Review Article **Open Access**

Gema Lingkungan Kesehatan
Vol. 24, No. 2 (2026), pp 349-365
e-ISSN 2407-8948 p-ISSN 16933761
doi: https://doi.org/10.36568/gelinkes.v24i2.507 *Journal Homepage: https://gelinkes.poltekkesdepkes-sby.ac.id/*

The Green Hospital: A Hybrid Systematic Literature Review and Bibliometric Analysis

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ABSTRACT

In recent decades, Green Hospitals have been the subject of numerous studies, yet conceptual fragmentation and ambiguity persist. Thus, the purpose of this study is to address the fragmentation and conceptual ambiguity in green hospital literature by a hybrid approach that integrates a systematic literature review (SLR) and bibliometric analysis. Unlike prior studies, which are predominantly descriptive, this study provides a structured synthesis, identifies theoretical gaps, and develops an integrative framework. A total of 169 Scopus-indexed articles between 2011 and 2025 were systematically identified using an expanded Boolean search strategy ("Green Hospital" OR "sustainable hospital" OR "green healthcare" OR "eco-friendly hospital") and analyzed following PRISMA guidelines. Bibliometric analysis was conducted using VOSviewer to map intellectual structure, collaboration networks, and thematic evolution. The study findings indicate that the existing study is heavily concentrated on environmental and infrastructure dimensions, while behavioral, governance, and policy aspects remain underexplored. The study also identifies geographic concentration and potential database bias in the global distribution of the study. Importantly, the study develops an integrated Green Hospital Sustainability Framework (IGHSF) based on an inductive thematic approach. This study contributes to the literature by improving methodological rigor in green hospital studies through a hybrid SLR-bibliometric approach, advancing theoretical understanding of sustainability integration in healthcare systems, and providing actionable insights for policymakers and healthcare managers in implementing sustainable hospital practices.

Keywords: Bibliometric analysis; Framework; Green Hospital; Literature review; VOSviewer

INTRODUCTION

The healthcare sector is increasingly acknowledged as a contributor to environmental degradation, including greenhouse gas emissions, energy consumption, and waste production. The concept of "green hospitals" has emerged as a strategic approach to integrating environmental sustainability into the healthcare system. Hospitals that implement the concept seek to compete more effectively with established healthcare institutions, in addition to providing tangible benefits, as reported by several studies (Boudhankar, 2017; Buyukcinar et al., 2024; Sadatsafavi et al., 2015). They promote healthier interior settings to enhance patient comfort, staff productivity, and the overall well-being by emphasizing better air quality, improved sunlight exposure, and more efficient use of natural resources (Boudhankar, 2017; Buyukcinar et al., 2024). Green hospitals reduce significant greenhouse gas emissions from the healthcare industry by utilizing eco-friendly design principles and sustainable energy technologies (O'Hara et al., 2022; Shelby, 2024; Vallée, 2024). In addition to environmental advantages, it has been demonstrated that giving patients and employees access to natural features, such as green areas, can lessen emotional discomfort and enhance mental health outcomes(O'Hara et al., 2022).

Furthermore, studies show a positive relationship between green hospital environments and patient satisfaction. According to (Sadatsafavi et al., 2015) Patients who receive care in green-certified hospitals, for example, are more likely to express higher levels of satisfaction and recommend the facility to others. Nevertheless, there isn't any solid proof yet that green hospital design lowers operational expenses (Sharda et al., 2024). Through sustainable practices, long-term adoption of green technology can lower costs, increase energy efficiency, and reduce waste (Schwab et al., 2025). However, there are significant challenges associated with the transition to green hospitals. Lack of staff, financial

limitations, complex technical requirements, and resistance to organizational change are some of the challenges (Norouzi et al., 2021; Olanrewaju et al., 2021; Shaabani et al., 2020a). Furthermore, the widespread adoption of green maintenance approaches is hindered by senior management's lack of comprehension and support (Olanrewaju et al., 2021).

Studies on green hospitals are still dispersed and conceptually inconsistent despite the expanding body of research, as seen by a number of the studies mentioned above. The majority of research concentrates only on infrastructure and technological elements, such as energy systems, environmental management, and green building design. Organizational, behavioral, and leadership, human resource practices, and policy implementation, however, have received less attention. Additionally, prior research frequently takes a descriptive approach without providing theoretical integration or critical synthesis.

The application of green hospitals in medical services is always being researched and examined. A systematic literature review (SLR) provides a thorough and rigorous synthesis of the body of current research. It guarantees that all pertinent research is included, lowering publication bias and boosting the reliability of findings (Paez, 2017). An SLR makes it possible to fully understand how, in the context of green hospitals, elements like waste minimization, water conservation, energy efficiency, and sustainable architecture interact to influence healthcare delivery and environmental impact. Additionally, by employing standardized methods for planning, data collection, analysis, and reporting, SLRs promote openness and reproducibility across investigations (García Peñalvo, 2022). Most importantly, they direct targeted studies by assisting in the identification of research gaps, such as the limited analysis of cost-effectiveness or relationships between patient outcomes (Carrión Toro et al., 2022). Previous reviews of green hospitals tend to be limited in scope, either focusing on a specific domain (e.g., waste management or energy efficiency) or lacking methodological rigor, such as transparent search strategies, quality assessment, and systematic synthesis.

Biblimetric analysis offers valuable quantitative insights by mapping publishing trends, looking at citation data, and identifying the leading academics in a field. For example, bibliometric analysis helps track the advancement of green hospital research and identify popular topics like green supply chain and green human resource management (GHRM), green supply chain management (GSCM), and highlights publications that have a significant impact (Alfarizi & Noer, 2024; Öztürk et al., 2024). To support interdisciplinary work and global sustainability initiatives, it also aids in identifying networks of cooperation between authors, organizations, and countries (Goswami, 2024). Using techniques like co-citation and keyword clustering, researchers can identify the thematic structure of the field and monitor the development of new fields, like integrating renewable energy into healthcare infrastructure (Pulsiri & Vatananan Thesenvitz, 2018). Bibliometric studies, while useful in mapping research trends, are often descriptive in nature and fail to provide deeper conceptual insights or theoretical implications.

This highlights a glaring research gap: there aren't many integrative studies that provide both quantitative mapping and qualitative synthesis of the area by combining thorough integration of SLR and sophisticated bibliometric analysis. According to Azarian et al. (2023), this enhances the effectiveness and rigor of analysis, allowing for faster and more precise evaluations through automated technologies. Given the rapid expansion of multidisciplinary knowledge and the need for structured, data-driven interpretation, this dual approach is highly beneficial for green hospital research. These methods not only enhance evidence-based decision-making but also help set the research agenda by drawing attention to significant issues, innovative works, and unexplored areas. These strategies provide a clear path ahead for the development of sustainable healthcare systems for researchers, practitioners, and policymakers.

