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Studies Focusing on the Green Hospital Concept; A Bibliometric Analysis

Engin Yavaş
Balikesir Vocational School, Department of Business Management, Balikesir University, Balikesir, Turkey
engin.yavas@balikesir.edu.tr
https://orcid.org/0000-0002-0371-5453

Fulya Güngör
Balikesir Vocational School, Department of Marketing and Advertising Balikesir University, Balikesir, Turkey
fulya.gungor@balikesir.edu.tr
https://orcid.org/0000-0002-4400-5677

Abstract: *Sustainability principles, which have become inevitable today, have become one of the main actors of the transformation in the health sector. In this study, scientific publications on green hospitals and green health services were examined from a bibliometric perspective, and publication trends, collaborations, and thematic focus points were examined. Publications with the theme of "green hospitals" and "green health services" in the Scopus database were analysed with VOSviewer software. The analysis results show that green hospital practices are becoming an increasingly important research area in the healthcare field. The high number of publications in 2022 and the average number of citations in 2021 indicate that this topic is of academic and practical interest. Strong collaboration networks between countries show that countries such as Saudi Arabia, India and the USA are leaders in this field and have formed a global research ecosystem. This study provides a basis for researchers and policy makers to better understand the role that green hospital practices can play in reducing the environmental footprint of healthcare.*

Keywords: *green hospital; green healthcare; Vosviewer; bibliometric.*

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1. Introduction

2.4 million tons of waste each year; it is also among the highest energy consumers in many societies. Hospital waste and high energy use directly affect the health of the environment and therefore human health. Hospitals are not only responsible for treating patients within their own walls; they also have the responsibility to protect the general health of their employees, patients and society through environmental practices beyond these walls. Creating an environmentally sensitive hospital and ensuring its sustainability is a shared responsibility of many stakeholders within the institution (Harris et al., 2009).

The green movement, which is seen as an effective method for healthcare providers with goals such as providing quality healthcare services, using resources effectively, and reducing costs, is being followed and implemented with interest by conscious healthcare businesses. The traces of this green movement should be seen in the design, construction, and technology and workflows used in service processes of hospitals. It is seen that leaders who adopt the green healthcare concept, internalise this concept in their corporate culture, and apply its methods, also have an important place in the green healthcare movement. Therefore, green healthcare services, which are a major approach that does not only include environmental movements, but also includes the design of the leader, employees, work processes, and physical resources, are expected to be a part of the entire healthcare system in the future.

For example, Global Green and Healthy Hospitals (GGHH), which was launched in late 2011, has quickly spread to 32 countries from every continent and reached over 600 members representing more than 20,000 hospitals and healthcare centers. With its framework created in line with ten basic and interconnected goals, GGHH supports its members in implementing sustainability projects, monitoring their progress and working collaboratively for comprehensive transformations in the healthcare sector. This global network operates as part of the Health Care Without Harm initiative (Global Green and Healthy Hospitals (GGHH), 2015).

According to the studies in the literature, the concept of green health services and green hospitals, which will become more important in the future, deserves more research today. In this study, it was aimed to examine the comprehensive studies by making a bibliometric analysis. The prominent authors, institutions, scientific collaborations and research trends in the literature on the subject will be scientifically mapped. In the light of the results, suggestions for future studies will be presented.

2. What is a Green Hospital?

The concept of sustainable green building gained importance in the mid-1990s with the Triple Bottom Line (TBL) approach developed and popularised by environmental business pioneer, John B. Elkington. The TBL framework envisages evaluating corporate success not only with economic returns, but also with social and environmental impacts. This approach argues that organisations that lack social responsibility and environmental awareness cannot maintain their sustainability in the long term due to increasing operating costs and decreasing customer loyalty. According to the TBL perspective, the main purpose of green building design is to contribute to the healthier, happier and more productive lives of individuals who reside, work, receive education or receive healthcare services in these structures by encouraging the efficient use of resources such as land, water, energy, and building materials (Kumari & Kumar, 2020). The United States Green Building Council (USGBC), established in 1993, was one of the first institutions in this field, and in 2000, it launched the LEED (Leadership in Energy and Environmental Design) rating system, which measures the sustainability of buildings. In India, the India Green Building Council (IGBC) was established in 2001, and these developments were carried to a global level with the establishment of the World Green Building Council (World GBC) in 2002 (Dhillon & Kaur, 2015; Wood et al., 2016).

Green buildings have also come to the fore in the healthcare sector because they are not limited to areas such as offices, shopping malls, residences, factories, and hotels, but are also used

in hospitals that are in use 24/7 and consume large amounts of energy, food, and medical supplies to provide high-quality care, are a significant source of pollution worldwide, and have a large and costly carbon footprint. They reduce pollution, waste, and inefficiency in the healthcare sector, and provide financial and ecological benefits, allowing for the creation of a sustainable healthcare infrastructure (Karaca, Atılgan, & Zekioğlu, 2018). During this period, different regional green building rating systems such as BREEAM (England), Green Star (Australia), CASBEE (Japan), and Green Mark (Singapore) have also begun to be developed. Green building applications have attracted attention, especially in the healthcare sector, and in 2009, Kohinoor Hospital in Mumbai became the first hospital in Asia and the second in the world to receive LEED Platinum certification. Today, more than 28 hospitals in the United States have LEED Gold and Platinum certification, and green hospitals play an important role in combating climate change, resource scarcity, and environmental toxins (Dhillon & Kaur, 2015; Wood, et al., 2016). Today, it is seen that environmental sustainability has become a priority approach in healthcare facilities in developed countries. While hospitals in the US are highlighted as the second-largest commercial sector in energy consumption, solutions are being produced for this; in the UK, the NHS is implementing strategies to reduce carbon emissions and increase resource efficiency. In this context, the Sustainable Development Commission was established, and with the green hospital concept, both the ecosystem is protected and the well-being of individuals is supported in the provision of healthcare services (Kılıç & Güdük, 2018).

