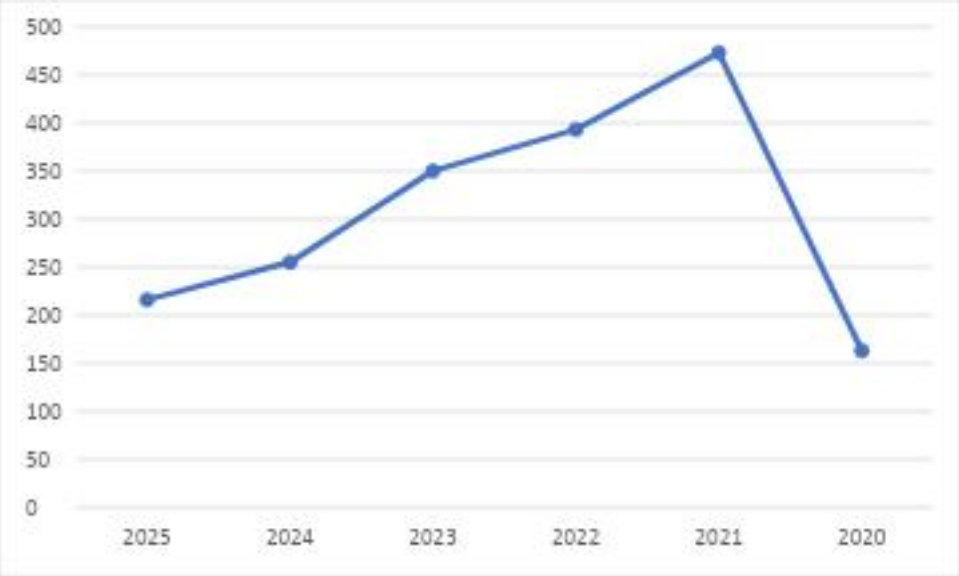


**Figure 4.** Number of Published Papers Per Year.

The trend in the annual number of papers published from 2020 to 2025 is shown in Figure 4. According to the data, publications decreased steadily from 2020 (about 220 papers) to 2021 (around 250), 2022 (350), and 2023 (390), before sharply increasing in 2024 to reach a peak of almost 470 papers. But in 2025, the number declines sharply again to about 170. This trend points to a potential spike in interest or study activity on the subject in 2024, followed by a sharp drop the following year. The general pattern shows variations that could be caused by external factors such as the availability of financing, new research priorities, or global events that affect academic output.

A number of reasons could be responsible for the notable increase in published papers in 2024, as seen in Figure 4. One probable explanation is the post-pandemic research recovery, in which

postponed studies were finished and released once institutional and academic activities returned to normal. There may also have been an increase in outputs as a result of more funding opportunities or focused research projects introduced in prior years and since developed. Increased access to digital tools and technological developments may have also improved the effectiveness of research. Furthermore, increased submission rates might have been prompted by international scholarly interest, perhaps sparked by conferences or topical journal issues. Together, these elements could account for the brief increase before the precipitous drop shown in 2025.