Additionally, a thorough conceptual framework that encompasses organizational, social, economic, and environmental aspects of green hospitals is required. This study uses a hybrid approach that combines SLR and bibliometric analysis to close these gaps. In particular, this research seeks to Examining the current state of Green Hospital research and evaluating the topic's ongoing relevance as a research topic are the primary goals of this study. In addition to reviewing the development of the academic discourse on green hospitals, this study seeks to: identify theoretical gaps and practical implementation for future research; analyze the global distribution and intellectual structure of the field; and examine the evolution and conceptual trend in green hospital research. Based on these objectives, the research questions posed are:

RQ1: How has the concept of green hospitals evolved in the academic literature?

RQ2: What is the global distribution and intellectual structure of the green hospital research?

RQ3: What are the key theoretical gaps and practical implications for advancing green hospital implementation?

By addressing these questions, this study contributes to the literature by providing a more rigorous, integrative, and theory-driven understanding of green hospitals, as well as offering a foundation for future research and policy development.

METHODS

Study Design

Bibliometric analysis and SLR are used in this study to provide both qualitative synthesis and quantitative mapping of the green hospital literature. This approach enables a comprehensive understanding of the field by integrating methodological rigor with data-driven insights. This study will examine publications about Green Hospital from a variety of periodicals using VOSviewer and the Scopus database, with an emphasis on articles published up until June 16, 2025. This methodology provides a

comprehensive grasp of the field's development and prospective research trajectories, together with the capacity to delineate the field's progress in meticulous detail. Researchers can map the terrain of research activity, identify important contributors, and spot emerging trends by combining bibliometric analysis and systematic review (Ni & Abdullah, 2025). Combining the two approaches provides a comprehensive view of the field's development, historical trajectory, and future orientation, which is essential for enhancing understanding of multidisciplinary research (Marzi et al., 2024).

Search Strategy and Data Collection

An enhanced Boolean search approach was employed to reduce selection bias and increase comprehensiveness. The Selection of keywords is the first step in this academic analysis, and it can be completed using a macro methodology (top-down), moving from broad search paths to more focused studies and discussions. Consequently, after evaluating the limitations inherent in prior research and the scarcity of studies addressing Green Hospital, researchers use the Scopus database for a wide range of investigative tasks, such as conducting literature reviews, locating subject-matter experts, and keeping an eye on research trends. Based on the search results conducted on June 16, 2025, from the Scopus database using article titles, abstracts, and keywords: "Green Hospital" OR "sustainable hospital" OR "green healthcare" OR "eco-friendly hospital" across various academic disciplines. The screening process began by filtering documents according to their classification.

Inclusion and Exclusion Criteria

The inclusion criteria established were: (1) articles published up until June 16, 2025, (2) peer-reviewed journal articles, (3) publications in English, and (4) focusing on the topic of green hospitals or sustainable healthcare practices. Articles were eliminated based on document type: Conference paper (34), Book chapter (13), Review (9), Note (2), Conference Review (2), Book (2), Editorial (1). The included articles concentrate on the following keywords: English (40), Green Hospital (45).

Screening Process

The study followed the PRISMA guideline to ensure transparency, reproducibility, and guarantee a comprehensive and repeatable literature review (Page et al., 2021), also makes the subject coherent and easy to grasp (Chotisarn & Phuthong, 2025) The screening process involved: identification of records from Scopus, removal of duplicates, title and abstract screening, and full-text eligibility assessment. The screening results, based on the categorization above, a total of 169 documents were identified initially. After applying the inclusion and exclusion criteria, 40 articles were selected for in-depth analysis (see Figure 1).

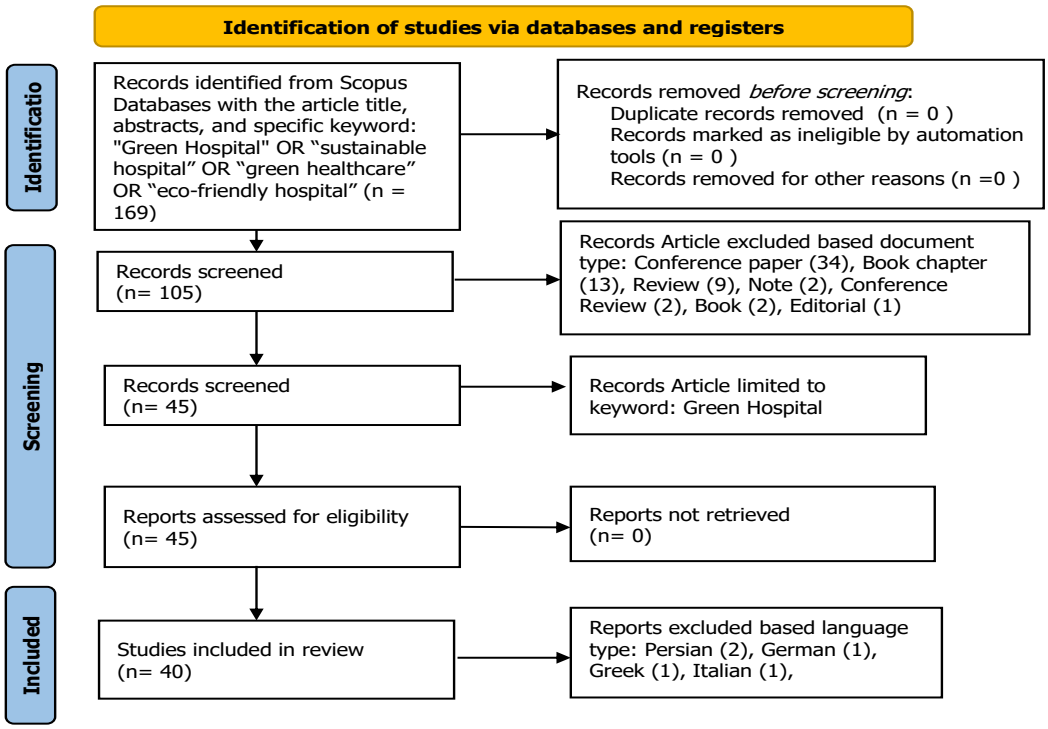


Figure 1. Systematic Literature Review: Information Flow Using PRISMA

Quality Appraisal

Using the Critical Appraisal Skills Programme (CASP) checklist, a quality evaluation was carried out to guarantee the validity and reliability of the examined studies. Each study was assessed according to the following criteria: relevance to the research topics, validity of findings, methodological rigor, and clarity of research objectives. The final synthesis only includes research that met basic quality standards.

Bibliometric Analysis

VOSviewer was used for bibliometric analysis in order to visualize bibliographic data and investigate co-authorship networks, co-citation links, and keyword co-occurrence patterns. This study includes conceptual evolution mapping, citation analysis, and thematic clustering in addition to descriptive data. This makes it possible to interpret data more deeply than just publication counts (Bukar et al., 2023; McAllister et al., 2022; Passas, 2024).