Steps supported as sustainable or green movements have increased their presence in the health sector, as in every field, due to reasons such as increasing costs, efficient use of natural resources and financial assets. Healthcare businesses are changing their infrastructures in this direction in order to use their resources effectively, reduce costs, gain competitive power, be supported by healthcare users and meet the environmental and economic expectations of healthcare investors.

The concept of green hospital is referred to as a health facility that fulfills some features such as efficiency in energy and water use, reasonable air pollution, use of valuable materials, and cares about sustainability in the design of structures and processes. These hospitals are driven by ecological concerns such as green education, green products, non-toxic environments, green cleaning, and waste reduction (Lattanzio et al., 2022). Management of non-medical waste in and around the hospital is a matter that people and all stakeholders need to achieve a healthy life in order to create a green hospital. Management of non-medical waste in terms of waste container, waste collection and transportation directly affects the comfort and satisfaction of patients (Suwasono et al., 2013). In addition, energy, water, waste management, and facility facilities are not enough to introduce the green hospital concept, but leadership is also essential at all levels. This means that leadership clearly states the basic priorities of the organisation and environmental health, safety, and sustainability. This can be accomplished through training, goal setting, accountability, and incorporating these priorities into all relationships and external communications (Azmal et al., 2014).

Finally, in order for a hospital to be described as a green hospital, it is necessary to explain the seven basic steps that summarise all these explanations. The seven basic elements of the World Health Organization for a green hospital are: (World Health Organization and Health Care Without Harm, 2009)

- Reduce your hospital energy consumption and costs with efficiency and savings measures (Energy efficiency).
- Build hospitals that are responsive to local climate conditions and optimised for reduced energy and resource demands (Green building design).
- Generate and/or consume clean, renewable energy on-site to ensure a reliable and resilient business (Alternative energy generation).
- Use alternative fuels for hospital vehicle fleets, encourage walking and biking to the facility, encourage staff, patients and the community to use public transportation, and locate healthcare facilities to minimise the need for staff and patient transportation (Transportation).
- Provide sustainably grown, local foods for staff and patients (Food).

- Reduce, reuse, recycle, compost; develop alternatives to incineration (Waste).
- Conserve water, avoid bottled water if safe alternatives are available (Water).

The concept of green hospitals has been changing and developing with great strides from past to present. In addition, green hospitals and green health services can be considered as a creative and new area where they can create a competitive advantage for health services with limited competitive areas. In fact, this understanding, which does not have many disadvantages other than human resources and initial costs, will bring a world where the winners in the field of health are mostly the environment and society, along with the many advantages it will bring.

3. Green Hospital Rating Systems

The spread of green hospital practices on a global scale has necessitated the development of various certification systems in order to ensure the traceability of standards in this field. These systems evaluate and score healthcare facilities in line with multi-dimensional criteria such as energy efficiency, waste management, environmental impact, user health and safety, and offer different certification levels, according to the scores obtained. These certificates are briefly summarised in the table below (Çilhoroz & Işık, 2019; Erdede, Erdede, & Bektaş, 2014).

Creating more standards for green hospitals and health services will be effective in improving the process. Strong standards to be created nationally and internationally, and a realistic audit process will provide the desired efficiency in the future of the system and health services.

Table 1. Healthcare Certification Systems Comparison

Certification System	Country/Year Developed	Evaluation Criteria	Certification Levels
BREEAM for Healthcare	UK / 1990	• Energy efficiency • Comfortable, healthy and peaceful environment • Innovation in production and other processes • Sustainable land use • Sustainable material selection • Sustainable management • Pollution prevention • Access to transportation • Waste reduction • Water efficiency	• Pass (30 Points) • Good (45 Points) • Very Good (55 Points) • Excellent (70 Points) • Outstanding (85 Points and above)
LEED for Healthcare	USA / 1998	• Location and transportation • Sustainable sites • Water efficiency • Energy and atmosphere • Materials and resources • Indoor environmental quality	• Certified (40-49 Points) • Silver Certificate (50-59 Points) • Gold Certificate (60-79 Points) • Platinum Certificate (80 Points and above)

		• Innovation in design • Regional priority • Integrative process	
CASBEE	Japan / 2001	• Indoor environment • Service quality • Outdoor environment on land • Energy • Resources and materials • Outdoor environment	Five different certificates can be awarded: C, B-, B+, A and S. C indicates the lowest level of environmental efficiency, while S indicates the highest level of sustainability.
Australian Green Star	Australia / 2003	• Management • Indoor environmental quality • Energy efficiency • Transportation • Water efficiency • Material use • Land use and ecology • Emissions • Innovation	• Best Practice (45-59 Points / 4 Stars) • Excellent for Australia (60-74 Points / 5 Stars) • World Leadership (75 Points and above / 6 Stars)