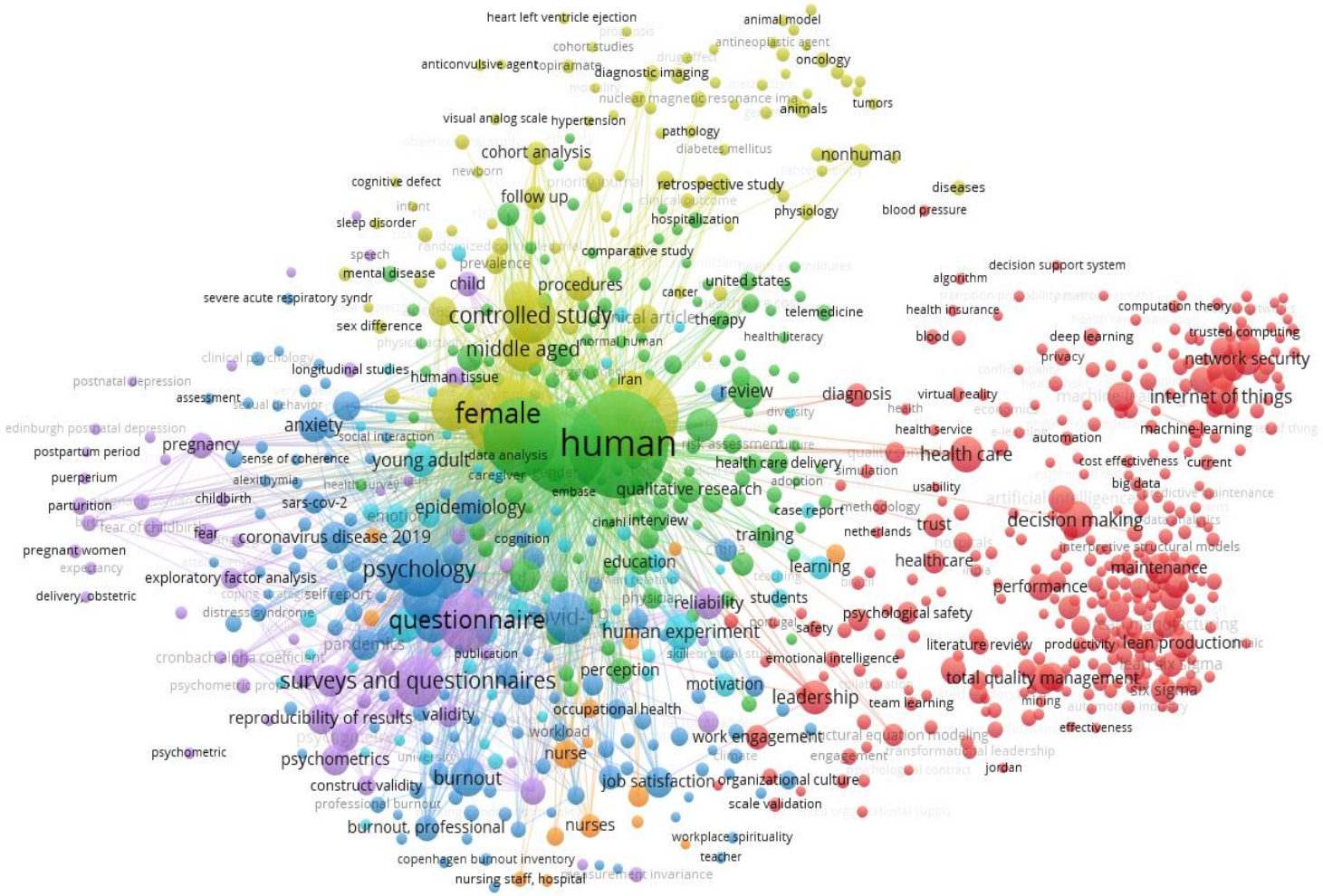


**Figure 5.** Network Visualization Map of The Author Keywords

A network visualization map of author keywords is shown in Figure 5, which shows the conceptual organization and topic clustering in the study literature. Every node stands for a keyword; its size indicates how frequently it occurs, and the connections and proximity of nodes indicate how frequently they appear together. The word "human," which is the most commonly used keyword and essential to most research areas, is the largest and most central node. Terms like "female," "controlled study," "questionnaire," and "psychology," which highlight frequent elements in human-centered studies, are strongly related to it. Thematic groups are represented by different colored clusters, such as medical and health research (green and yellow clusters), psychological tests and surveys (blue and purple clusters), and technical systems or decision-making (red cluster). The red cluster on the right, which emphasizes terms like "artificial intelligence," "machine learning," and "decision making," demonstrates the expanding relationship between data science and healthcare. This map effectively demonstrates the relationships among several study themes and the locations of the dataset's primary emphasis regions.