Data Synthesis

In contrast to purely descriptive reviews, this study uses thematic synthesis, which allows for the development of a conceptual framework based on empirical data. The chosen articles were coded and grouped into major themes, such as environmental and infrastructure dimensions, operational and efficiency dimensions, human and behavioral dimensions, and policy and governance dimensions.

The final document was then further analyzed in this study to answer RQ1: How has the concept of green hospitals evolved in the academic literature? RQ2: What is the global distribution and intellectual structure of the green hospital research? RQ3: What are the key theoretical gaps and practical implications for advancing green hospital implementation?

RESULTS AND DISCUSSION

Overview of the Literature and Thematic Structure

The results of this study focus on the analysis of findings from 40 articles in the Scopus database on Green Hospital using a combination of bibliometric and thematic synthesis. This data is sourced from identifying the number of articles published, publications throughout the years, and journal sources. After searching for quantitative papers within the green hospital field, we constructed a table containing the most relevant data retrieved from them: author names, objectives, methodologies, key findings, and themes. Table 1 contains review articles that will be subjected to further analysis

Table 1. Review of Collected Articles

No	Author (year)	Objective	Methodology	Key Findings	Themes
1	(Aini et al., 2023a)	Analyze the effects of green building, green innovation, and green HRM on green hospital implementation.	Quantitative survey; SEM-PLS; 83 hospital employees.	Green HRM and green innovation had a significant influence on green hospital implementation, while green building did not.	Environmental and infrastructure dimensions
2	(Aini et al., 2023b)	Develop a sustainable development model toward Environmentally Friendly Hospitals (EFH).	Quantitative; SEM-PLS; employees, visitors, surrounding community.	Green hospital mediated the relationship between green building, innovation, and HRM toward EFH.	Environmental and infrastructure dimensions
3	(AlShareef et al., 2022)	Assess COVID-free "green hospitals" for elective surgery recovery.	Multicenter quasi-experimental; 5 intervention hospitals vs 1 control.	Surgical backlog reduced by a median 74%.	Environmental and infrastructure dimensions
4	(Asamoto et al., 2024)	Evaluate the urgency and implementation of green hospitals in Japan (with a focus on neurosurgery).	Narrative review; institutional evaluation.	Hospitals are major carbon emitters; anesthetic gases key GHG source; the "8Rs" framework is recommended.	Environmental and infrastructure dimensions
5	(Ayçam & Yazici, 2017)	Evaluate operating rooms using green design criteria.	Qualitative; site visits; 5 hospitals.	ORs are the highest energy consumers; IAQ standards are often unmet.	Environmental and infrastructure dimensions, Operational and efficiency factors

No	Author (year)	Objective	Methodology	Key Findings	Themes
6	(Aziz Kemal Konyalıoğlu, Tuğçe Beldek, 2022)	Prioritize green hospital attributes using Fuzzy ANP.	Quantitative; MCDM; Fuzzy ANP.	Energy criteria has the highest weight; renewable materials most important sub-criterion.	Environmental and infrastructure dimensions
7	(Badanta et al., 2025)	Explore hospital roles in sustainability strategies.	PRISMA systematic review; 27 studies.	Two themes: environmental sustainability & professional engagement.	Environmental and infrastructure dimensions, Human and behavioral aspects
8	(Cenani & Can, 2025)	Prioritize LEED Healthcare criteria (cost–quality–time).	AHP; 10 experts; 28 pairwise comparisons.	Materials & Resources highest priority; Innovation lowest.	Environmental and infrastructure dimensions, Operational and efficiency factors
9	(Dhillon & Kaur, 2015)	Link green hospitals with climate change mitigation.	Literature review.	Hospitals are resource-intensive; simple measures reduce footprint.	Policy and governance mechanism
10	(Golbazi & Aktas, 2020)	Assess patient well-being in LEED hospitals.	LEED scorecard (140 hospitals) + HCAHPS (52 hospitals).	3.6% higher patient satisfaction in green hospitals.	Policy and governance mechanism
11	(Hayati et al., 2025)	Analyze the impact of medical tourism on hospital waste.	Waste management study: 4 hospitals.	5.17 kg/day waste; tourism increases infectious waste.	Human and behavioral aspects
12	(Imron & Husin, 2021)	Improve cost performance via value engineering.	Interviews with construction stakeholders.	Green hospital, LCC, and VE significantly improve cost performance.	Operational and efficiency factors
13	(Ismaeil & Sobaih, 2023)	Evaluate high-performance glass (HPG).	HAP simulation; glass comparison.	Coated glass reduces peak temperature by 16.5°C.	Operational and efficiency factors
14	(Al Fannah et al., 2023)	Quantify the green hospital environmental impact in Oman.	Descriptive case study.	Telemedicine & anesthetic gas management are key for emission reduction.	Environmental and infrastructure dimensions
15	(Jiao & Li, 2016)	Apply the CRS model in hospital construction.	Theoretical & practical analysis.	Four factors: site, efficiency, energy-saving tech, and management.	Operational and efficiency factors
16	(Kamath et al., 2019)	Review green hospital techniques.	Literature review & international case studies.	Green design improves patient health index (13.5–87%).	Environmental and infrastructure dimensions
17	(Kara et al., 2025)	Assess the LEED certification's impact on expansion.	Fractional-order model; 2 hospitals.	LEED hospitals show superior service quality & staff satisfaction.	Policy and governance mechanism
18	(Kumari & Saini, 2022)	Identify green hospital adoption factors.	Exploratory; EFA & regression; 300 professionals.	Environmental friendliness strongest motivator.	Environmental and infrastructure dimensions
19	(Lee et al., 2023)	Analyze stakeholder behavioral intention (TPB).	Cross-sectional survey; 339 employees.	Attitude, subjective norms, and PBC positively influence intention.	Human and behavioral aspects
20	(Manotas et al., 2021)	Analyze the renewable energy contribution to healthcare sustainability.	Documentary qualitative content analysis.	Renewable energy reduces fossil dependence; 75–90% hospital waste is recyclable.	Environmental and infrastructure dimensions