4. Green Healthcare

Green healthcare refers to the integration of environmentally friendly practices into healthcare service delivery. This green movement, which is gaining strength in the healthcare sector, allows hospitals to provide services with environmental sustainability in mind, raise environmental awareness in society, assume a leadership role and reduce costs at the same time. Many healthcare professionals find this approach extremely valuable due to its potential to contribute to the protection and development of health. In line with the increasing awareness and interest in recent years, it has become important to determine and examine the basic components of this movement (Albrecht & Petrin, 2010). The green healthcare system goes beyond being just an environmental approach and refers to a holistic transformation encompassing all components of healthcare services. This approach includes integrated practices in many areas such as leadership, substituting harmful chemicals with safer alternatives, disposing of waste safely in terms of the environment and human health, energy efficiency and use of renewable energy, sustainable transportation policies, healthy and local food supply, environmentally friendly building design, safer drug use, and purchasing processes based on environmental criteria. Thus, health systems become sustainable structures that not only treat diseases but also take care of ecosystem health (Fadda, 2019). In recent years, it has become important for hospitals, which attach importance to service quality and economy, to adopt environmentally friendly strategies compatible with the ecological environment. From the construction of hospital buildings, attention is paid to the widespread use of modern technologies in all designs and processes, to the organisation of all clinical and non-clinical workflows, and to making them process-oriented and optimal. In this context, for an effective health service, a cultural change dominated by a green understanding, the use of safer and healthier alternative materials, environmentally friendly waste management practices, and the minimisation of operating expenses should be aimed for both society and businesses (Terekli, Özkan, & Bayın, 2013).

5. Methodology

5.1. Purpose and Method of The Research

This study aims to determine academic trends in green hospital practices in healthcare. For this purpose, the following research questions were formulated to analyse and map the trends of academic studies on the green hospital concept over the years:

- What is the distribution and change of articles focusing on green practices in healthcare institutions over the years?
- What is the change in the average number of citations to articles on green practices in healthcare institutions over the years?
- Which sources publish the most articles on green practices in healthcare institutions?
- Which are the most frequently cited works on green practices in healthcare institutions?
- Which authors have established the strongest intellectual collaborations among authors focusing on green practices in healthcare institutions?
- Which countries have established collaborations among authors focusing on green practices in healthcare institutions?
- What are the most frequently used keywords in articles on green practices in healthcare institutions?
- How have the theoretical and methodological clusters that authors examining green practices in healthcare institutions jointly utilised been shaped?

Table 2. Procedures of the research

Performance Analysis	Science Mapping
Annual Scientific Production of The Concept	Co-authorship of Authors
Annual Average Citation of The Concept	Co-authorship of Countries
Most Relevant Sources About The Concept	Word Cloud of Keyword
Most Global Cited Articles About The Concept	Co-citation of Cited Authors

To find answers to research questions, performance analysis and scientific mapping methods (Noyons, Moed, & Luwel, 1999) are used (See Table 2.). The Biblioshiny interface was used to visualise performance metrics. In the evaluation of publication performances, the numerical magnitudes of productions because of documents, journals, authors and countries were taken as the basis (Thelwall, 2008). Bibliometric and scientific mapping analysis was applied to define the relationships between publications and authors, and to examine the structure and evolution of the research field (Guleria & Kaur, 2021). VOSviewer software was used to visualise scientific mapping analyses. In scientific mapping, each node represents a unit of analysis, the size of the node represents the volume of the research output, the thickness of the lines represents the density of the connection, and the distance between the nodes represents the closeness of the collaboration (Huang et al., 2019).

5.2. Data

The data collection process was conducted through the SCOPUS database. The research was limited to studies published between 2000-2022. Within the scope of the search strategy, the term "Green" was used in the first line, and the terms "hospital", "hospitals", "healthcare", "health care", or "health services" were used in the second line. These two lines were combined with the AND conjunction. Keywords were searched in the title sections of the articles. Only articles written in English were included in the scope and only articles were selected as the document type. As a result of these criteria, 205 works were obtained and exported for analysis.

• Findings

• Performance Analysis Findings

When the distribution of articles on green hospital applications in healthcare institutions is examined by year, it can be said that interest in this subject has increased in recent years. An exponential growth is observed in publications related to the concept, especially as of 2018. It is observed that the year with the most publications is 2022, reaching a total of 38 (See Figure 1.)