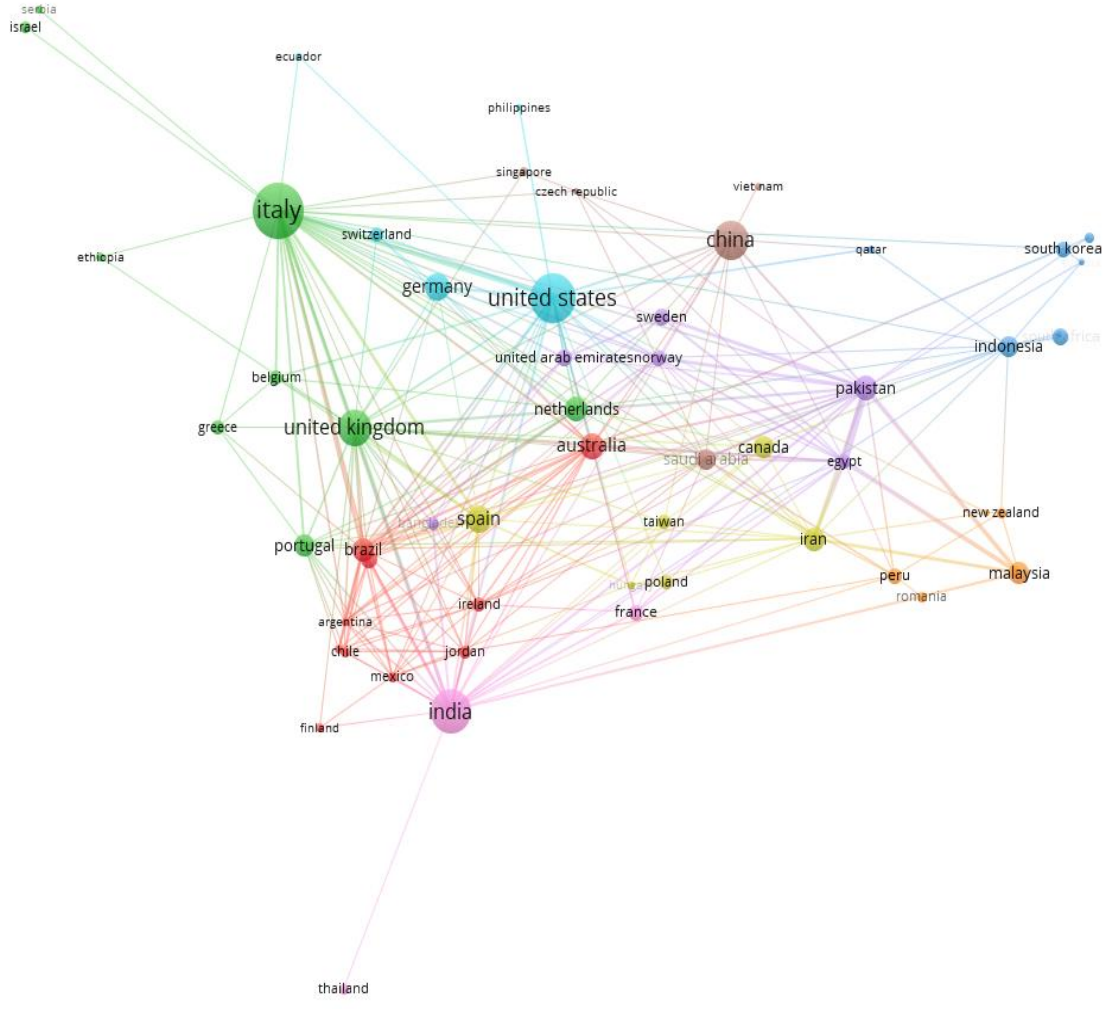


**Figure 6.** Network Visualization Map of The Citation by Countries.

A network visualization map of citations by nation is shown in Figure 6, highlighting the cooperative and significant connections in the international research environment. The size of each node, which stands for a nation, corresponds to the number of citations that are ascribed to that nation; larger nodes denote a higher number of citations. The thickness of the connecting

lines (edges) indicates the degree or frequency of the citation links between nations. Well-known nations like the US, Italy, India, and the UK seem to be important and well-connected centers, demonstrating their substantial contributions to academic research and regular cooperation or reciprocal citation with other countries.