No	Author (year)	Objective	Methodology	Key Findings	Themes
21	(Mkalaf et al., 2023)	Evaluate the ISO 14001-based green hospital recovery.	Factor analysis; 6 hospitals.	ISO 14001 critical; infrastructure gaps identified.	Environmental and infrastructure dimensions
22	(Ngatindriatun et al., 2024)	Assess green practices and patient satisfaction.	Survey; PLS-SEM; 572 respondents.	Green practices positively impact patient satisfaction.	Policy and governance mechanism
23	(Nurfikri et al., 2024)	Analyze public awareness & green hospital image.	Linear regression; 400 users.	Public awareness strengthens the green hospital image.	Human and behavioral aspects
24	(Oruçoğlu et al., 2024)	Reduce water & GHG via sustainable menus.	Water footprint & GHGE analysis; 42 hospitals.	Mediterranean diet reduces WF & GHGE.	Operational and efficiency factors
25	(Palm et al., 2024)	Identify sustainability factors in radiology.	Nationwide survey.	Imaging energy efficiency prioritized.	Operational and efficiency factors
26	(Quitmann et al., 2023)	Reduce the university hospital's carbon footprint.	Qualitative interviews; 29 participants.	Structural complexity main barrier; anesthetic gas change is effective.	Operational and efficiency factors
27	(Read & Meath, 2025)	Develop a sustainable EBD conceptual framework.	Systematic review; 65 studies.	Synergy in IEQ and energy atmosphere.	Policy and governance mechanism
28	(Ryan-Fogarty et al., 2016)	Evaluate a whole-system environmental program.	Evaluative case study: Cork University Hospital.	A systemic approach is more effective; stakeholder coordination is critical.	Environmental and infrastructure dimensions
29	(Sadatsafavi et al., 2015)	Compare patient experience (LEED vs non-LEED).	Cross-sectional comparative; HCAHPS data.	Higher patient experience scores in green hospitals.	Policy and governance mechanism
30	(Sepetis & Parlavantzas, 2025)	Analyze circular economy behavior.	Survey: 379 health workers.	Climate knowledge gap hinders reform.	Human and behavioral aspects
31	(Sepetis et al., 2024)	Evaluate environmental cost in healthcare.	Multiple linear regression; 119 observations.	Environmental costs significant in operations.	Operational and efficiency factors
32	(Sepetis et al., 2025)	Calculate environmental costs in Greece.	Multiple case study; cost analysis.	Environmental accounting is poorly integrated.	Operational and efficiency factors
33	(Shaabani et al., 2020b)	Design a green hospital model (Iran).	Comparative & Delphi; 120 participants.	19 validated dimensions.	Environmental and infrastructure dimensions
34	(Sharda et al., 2024)	Review the impact of green design on well-being & cost.	Systematic review; 10 studies.	Strong link to patient well-being; limited cost evidence.	Operational and efficiency factors
35	(Taie, 2023)	Design a greening protocol for nurse managers.	Quasi-experimental; 112 managers.	Knowledge improved significantly post-intervention.	Policy and governance mechanism
36	(Tarkar, 2022)	Analyze green hospitals in sustainable construction.	Database review.	IGBC & GRIHA rating systems support environmental reduction.	Environmental and infrastructure dimensions
37	(Vallée, 2024)	Analyze green hospitals and climate change.	Literature review.	Urgent CO_2 reduction & resource reform needed.	Environmental and infrastructure dimensions
38	(Weisz et al., 2011)	Develop a socio-ecological sustainable hospital model.	Conceptual model development.	Sustainability must integrate patient, staff, environment dimensions.	Environmental and infrastructure dimensions

No	Author (year)	Objective	Methodology	Key Findings	Themes
39	(Wu, 2021)	Optimize AI communication systems for green hospitals.	Quantitative simulation model.	AI systems improve operational efficiency & reduce energy use.	Operational and efficiency factors
40	(Yaghoubi et al., 2022)	Identify green hospital challenges.	Mixed methods; checklist + interviews; 10 staff.	56.8% compliance; HR, financial, legal barriers.	Policy and governance mechanism

Sources: Author's analysis of cited studies in the table

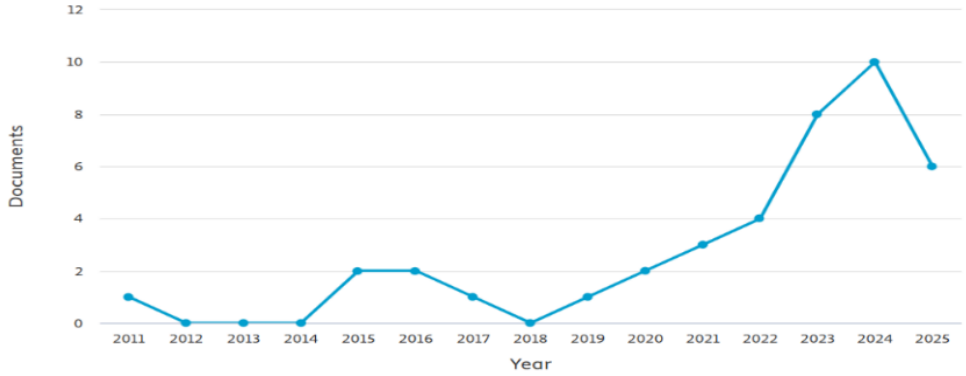
CONCLUSIONS

The results are organized into four primary theme domains—environmental and physical, operational and efficiency, human and behavioral, and policy and governance—that represent the multifaceted nature of green hospital research. This classification was created using cross-study comparison and inductive coding themes, allowing for a more organized reading of the literature. The findings show that the literature is dominated by the environmental and infrastructure dimension, especially when it comes to waste management, energy efficiency, and green building design. The human, behavioral, policy, and governance aspects, however, are still understudied, underscoring a crucial disparity in the state of the field.

RQ1: Evolution and Conceptual Trends in Green Hospital Research

Based on data obtained from the Scopus database, there have been 40 scholarly publications about Green Hospital in the last 14 years; Figure 2 illustrates the paucity of research on Green Hospital. Green Hospital exploration has developed progressively over the past five years, especially since 2019. (Weisz et al., 2011) The first study we carried out was entitled "Sustainable hospitals: A socio-ecological approach," which marked the emergence of the term now known as Green Hospital, and there were no publications for two years after that. Only in 2015 did publications related to green hospitals reappear, discussing the relationship between green hospitals and climate change (Dhillon & Kaur, 2015), and patient experiences in green hospitals and non-green hospitals (Sadatsafavi et al., 2015). Conceptual and exploratory research on sustainability awareness and the environmental impact of healthcare systems defined the early phase (2011–2015). The concept of incorporating ecological concepts into hospital systems was first presented in foundational publications. Technical and infrastructural applications, such as environmental management systems, energy efficiency, and green building certification, became more prevalent during the second phase (2016–2019).

The evolution of research on Green Hospital has begun to attract many academics, with the most recent phase (2020-2025) focusing on organizational commitment (Cenani & Can, 2025; Yusuf et al., 2024), public awareness (Lee et al., 2023; Lim et al., 2025; Nurfikri et al., 2024), attitudes (Nurfikri et al., 2024), behavior (Asamoto et al., 2024; Lim et al., 2025; Nurfikri et al., 2024; Yusuf et al., 2024), relationships with climate change (Aini et al., 2023b; Asamoto et al., 2024; Dhillon & Kaur, 2015), cost-benefit (Imron & Husin, 2021; Sepetis & Parlavantzas, 2025; Sharda et al., 2024)and green hospital design (Aini et al., 2023b; Asamoto et al., 2024; Buyukcinar et al., 2022; Cenani & Can, 2025; Nurfikri et al., 2024; Read & Meath, 2025; Sadatsafavi et al., 2022). Furthermore, (Sharda et al., 2024) Assert that Green Hospital significantly enhances patient well-being and satisfaction (Ngatindriatun et al., 2024).