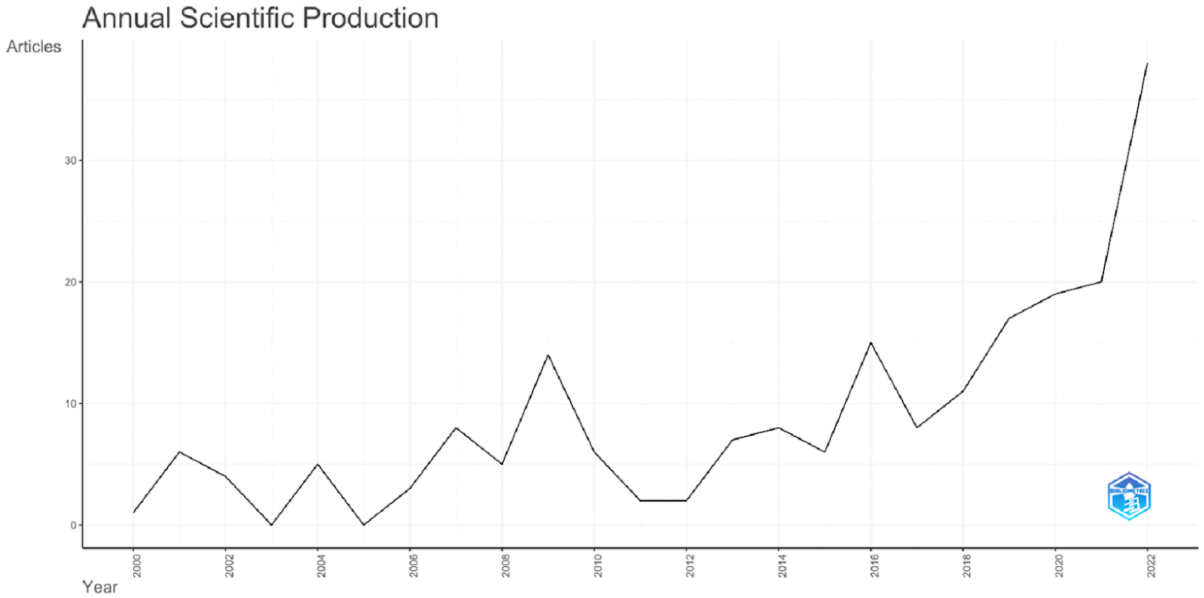

Figure 1. Annual Scientific Production

When the distribution of citations (average citations per year) given to articles on green hospital practices in healthcare institutions is examined by year, it is observed that it is parallel to the increasing number of publications. It is seen that the annual average of citations given to articles related to the concept reached 8.8 in 2021. (See Figure 2.)

In terms of sources, when looking at the journals in which articles on the concept are published, it is seen that Journal of Cleaner Production (8), New Zealand Medical Journal (8) and Health Facilities Management (7) are the most published sources on the subject. (See Figure 3.)