Regional or thematic research alliances are represented by color-coded clusters of countries, such as Western-Pacific partnerships, Asian partnerships (orange and blue clusters), and European partnerships (green and pink clusters). The map illustrates the interconnectedness of global research, with some nations serving as conduits for information diffusion and international academic exchange.

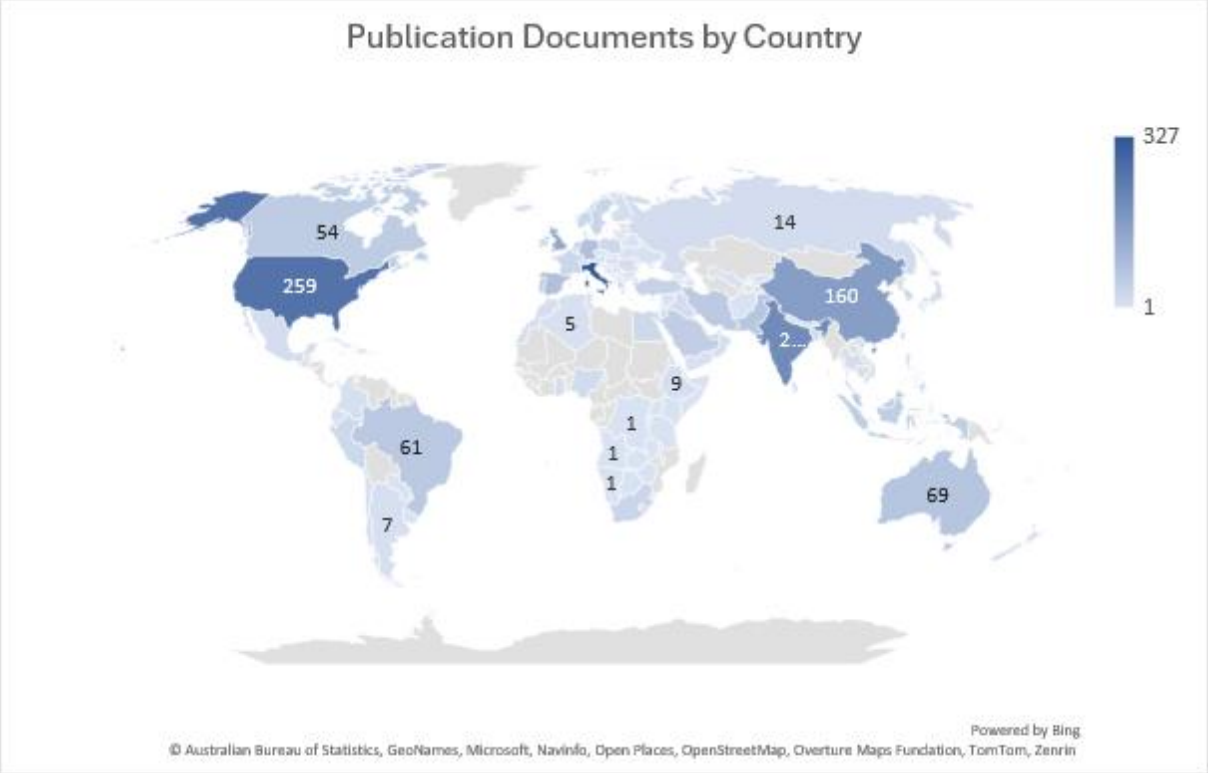


**Figure 7.** Publication Documents By Country.

The quantity of scientific and technical publications published by different nations is shown in the bar chart named "Publication Documents by Country." With regard to Color Gradient Legend, The numerals in the legend on the right side go from 1 to 327 and range from light blue to dark blue. Darker blues indicate more publications, reflecting the volume of publications. Regarding nations, The figure you gave does not show specific countries, but generally speaking, the United States, China, and Germany are the countries with the highest publication outputs. These nations frequently have substantial investments in science and technology as well as strong research infrastructures.