Source: Scopus Database

Figure 2. Number of Green Hospital Publications

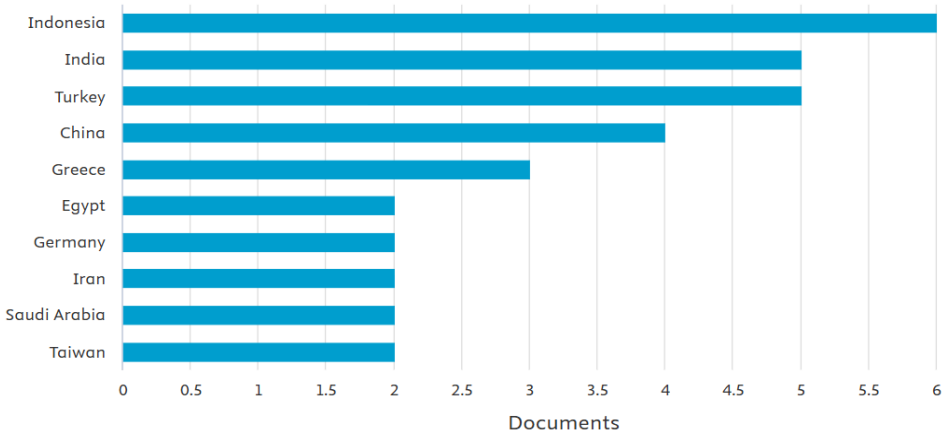
Crucially, despite the fact that numerous studies indicate that green hospitals can support environmental sustainability, there is still conflicting empirical data, especially when it comes to cost-effectiveness and long-term operational results. This result casts doubt on the widely held belief that implementing green hospitals always has positive effects on the economy and environment. This research is important to advance the insight into Green Hospital, which influences behavior and

commitment, and the evolution of the Green Hospital framework. This can facilitate a deeper understanding of the practical and sustainable implementation of the Green Hospital in various sectors.

RQ2: Global Distribution and Collaboration Patterns related to the Green Hospital

The analysis of the distribution of Green Hospital research in 40 articles was conducted by categorizing articles according to classifications such as country, region, affiliation, source, and author, with a limit of only the top ten articles in each classification. The sharpness of the allocation of scholarship relevant to Green Hospital will be useful for academics and practitioners in explaining the future research agenda, especially in the continuous advancement of the Green Hospital paradigm.

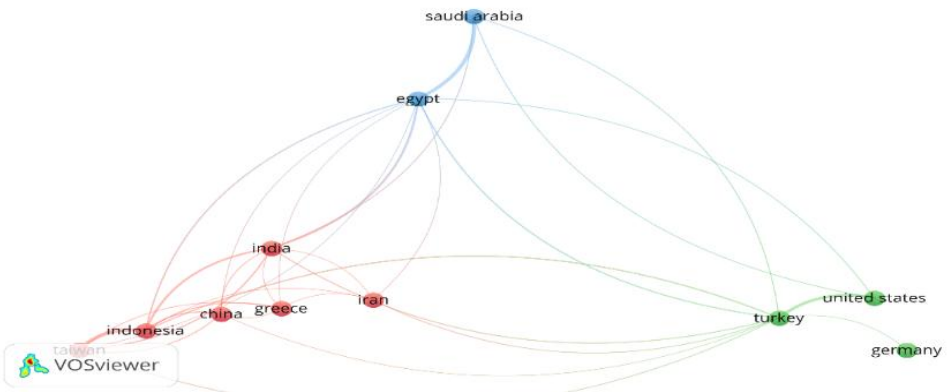
First, the spread of scientific research on Green Hospitals, when grouped by country or region, is mostly led by Indonesia, which has six articles. Next are India and Turkey, each with five articles. China has four articles, three articles in Greece. Egypt, Germany, Iran, Saudi Arabia, and Taiwan each have two articles (see Figure 3).



Source: Scopus Database

Figure 3. Number of Articles by Country or Territory (Top 10 Countries)

Indonesia leads the world with six articles, followed by India and Turkey with five, according to the distribution of scientific questions on green hospitals by nation or region. In addition, several other countries have made significant contributions to this research. These findings indicate that the issue of Green Hospitals has received attention in several countries, reflecting the global relevance of the topic. The researchers will also analyze the relationship between countries involved in Green Hospital research using VOSviewer software. This stage is essential for developing a methodical, forward-looking research agenda. When looking at the subject of green hospitals, the VOSviewer analysis's findings show how various countries relate to one another (see Figure 4).



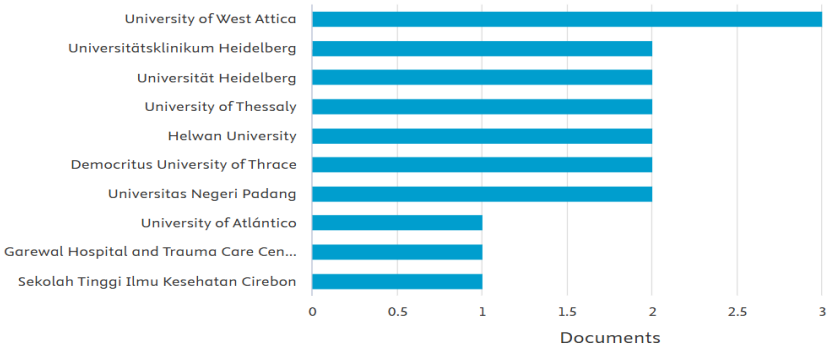
Source: Output Vosviewer Software

Figure 4. Network Country Visualization

Three major clusters are depicted in this network visualization, which depicts the global collaboration landscape in green hospital research: a blue cluster that Saudi Arabia and Egypt dominate; a red cluster that includes India, Iran, China, Indonesia, and Greece; and a green cluster that includes Turkey, the United States, and Germany. Saudi Arabia and Egypt seem to be the primary centers of cooperation. Significant geographic differences are also visible in the visualization, with little representation from Latin America, Oceania, Africa (except Egypt), and a large portion of Western and Northern Europe. This research supports the notion that, despite the increased awareness of Green Hospital principles, few

nations are implementing them and working to create a more inclusive Green Hospital model.