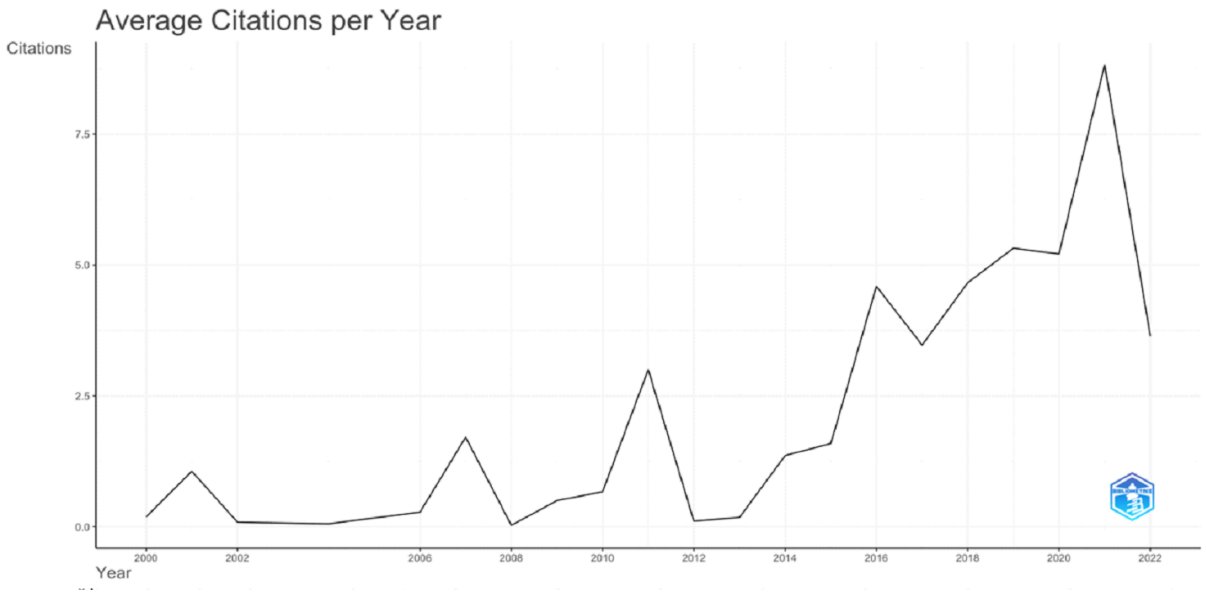

Figure 2. Average Citation per Year

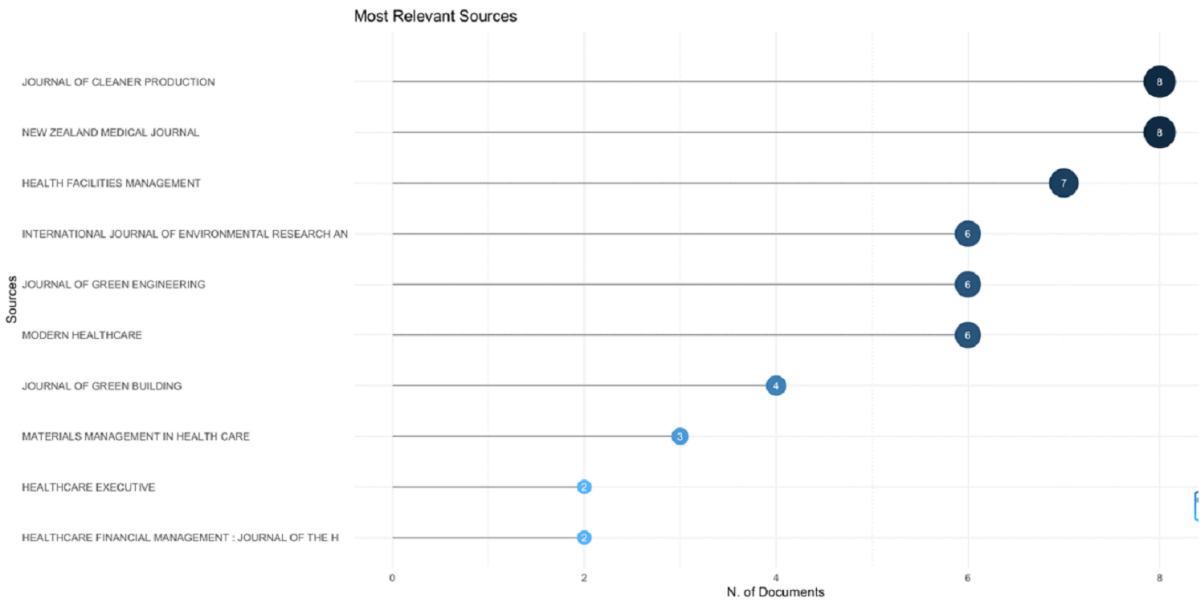

Figure 3. Most Relevant Sources

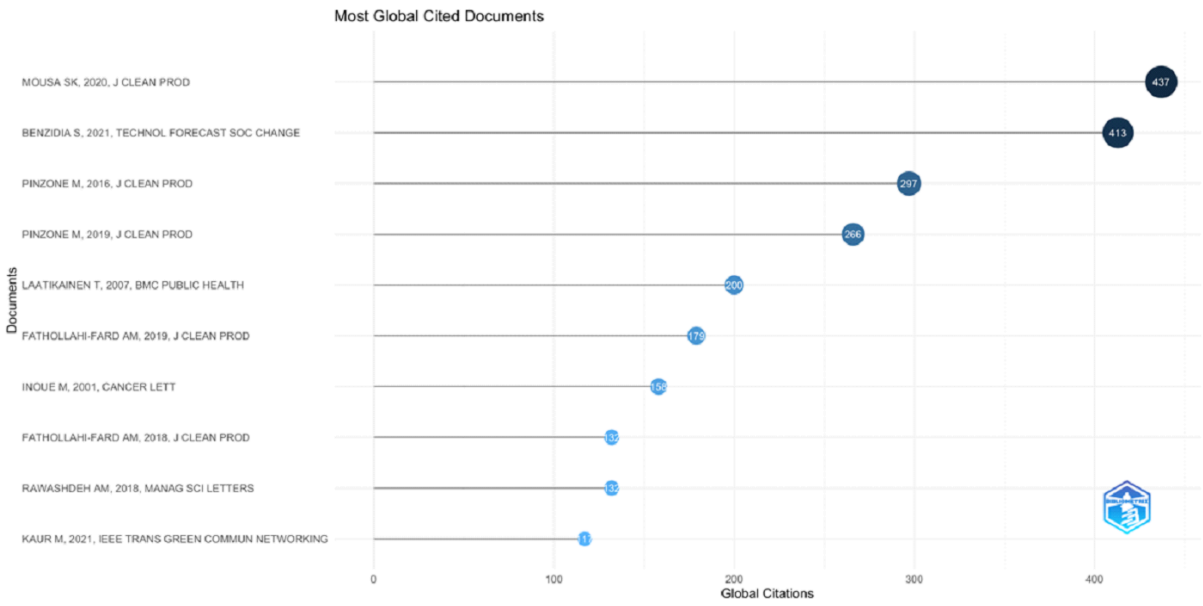

Figure 4. Most Global Cited Articles

When the most cited works on the concept are examined, the most cited work (437) is the study titled "The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework" published by Mousa (2020) in the Journal of Cleaner Production. Other studies that follow this are the work titled "The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance" published by Benzidia (2020) in New Zealand Medical Journey, which is cited 312 times. It is observed that the work titled "Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM" published by Pinzone (2019) in the Journal of Cleaner Production is cited 297 times. (See Figure 4.)

- Bibliometric and scientific mapping findings
- Co-authorship of Authors

According to the co-authorship analysis of the authors, a network map was created by determining the criteria of at least 1 publication and at least 1 citation to identify the most connected and collaborating authors. According to the analysis made among the names with the highest connection, it is seen that there are 15 names that are combined in 2 clusters, a total of 89 connections. It is observed that the analysis of the network map reveals two well-differentiated clusters. The first cluster represented in red includes researchers named James D. Best, Stephen Bunker, James A. Dunbar, Edward D. Janus, Adrienne O'Neil, Ben Philpot, Prasuna Reddy, and Erkki Vartiainen. The second cluster represented in green includes researchers named Sami Heistaro, Annamari Kilkkinen, and Tiina Laatikainen. (See Figure 5.)