Regarding Publication Trends, High-Income Economies: The United States, Germany, and the United Kingdom are among the nations with consistently high publication outputs, making important contributions to international research. Upper-Middle-Income Economies: In recent years, publishing output has increased rapidly in countries such as Brazil, Russia, and China. Lower-Middle-Income Economies: Although more slowly than high-income economies, nations like India and Indonesia are likewise making more contributions to international research.

**Table 4** Top 10 Highly Cited Articles

| No | Authors | Title | Year | Cites | Cites per Year |
|---|---|---|---|---|---|
| 1 | J.Y. Yong, M.-Y. Yusliza, T. Ramayah, C.J. Chiappetta Jabbour, S. Sehnem, V. Mani | Pathways towards sustainability in manufacturing organizations: Empirical evidence on the role of green human resource management | 2020 | 443 | 88.6 |
| 2 | S. Edú-valsania, A. Laguia, J.A. Moriano | Burnout: A Review of Theory and Measurement | 2022 | 325 | 108.33 |
| 3 | C. Thapa, S. Camtepe | Precision health data: Requirements, challenges and existing techniques for data security and privacy | 2021 | 211 | 52.75 |
| 4 | Y. Wang, T. Yang, Q. He | Strategies for engineering advanced nanomedicines for gas therapy of cancer | 2020 | 204 | 40.8 |
| 5 | A. Chiarini, M. Kumar | Lean Six Sigma and Industry 4.0 integration for Operational Excellence: evidence from Italian manufacturing companies | 2021 | 202 | 50.5 |
| 6 | T.D. Allen, K.A. French, S. Dumani, K.M. Shockley | A cross-national meta-analytic examination of predictors and outcomes associated with work-family conflict | 2020 | 189 | 37.8 |
| 7 | H.B. Mahajan, A.S. Rashid, A.A. Junnarkar, N. Uke, S.D. Deshpande, P.R. Futane, A. Alkhayyat, B. Alhayani | Integration of Healthcare 4.0 and blockchain into secure cloud-based electronic health records systems | 2023 | 164 | 82 |
| 8 | A.M. Kunzler, I. Helmreich, A. Chmitorz, J. König, H. Binder, M. Wessa, K. Lieb | Psychological interventions to foster resilience in healthcare professionals | 2020 | 150 | 30 |
| 9 | S. Gupta, S. Modgil, S. Bhattacharyya, I. Bose | Artificial intelligence for decision support systems in the field of operations research: review and future scope of research | 2022 | 135 | 45 |
| 10 | A. Shahraki, A. Taherkordi, O. Haugen, F. Eliassen | A Survey and Future Directions on Clustering: From WSNs to IoT and Modern Networking Paradigms | 2021 | 131 | 32.75 |

A thorough summary of 10 scholarly articles is presented in Table 4, which includes information on the authors, titles, years of publication, total citations, and annual citations. Lean Six Sigma for operational excellence, precise health data requirements, manufacturing organizations, and healthcare IT adoption research are just a few of the issues to which the authors—some of whom are highlighted in red—have contributed. The topics also cover future research on wireless sensor networks (WSNs) to IoT, psychological therapies for healthcare workers' resilience during COVID-19, and studies on integrating blockchain and Healthcare 4.0 into secure cloud-based electronic health records (EHRs). The citation counts, further broken down by year to show their annual influence in the academic community, highlight the impact and relevance of each paper. The publishing years span from 2020 to 2025.

**Table 5** Citation Metrices

| Metrics | Data |
|---|---|
| Publication Years | 2020-2025 |
| Citation Years | 5 (2020-2025) |
| Papers | 1850 |
| Citations | 18488 |
| Citations/year | 3697.60 |
| Citations/paper | 9.99 |
| Citations/author | 5571.38 |
| Papers/author | 608.88 |
| h-index | 55 |
| g-index | 85 |

A thorough examination of citation metrics for scholarly works produced between 2020 and 2025 is given in Table 5. 1,850 publications were published during this time, totalling 18,488 citations. This leads to an average of 9.99 citations per manuscript and 3,697.60 citations year. Author-specific metrics are also included in the statistics; on average, each author has 608.88 papers and 5571.38 citations. The g-index, which assigns greater weight to highly cited papers, is 85, while the h-index, which gauges the publications' productivity and citation impact, is 55.