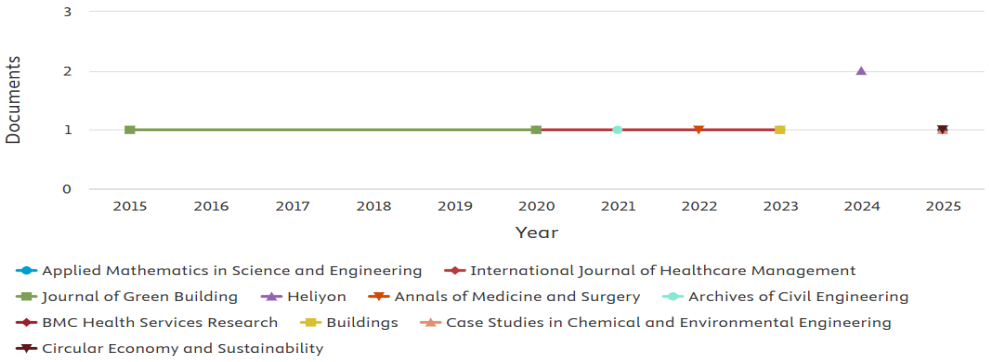
Second, Green Hospital reports that the University of West Attica in Greece has the largest scholarship distribution with three publications. Other universities having two articles each are Helwan University in Egypt, the University of Thessaly and Democritus University of Thrace in Greece, Universitätsklinikum Heidelberg and Universität Heidelberg in Germany, and Padang State University in Indonesia. There is also one article each from the University of Atlántico in Colombia, Garewal Hospital and Trauma Care Center in India, and Cirebon Health Sciences College in Indonesia (see Figure 5). The Green Hospital scholarship's distribution among ten prominent publications by affiliation demonstrates that it is drawing attention in both the clinical and academic settings



Source: Scopus Database

Figure 5. Number of Articles by Institutional Affiliations (Top 10 Affiliations)

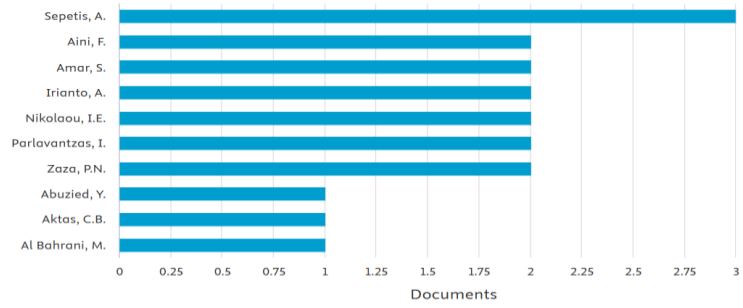
Third, Heliyon has two articles, the International Journal of Healthcare Management has two articles, the Journal of Green Building has two articles, the Annals of Medicine and Surgery has one article, Applied Mathematics in Science and Engineering has one article, the Archives of Civil Engineering has one article, BMC Health Services Research has one article, Buildings has one article, Case Studies in Chemical and Environmental Engineering has one article, and Circular Economy and Sustainability has one article. The distribution of queries on Green Hospital is defined by these primary published sources (see Figure 6).



Source: Scopus Database

Figure 6. Number of Articles by Sources (Top 5 Sources)

Fourth, three authors (Abuzied, Y.; Aktas, C.B.; Al Bahrani, M.) have written one article, while six authors (Aini, F.; Amar, S.; Irianto, A.; Nikolaou, I.E.; Parlavantzas, I.; Zaza, P.N.) have written two articles each. The distribution of research on Green Hospital by authors shows that only Sepetis, A. has written three articles (see Figure 7).



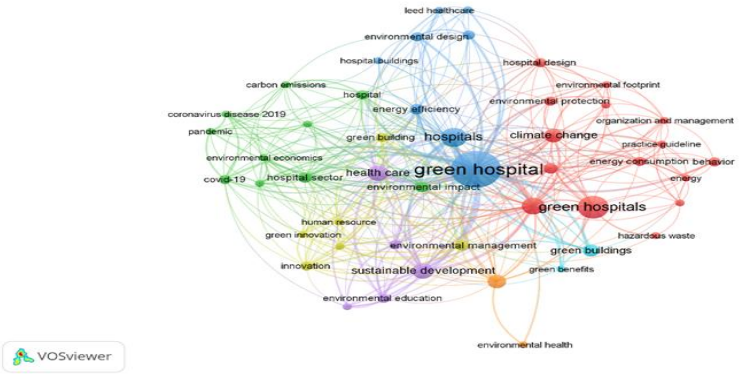
Source: Scopus Database

Figure 7. Count of Publications by Authors (Top 10 Authors)

The review of previous studies has revealed a gap in the literature, with previous research on green hospitals still displaying notable limitations, such as the countries or regions in question. This research is dominated by a few countries, including Saudi Arabia, Egypt, India, Iran, and Indonesia, whereas other regions, like Africa (except Egypt), South America, Oceania, and Europe, have none. Countries with developed health systems and environmental legislation, such as the United Kingdom, France, the Netherlands, and Scandinavia, are not included in this collaborative network. Figures 3 and 4 show that there is minimal interaction between clusters and that collaboration patterns are still isolated within their respective regional clusters. Research findings are skewed toward their local contexts due to the predominance of Middle Eastern and South Asian nations, which lowers the degree of global generalization. Analysis of the results from Figures 5, 6, and 7 shows that collaborative networks indicate that research groups tend to be regionally concentrated, with limited cross-regional collaboration and publications. Future studies must therefore increase their geographic scope and encourage interregional cooperation to generate findings that are more globally representative and that address the range of potential outcomes and challenges related to the establishment of green hospitals in various health care systems around the world.

RQ3: Theoretical and Practical Implications of the Green Hospital

The VOSviewer was used to illustrate that the results may have theoretical and pragmatic consequences for future research on Green Hospitals. Based on the results of metadata analysis using VOSviewer can be seen which variables have been extensively studied by previous researchers and which variables have not been widely explored, which serves as a foundation for further research. From a practitioner's perspective, the results of literature analysis using VOSviewer will help practitioners in implementing Green Hospitals sustainably in the future and promoting the Green Hospital style for healthcare organizations worldwide.



Source: Output Vosviewer Software

Figure 8. Co-Occurrence Framework and Representation of Key Terms

From Figure 8, we can see that the frequently discussed topics are Green Hospital (28), green hospitals (13), Hospital (10), Waste Management (8), Health Care (7), Sustainable Development (7), Climate Change (6), Sustainable Healthcare (6), Environmental Impact (5), Energy Efficiency (4), Environmental Management (4), hospital sector (4), sustainability (4), covid-19 (4), green building (3), energi consumption (3), hospital (3), innovation (3), hospital design (3), environmental education (3), green healthcare (3), environmental economics (2), green economy (2), green innovitaon (2), human resource (2), practice guideline (2), resource management (2), and organization and management (2), Finally, the 10 keywords that best indicate the strength of the relationship between one item and another are shown in Table 2.