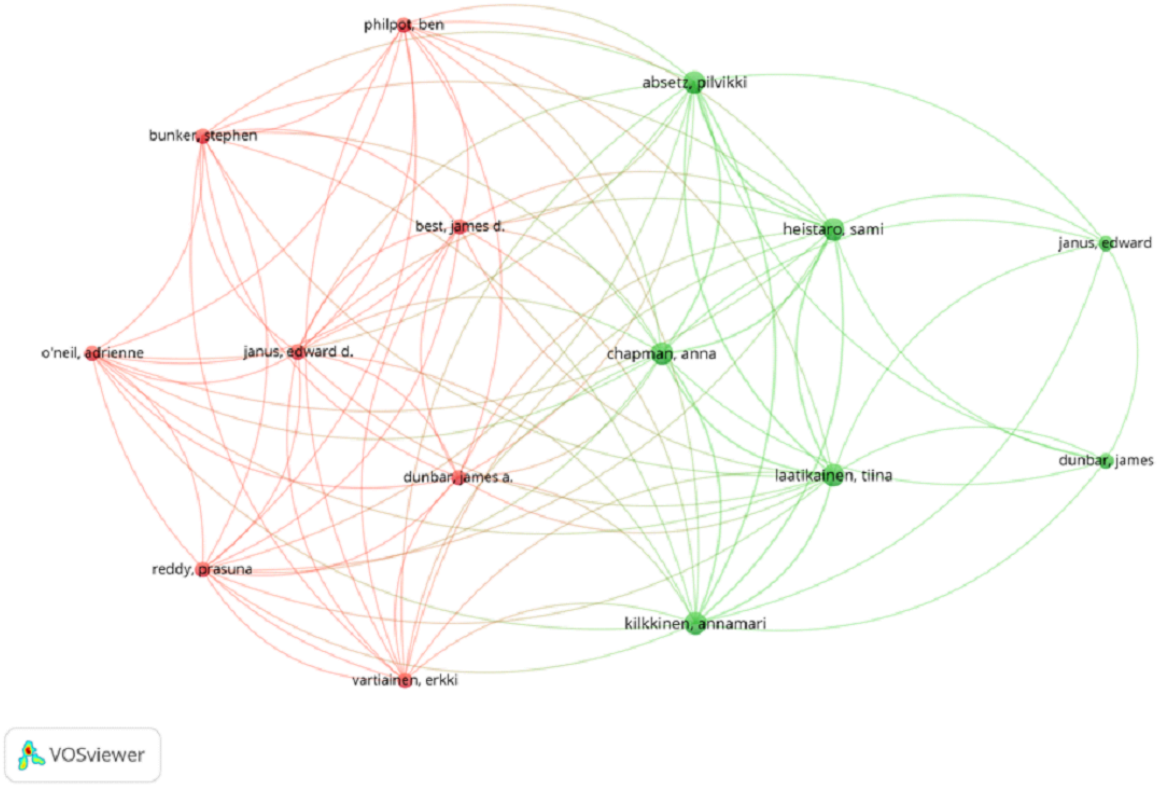

Figure 5. Co-authorship of Authors

5.3. Co-authorship of Countries

In order to identify the countries of authors with the highest levels of collaboration and connectivity, a network map was created based on the criteria of having at least one publication and one citation. According to the analysis of the countries with the highest link strength, 30 countries formed seven clusters with a total of 66 links. The countries with the strongest collaboration strengths were Saudi Arabia (20), India (17), and the United States (15). These collaboration networks highlight the global significance of the topic and demonstrate mutual interest and interdependence in advancing research on green hospitals at an international scale (see Figure 6).

The prominence of these countries is not solely a reflection of academic productivity, but also appears to be supported by their respective national policies and strategic initiatives. For instance, Saudi Arabia's "Vision 2030" agenda includes objectives related to environmental sustainability and the modernisation of healthcare infrastructure. Similarly, India promotes green building certification processes, including for hospitals, through the Indian Green Building Council (IGBC). The United States, on the other hand, encourages the development of environmentally friendly healthcare facilities via the widespread implementation of the LEED (Leadership in Energy and Environmental Design) certification system. These national strategies likely contribute to the increased scholarly attention devoted to these countries in the field of green hospital research.