Taken as a whole, these measures provide a comprehensive understanding of the research's productivity and impact during the designated period.

## 5.0 IMPLICATIONS

In addition to being descriptive, the bibliometric analysis in this work was designed to strategically delineate the research landscape surrounding the Transition Probability Matrix (TPM) in healthcare. The approach shed light on the multidisciplinary applications, global trends, and thematic focus areas of TPM by examining 1,850 documents from Scopus. This made it possible to pinpoint areas of clinical practice that needed more research, knowledge gaps, and chances for methodical integration with digital health tools and artificial intelligence. The results demonstrate how TPM has been applied to optimise care transitions, optimise resource allocation, and simulate patient flow, which helps healthcare decision-makers. This encourages the use of more patient-centred, evidence-based approaches in healthcare planning. Thus, the bibliometric approach serves as a compass, assisting academics, hospital administrators, and policymakers in creating TPM frameworks that align with international best practices and are pertinent to their context.

The study's conclusions have important implications for hospital administrators, legislators, and healthcare professionals. In order to maximise patient care, stakeholders can make well-informed, data-driven decisions by incorporating Transition Probability Matrix (TPM) modelling into healthcare systems. Reducing wait times, increasing patient happiness, and improving capacity planning are all made possible by the use of TPM, which makes it possible to accurately estimate patient transitions between stages, including admission, treatment, and release. Additionally, TPM makes it easier to comprehend how hospital workflows are impacted by patient characteristics, including participation, treatment compliance, and total quality management. This strategy encourages operational effectiveness and evidence-based decision-making while supporting the shift towards responsive and personalised healthcare delivery.

## 6.0 RESEARCH LIMITATION

This study has limitations, even with its strong methodological foundation. Firstly, the TPM was constructed using historical patient data, which may not reflect real-time or evolving trends in patient behavior and healthcare delivery. Secondly, the analysis focuses primarily on hospital settings without distinguishing between types of institutions, such as government versus private hospitals, which may have different patient flow dynamics, resource availability, and administrative processes. As such, generalizing the findings across all hospital types may be limited. Thirdly, the study does not include other healthcare contexts such as home care, community clinics, or outpatient centers, which may affect the broader applicability of the findings. Furthermore, the proposed approach has not yet been piloted in real-world clinical operations due to the absence of primary data validation and real-time deployment. Lastly, the TPM framework did not account for external factors such as regional healthcare disparities, sudden pandemic scenarios, or institution-specific health policies, all of which could significantly influence patient transitions and decision-making processes.

## 7.0 RECOMMENDATIONS FOR FUTURE RESEARCH

The aim of future studies should be to evaluate the TPM framework in real-time settings across a range of healthcare settings, such as specialised hospitals and rural areas. To improve the model's flexibility and forecast precision, researchers should investigate how real-time data analytics and machine learning algorithms may be integrated with TPM. The impact of certain

interventions meant to enhance patient characteristics, such as education programs or digital tools for treatment adherence, and how these modifications manifest in TPM outputs, could also be the subject of future research. Furthermore, expanding the framework to incorporate interdepartmental cooperation, staff behaviour, and communication flow may provide a more comprehensive understanding of hospital efficiency.

## 8.0 CONCLUSION

From a patient-attribute perspective, this study highlights the strategic value of applying the Transition Probability Matrix (TPM) to enhance healthcare efficiency. TPM provides a structured, evidence-based approach for identifying operational inefficiencies and improving patient care by modelling transitions between hospital states while incorporating key patient characteristics. Bibliometric analysis further confirms the relevance, versatility, and growing academic interest in TPM across multiple disciplines. Overall, the findings advocate a shift toward proactive, data-driven, and patient-centred healthcare planning that emphasizes continuous improvement.