Table 2. Keywords by Authors

Rank	Keyword	Total link strength
1	Green Hospital	131
2	Hospitals	59
3	Waste Management	58
4	Health Care	57
5	Sustainable Development	47
6	Environmental Impact	37
7	Energy Efficiency	34
8	Environmental Management	34
9	Hospital Sector	33
10	Sustainable Healthcare	30

Source: Output Vosviewer Software

Theoretical Implications

This study advances a more comprehensive understanding of green hospitals, which adds to the body of literature. Previous research often takes a technocentric stance, emphasizing environmental performance and

infrastructure. However, this study emphasizes how crucial it is to include: system-level integration (e.g., alignment between environmental and healthcare objectives), governance mechanisms (e.g., leadership, policy support), and behavioral elements (e.g., staff attitudes, organizational culture). These results are in accordance with several studies on green hospitals that have been conducted. The related green hospital researches the use of minimizing waste, maximizing the use of resources, including water and electricity, and utilizing renewable energy sources and low-emission materials (Buyukcinar et al., 2022, 2024; Chías & Abad, 2017). Green hospital development, especially in academic settings, is guided by the design principles of safety, patient-centeredness, efficiency, timeliness, and effectiveness (SPETE) (Aziz Kemal Konyalıoğlu, Tuğçe Beldek, 2022). Important architectural features include green roofs, natural lighting, eco-friendly construction materials, and smart building systems (Vallée, 2024). In addition to reducing greenhouse gas emissions and promoting environmental resilience, these traits result in tangible benefits like lower energy and water use, as well as intangible benefits like better hygiene and faster patient recovery (Buyukcinar et al., 2024; Schwab et al., 2025). Better surroundings that can improve patient recovery and general health outcomes are another objective of green hospitals (Golbazi & Aktas, 2020; Sadatsafavi et al., 2015). Research indicates that compared to patients receiving care in traditional settings, those who receive care in green-certified hospitals are more satisfied and inclined to recommend the facility (Sadatsafavi et al., 2015). Better treatment outcomes and reduced operating costs are two potential financial benefits of green hospitals (Vallée, 2024).

Green hospitals cover several important areas. Sustainable materials and energy-efficient systems are used in green building design to improve indoor air quality and natural lighting (Boudhankar, 2017; Golbazi & Aktas, 2016). Programs for recycling, waste reduction, and efficient use of energy and water are all important components of resource management (Buyukcinar et al., 2024; Lattanzio et al., 2022). Additionally, initiatives to enhance indoor environmental quality by improving ventilation, daylight access, and general comfort demonstrate a focus on the well-being of patients and staff (Golbazi & Aktas, 2020; Sadatsafavi et al., 2015). To reduce their environmental impact, hospitals also incorporate sustainability practices like renewable energy and green supply chain management (Sharma, 2016; Tooranloo et al., 2022; Ultreras-Rodríguez et al., 2024). The results imply that green hospitals should be viewed as intricate socio-technical systems rather than just as physical infrastructure.

Practical Implications

Practically speaking, the results show that more than just technology is needed for green hospitals to be implemented successfully. Strong leadership commitment, employee engagement and training, favorable regulatory frameworks, and incorporating sustainability into company strategy are all important success factors. Crucially, the report also emphasizes that long-term planning and policy support are necessary because financial advantages are not always assured or instantaneous. This finding aligns with several studies that have been conducted on factors influencing the success of green hospital implementation. Studies conducted by (Aini et al., 2023a; Mkalaf et al., 2023; Susanto & Nopiyanti, 2020) About green hospital goals and making sure that sustainable practices are followed depend heavily on management and leadership. Furthermore, cultivating a green corporate culture depends heavily on employee motivation and cultural values (Kumari & Saini, 2022; Susanto & Nopiyanti, 2020). Validating green credentials requires adherence to certification and regulatory requirements, such as leadership in energy and environmental design (LEED) (Boudhankar, 2017; Buyukcinar et al., 2024). In the meantime, financial and technical assistance ensure the sustainability of green infrastructure and innovation (Buyukcinar et al., 2024; Teymourzadeh et al., 2022; Ultreras-Rodríguez et al., 2024). Furthermore, societal support for green healthcare practices is influenced by public perception and awareness (Lee et al., 2023; Nurfikri et al., 2024).

Critical Discussion and Comparison with Previous Studies

By shifting from descriptive analysis to critical synthesis and theoretical integration, this study expands on earlier studies. Although previous research highlights the environmental advantages of green hospitals, this study discovers that: implementation difficulties are frequently underestimated; behavioral and organizational hurdles are not adequately addressed; and evidence on cost savings is still inconclusive. Unlike previous assessments that concentrate on particular areas (such as The green hospital Ma hybrid systematic literature review and bibliography analysis, energy efficiency or waste management), this study offers a comprehensive viewpoint by incorporating several domains. This finding is in accordance with studies that have been conducted that implementing green practices in hospitals is fraught with difficulties. Implementation is frequently hampered by inadequate infrastructure and resources (Mkalaf et al., 2023; Sadatsafavi et al., 2022; Teymourzadeh et al., 2022; Ultreras-Rodríguez et al., 2024). Maintaining compliance while negotiating intricate regulatory environments can be challenging. Furthermore, a burdensome obstacle to transformation is internal cultural resistance, particularly from employees used to traditional procedures (Teymourzadeh et al., 2022; Vallée, 2024). Last but not least, many institutions continue to face significant financial challenges, especially the high upfront costs of green technologies (Teymourzadeh et al., 2022; Ultreras-Rodríguez et al., 2024; Vallée, 2024). However, there is still little empirical data to back up these financial benefits, especially when it comes to operational cost savings

(Sharda et al., 2024). These contradictions highlight the need for more empirical and longitudinal research.

Toward an Integrated Understanding of Green Hospitals

According to the findings, green hospitals can be viewed as systems formed by the interplay of human and behavioral factors, operational and efficiency dimensions, environmental and infrastructural dimensions, and policy and governance elements (see Figure 9). This perspective supports the development of a more comprehensive framework, which is further elaborated in the next section.

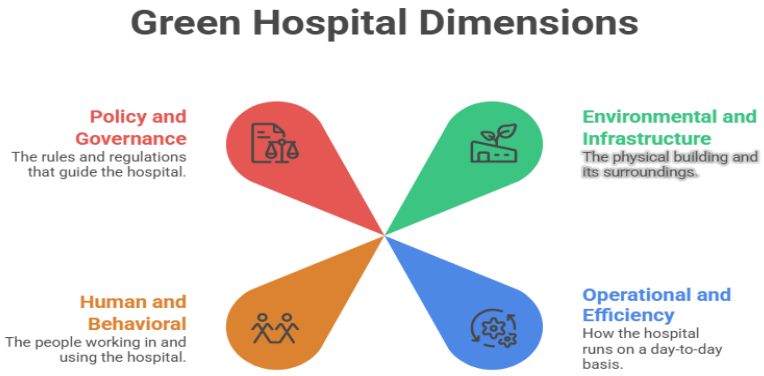


Figure 9. Green Hospital Dimensions

Integrated Green Hospital Sustainability Framework

Frameworks development process

The 40 chosen papers were systematically and inductively synthesized to create the Integrated Green Hospital Sustainability Framework (IGHSF). Thematic coding of the literature, cross-study comparison of important variables and constructs, and integration with current theoretical viewpoints, such as socio-technical systems and sustainability frameworks, are the explicit sources of this framework. Recurring constructs from many studies were found through the coding process and further categorized into higher-order groups. To guarantee conceptual coherence and clarity, these classifications were improved progressively.