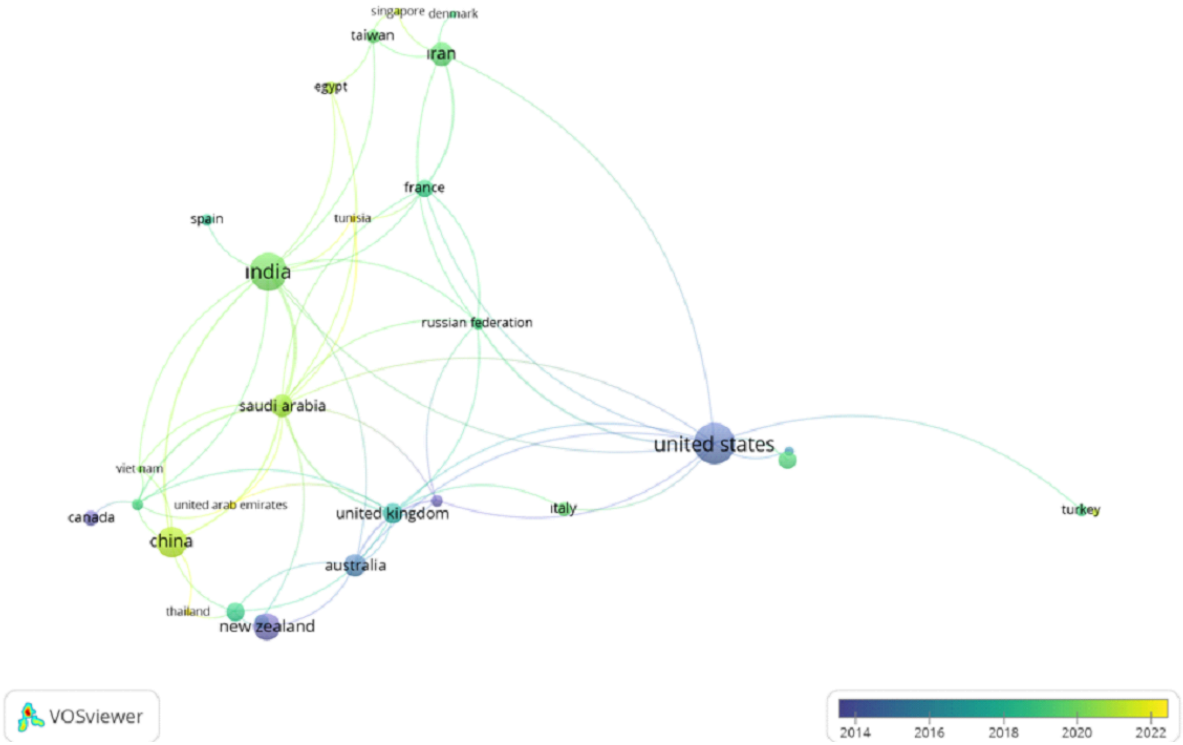

Figure 6. Co-authorship of Countries

5.4. Word Cloud of Author Keywords

The keywords used in the articles whose data were collected within the scope of bibliometric analysis were used to analyse the most frequently used words on this subject. Like thematic development, green hospital and hospital (11) times are used most frequently in the keywords of the studies. In addition to these, it is observed that the themes sustainability (8), climate change (7), Green Building (6) and environment (5) are prominent. (See Figure 7.)

Figure 7. Word Cloud of Author Keywords

5.5. Trend Topics of Author Keywords

A trend topic visual was prepared to understand the thematic development of the keywords used in the articles, whose data were collected within the scope of bibliometric analysis (See Figure 8). While preparing the visual, we excluded the concepts of "health services" and "hospital", which

were the keywords we used when preparing the data set. In this way, we aimed to reveal the sub-themes of the "green hospital" theme.

According to Figure 8, it can be mentioned that the sustainability keywords were weighted in relation to the concept after 2006. Later, it is seen that the weight shifted to climate change. It is understood that the themes that emerged especially in the period after 2020 are related to the covid-19 and green hospital keywords.

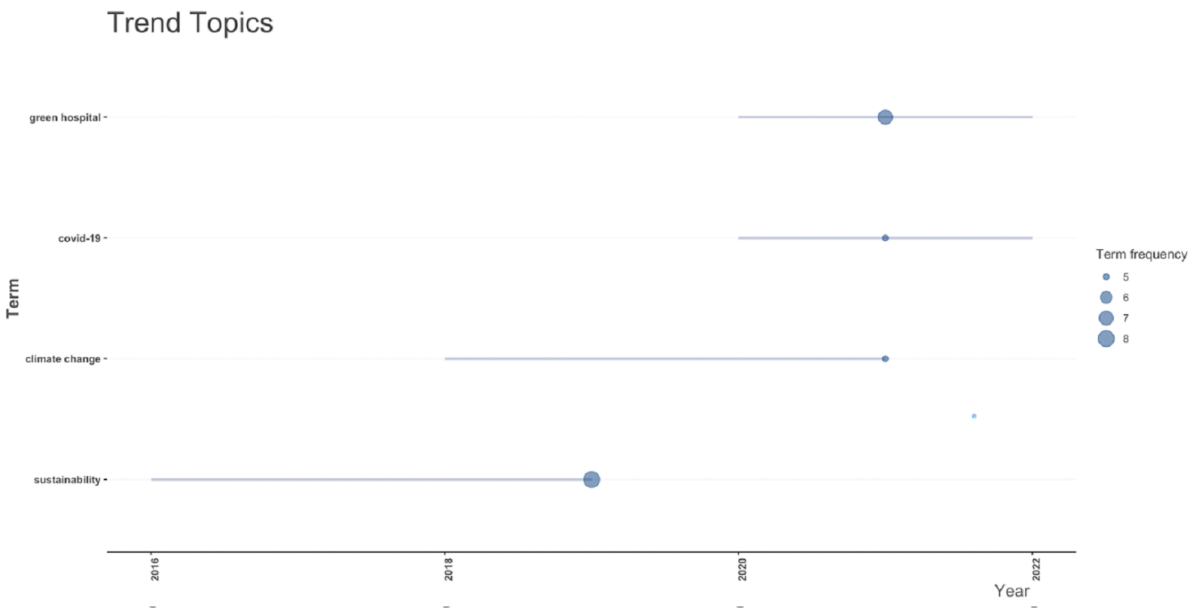

Figure 8. Trend Topics of Author Keywords

5.6. Co-Citation of Cited Authors

Different sources cited in a publication are called co-citations (See Figure 9). A total of 10 clusters, 9,277 connections and 53,666 total connection strengths were identified based on the analysis conducted on 289 units, by selecting a minimum of 5 citations. The authors with the highest number of co-citations were Jabbour C. J. C (37), Hajiaghaei-keshteli M. (34), and Barratt-Boyes B.G. (34).