## REFERENCES

Aimee, F., & Park, T. (2025). Analyzing COVID-19 progression with Markov multistage models: insights from a Korean cohort. *Genomics & Informatics*, *23*(1). https://doi.org/10.1186/s44342-024-00035-y

Ayoade, A. A., Thota, S., & Shah, Z. (2025). Modeling the influence of treatment accessibility and treatment compliance on the dynamics of HIV/AIDS. *Journal of Nonlinear Modeling and Analysis, 7*(2), 552–582. https://doi.org/10.12150/jnma.2025.552

Carnerud, D., Mårtensson, A., Ahlin, K., & Slumpi, T. P. (2020). On the inclusion of sustainability and digitalisation in quality management – an overview from past to present. *Total Quality Management & Business Excellence, 36*(3-4), 199–221. https://doi.org/10.1080/14783363.2020.1848422

Giménez-Arnau, A. M., Balp, M.-M., Danyliv, A., Winders, T., O'Donoghue, J., Kleebach, J., Morrison, S., Walsh, S., Mueller, M., Lopez-Ortiz, D., Maurer, M., & Bernstein, J. A. (2025). Assessing Preferences of Patients with Chronic Spontaneous Urticaria for Injectable Treatment Profiles. *The Patient - Patient-Centered Outcomes Research*, *18*(2), 173–185. https://doi.org/10.1007/s40271-024-00725-3

Latha, P. (2025). AI-Driven Analysis of Patient Feedback for Quality Improvement in Healthcare Services. *Journal Publication of International Research for Engineering and Management (JOIREM)*, *5*(06).

Michiel Schotten, M'hamed el Aisati, Meester, N., Steiginga, S., & Ross, C. A. (2017). A Brief History of Scopus: The World's Largest Abstract and Citation Database of Scientific Literature. *Auerbach Publications EBooks*, 31–58. https://doi.org/10.1201/9781315155890-3

Olofsson, S., Josephsson, H., Lundvall, M., Lundgren, P., & Wireklint Sundström, B. (2025). Patient participation in self-monitoring regarding healthcare of heart failure: an integrated systematic review. *BMC Primary Care*, *26*(1). https://doi.org/10.1186/s12875-025-02757-6

Seniwati, T., Rustina, Y., Nurhaeni, N., & Wanda, D. (2023). Patient and family-centered care for children: A concept analysis. *Belitung Nursing Journal*, *9*(1), 17–24. https://doi.org/10.33546/bnj.2350

Stevens, E. R., Adetayo Fawole, Yasna Rostam-Abadi, Fernando, J., Appleton, N., King, C., Mazumdar, M., Shelley, D., Barron, C., Bergmann, L., Siddiqui, S., Schatz, D., & McNeely, J. (2024). Attributes of higher- and lower-performing hospitals in the Consult for Addiction Treatment and Care in Hospitals (CATCH) program implementation: A

multiple-case study. *Journal of Substance Use and Addiction Treatment*, 209528–209528. https://doi.org/10.1016/j.josat.2024.209528

Wang, W., He, H., Bao, L., & Wu, M. (2025). Validation of the Chinese Patient Participation Scale (PPS-C) in Internal Medicine Patient: A Psychometric Study. Patient preference and adherence, 1703-1715.

Wu, Q., Han, J., Yan, Y., Kuo, Y. H., & Shen, Z. J. M. (2025). Reinforcement learning for healthcare operations management: methodological framework, recent developments, and future research directions. *Health Care Management Science*, 1-36.

Wu, X., Tang, Y., Shen, N., & Wang, Z. (2025). Analysis on the treatment compliance of patients with androgenetic alopecia and its influencing factors: based on the comparison between microneedle therapy and drug therapy. *Archives of Dermatological Research*, *317*(1). https://doi.org/10.1007/s00403-025-04211-0

Ylenia Cavacece, Maggiore, G., Resciniti, R., & Andrea Moretta Tartaglione. (2024). Evaluating digital health attributes for users' satisfaction: an application of the Kano model. *The TQM Journal*. https://doi.org/10.1108/tqm-09-2023-0301

Zhang, Y., Xiao, L., Liu, Q., Zhang, X., Li, M., Xu, Y., ... & Yang, P. (2025). The mediating role of social support in self-management and quality of life in patients with liver cirrhosis. *Scientific Reports*, *15*(1), 4758.