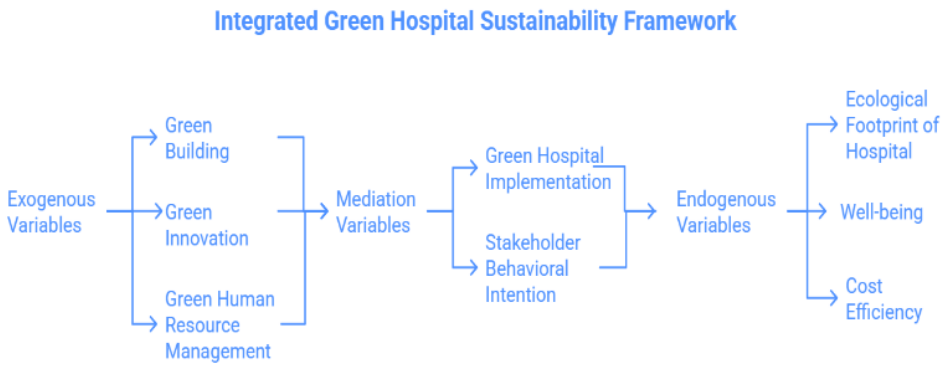


Figure 10. Integrated Green Hospital Sustainability Framework

Structure of the IGHSF

According to the IGHSF, green hospitals are a dynamic, multifaceted system made up of four interrelated parts (see Figure 10):

Exogenous variables:

This component is the initial foundation that an organization must have to begin a green transformation. Green Building (GB): encompasses efficient physical structures and building processes (Aini et al., 2023b; Dhillon & Kaur, 2015). Key indicators include the selection of environmentally friendly materials, earthquake-resistant design, and the utilization of natural energy sources (Aini et al., 2023b). Green Innovation (GI): encompasses product innovation (use of recycled materials), process innovation (digitalization of services) (Aini et al., 2023b, 2023a; Al Fannah et al., 2023), and reduced paper use and emissions (Aini et al., 2023b). Green Human Resource Management (GHRM): practices that align hospital staff behavior with goals through training, competency development, and environmental awareness (Aini et al., 2023a, 2023b).

Mediating variable

Transformation does not occur directly, but rather through a system implementation process. Green Hospital Implementation (GHI): a mediator that operationalizes the principles of GB, GI, and GHRM into concrete policies. GHI

focuses on chemical management, waste segregation, and the use of alternative energy (Aini et al., 2023b). Stakeholder Behavioral Intention: Staff behavior is influenced by their attitudes, perceptions, and behavioral control toward green policies (Lee et al., 2023).

Contextual variables

These factors determine how effectively exogenous variables can be translated into tangible results. Internal context: management commitment, organizational culture, budget availability, and environmental information systems (EMS) (Mkalaf et al., 2023; Sepetis et al., 2024). External context: government regulations (tax incentives or permits), accreditation standards (LEED, ISO), and public awareness (Dhillon & Kaur, 2015; Imron & Husin, 2021; Kamath et al., 2019; Nurfikri et al., 2024). Community support and social norms are crucial in strengthening the image and strength of a green hospital (Nurfikri et al., 2024).

Endogenous variables:

The variables resulting from this framework have three main dimensions. Ecological Footprint Hospital: Hospitals that mitigate environmental impacts, reduce carbon footprint, and implement stringent waste management (Aini et al., 2023b; Dhillon & Kaur, 2015; Nurfikri et al., 2024). Well-Being: Hospitals increase patient satisfaction, improve clinical outcomes, and enhance staff productivity(Golbazi & Aktas, 2020; Read & Meath, 2025; Sadatsafavi et al., 2015). Cost Efficiency: Although initial investment costs are often higher, implementing green hospitals through value engineering and life cycle analysis has been shown to reduce operational costs (Dhillon & Kaur, 2015; Imron & Husin, 2021)**.**

Conceptual Contribution

Three important ways that the IGHSF advances the literature are as follows: 1. Integration across dimensions: This framework incorporates environmental, organizational, behavioral, and policy dimensions, in contrast to previous models that concentrate on individual elements (such as building design). 2. Process-oriented viewpoint: The framework emphasizes transformation as a dynamic process as opposed to a static result. 3. Connecting theory and practice: The framework gives researchers and practitioners useful insights by connecting drivers, mechanisms, and outcomes.

Limitations and Future Research

The researchers also recognize the limitations of the study. For the most part, the analysis relied on papers from the Scopus database; therefore, the conclusions might not be as broadly relevant as they could be. Future studies are urged to address this by incorporating information from other databases, such as Web of Science, to guarantee more comprehensive findings. Furthermore, to gain a deeper understanding, future research could examine more specialized areas within the field. Finally, even though a strict methodology was used to lessen interpretational bias, creative approaches could be used in future studies to reinforce and expand on the current findings.

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CONCLUSIONS

After examining 40 academic publications from the Scopus database, this study presents a number of key conclusions. First, the Green Hospital study has improved over the last five years, especially after 2019. Early conceptual debates on more technological and infrastructure applications were part of green hospital research, which has since expanded into the organizational and behavioral realms. Nevertheless, there is still an imbalance in this evolution, with studies pertaining to infrastructure and the environment predominating. Second, database and keyword biases may have an impact on the uneven global distribution of research. This emphasizes the necessity of conducting research that is more inclusive and globally representative. Third, this study points up important gaps in the literature, especially with regard to leadership and governance, human factors and behavioral change, policy integration, and implementation techniques. These gaps show that green hospitals should be viewed as complex socio-technical systems that require an interdisciplinary approach rather than just as technological solutions. Fourth, the integrated green hospital sustainability framework, which offers a methodical and comprehensive knowledge of green hospital implementation, is developed in this study. The paradigm offers theoretical and practical benefits by integrating environmental, organizational, behavioral, and ploidcy elements.

SUGGESTION

It is necessary and crucial that holistic, integrative, and interdisciplinary approaches that linkiing environmental actions, policy frameworks, human factors, infrastructure aspects, impact evaluation, and stakeholder engagement should be given priority in future research, and policymakers are encouraged to develop standardized guidelines.

ACKNOWLEDGMENTS

We would like to express our gratitude to all parties who have supported and assisted in the preparation of this

article, especially Scopus for the database, and VOSviewer for the bibliometrics.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, AS and KSN; methodology, AS; software, AS; validation, AS, KSN, and DIM; formal analysis, AS and DIM; data curation, AS; writing and drafting of the original draft, AS and KSN; writing, review, and editing, AS, KSN, and DIM. All authors have read and approved the published version of the manuscript.

FUNDING INFORMATION

The authors received no financial support for the research, writing, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest.

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