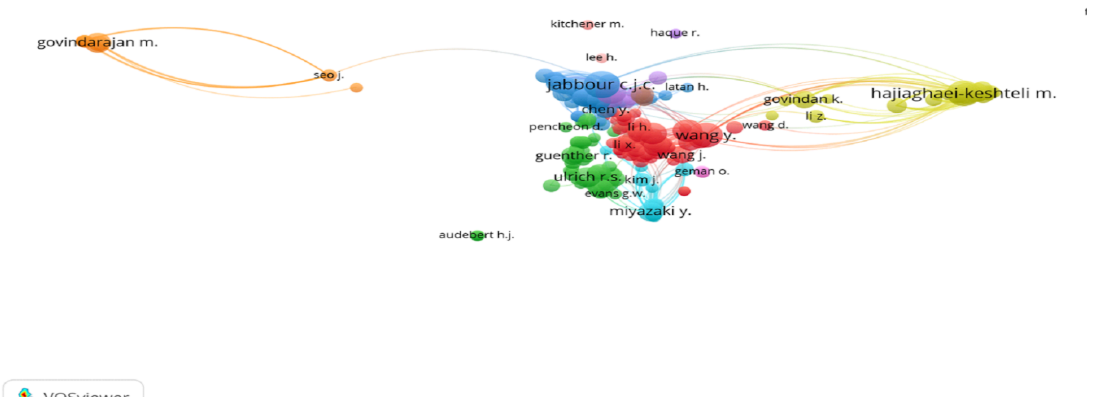

Figure 9. Trend Topics of Author Keywords

6. Results and Conclusions

The green hospital and green health service products created by the sustainable approach in health services include only the reduction of costs, energy saving, and protection of waste in the process. While a more comprehensive process including this information continues; the issue of

maintaining its standards and inspection also draws attention. The health sector is not limited to treatment and care services. It is to ensure that energy efficiency, waste consumption, carbon emissions, temperature, and the economic system are maintained in society. For these, not only technological solutions, but also its work step and service approach should carry the traces of this approach.

It would be beneficial for academic studies to contribute scientifically as much as sectoral applications to adopt sustainable green strategies and ensure continuity. Although scientific interest in this field has increased, it can be said that there are still gaps in the literature. Therefore, this study is also important for future academic studies to fill the gaps in the literature, increase case studies, and examine the effects of these applications on the quality and cost-effectiveness of health services in more depth. In this context, bibliometric analyses provide a guiding resource for both researchers and decision-makers, by revealing the structure and trends of the field.

The research was based on content indexed in the Scopus database. The search strategy focused on leadership types in healthcare institutions and combined the term "Green" with the expressions "hospital", "hospitals", "healthcare", "health care", or "health services", with the conjunction AND. The years examined ranged from 2000 to 2022 and were limited to the article document type only. As a result of the search conducted with these criteria, data belonging to 205 articles were exported.

With the data of 205 exported articles, performance analyses were performed on the concept using techniques such as counting publications by authors, institutions, or countries and visualised with the Biblioshiny interface. The metrics used in the performance analysis are the annual publication numbers, annual average citation numbers, the journals with the most publications and the publications with the most citations. In addition, using the VOSviewer software, co-authorship of authors, co-authorship of authors' countries, wordcloud of author keywords, and Co-Citation of Cited Authors, analyses were performed and network maps were created.

According to the findings, the year with the most publications (38) on green hospital practices in healthcare services is 2022. In 2021, an average of 8.8 citations were made to all articles on the concept. Journal of Cleaner Production (8) and New Zealand Medical Journal (8) stand out as the sources that publish the most articles on the subject. The study titled “The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework” published by Mousa (2020) in the Journal of Cleaner Production is the most cited work (437). The co-authorship analysis reveals two differentiated clusters, and it is seen that there are 15 names and a total of 89 connections. In the analysis conducted to understand the cooperation between countries, it is seen that there are 30 countries united in 7 clusters and a total of 66 connections. The countries with the strongest connection strength are observed as Saudi Arabia (20), India (17), and US (15). In the word cloud analysis of the keywords, it is seen that in addition to the most frequently used expressions such as green hospital and hospital (11), themes such as sustainability (8), climate change (7), Green Building (6), and environment (5) also emerge.

These findings indicate that green hospital practices are becoming an increasingly important area of research in healthcare. The high number of publications in 2022 and the average number of citations in 2021 reveal that this topic is attracting academic and practical attention. The high citation of Mousa’s (2020) study emphasises that issues such as green human resource management are critical for sustainable healthcare. The strong cooperation networks between countries show that countries such as Saudi Arabia, India, and the US are leading in this field and have created a global research ecosystem.

Keyword analysis reveals that green hospitals not only reduce environmental impacts but are also linked to broader global issues such as sustainability and climate change. This provides researchers and policymakers with a foundation to better understand the role that green hospital practices can play in reducing the environmental footprint of healthcare.

However, it is important to acknowledge certain limitations of this study. The research was based solely on data indexed in the Scopus database and was limited to articles published in

English. This may have led to a language and database bias, potentially overlooking valuable studies published in other languages or indexed in different regional databases. To obtain a more comprehensive and global perspective, future studies are encouraged to incorporate additional data sources such as Web of Science, PubMed, or regional databases.

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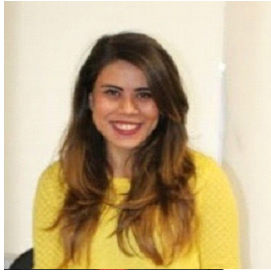
Engin YAVAŞ (b. November 27, 1986) received his BA in Economics from Bolu Abant İzzet Baysal University (2011), his MA in Business Administration Programming from Ankara Atılım University (2014), and his PhD in Health Management from Ankara Gazi University (2023). He is currently a lecturer in Healthcare Institutions Management at Balıkesir University. His current research interests include different aspects of Health Insurance, Health Economics and Health Tourism. He is the author of 1 book chapter and (co-)author of more than 4 articles.



Fulya GÜNGÖR (b. May 01, 1990) Bachelor of Business Administration (2012), Master's degree in Marketing Programme (2016) from Marmara University. PhD in Business Administration (2023) from "Balikesir" University. Now she is assistant professor in the Department of Marketing and Advertising, at Balikesir University, Turkey. Her areas of interest include research on entrepreneurship, strategic management, human resources and marketing.