Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Sustainable Healthcare: Unveiling the Green Innovation Landscape in Nursing and Health Sciences

Syaifurrahman Hidayat[1*], Mujib Hannan[2], Nailiy Huzaimah[3], Emdat Suprayitno[4], Elyk Dwi Mumpuningtias[5], Ratna Indriyani[6], Sri Yunita Suraida Salat[7]

[1,2,3,4,5,6,7] *Faculty of Health Science, Universitas Wiraraja, Indonesia*

Abstract : This article discusses the importance of green innovation in nursing and health sciences to create sustainable and environmentally friendly practices. Through bibliometric analysis of 400 publications indexed by Scopus, Web of Science, and Google Scholar from 2014-2024, this article identifies factors that drive green innovation in the field. The findings of the analysis provide a basis for policy development, educational curriculum development, and guidance for health practitioners to implement sustainable practices. It is expected that this article will not only provide academic contributions but also have significant practical impacts in improving the quality of health services and environmental sustainability.

***Keywords*:** green innovation, nursing, health, bibliometrics

Introduction

In an era of increasing environmental awareness, sustainable innovation is becoming increasingly important in various fields, including nursing and health sciences. Green innovation is a concept that aims to develop products, services, and processes that minimize negative impacts on the environment and promote ecological restoration[1]. Green innovation is needed in various aspects of life, including nursing and health sciences. This is because:

Green innovation helps reduce the negative environmental impacts of health practices, such as reducing medical waste and energy efficiency, thereby supporting environmental sustainability[2]. Green innovation practices can improve the operational efficiency of health facilities, such as the use of green technology, which in turn can improve the overall quality of health care[3]. Green training can increase the commitment of healthcare staff to pro-environmental behaviors, which is important in improving the environmental impact of daily health practices[4]. The implementation of green innovation can help improve the overall quality of health care, both in terms of operational efficiency and positive impacts on the environment[5].

With increasing awareness of environmental and sustainability issues, green innovation is important in responding to the global demand for environmentally friendly health practices[6]. Green innovation in nursing and health sciences is a growing area of interest driven by factors such as rising resource costs, climate change mitigation efforts, and the need for sustainable practices in healthcare facilities [7]. Research in this area covers a wide range of aspects, including sustainability in healthcare operations, such as water and energy conservation [7], promoting sustainable diets in healthcare systems [8], and integrating sustainability into healthcare quality management practices (Sustainability and Quality Management in Healthcare During COVID-19). Studies have shown that providing green training can increase commitment to pro-environmental behaviors among healthcare staff [9], and adapting green human resource management practices can improve sustainability performance in the healthcare sector[10].

Furthermore, there is a call for healthcare professionals to play a role in promoting sustainability in clinical and community settings [11], with initiatives such as the Australian and New Zealand College of Anaesthetists highlighting the importance of environmental sustainability in medical practice [7]. Integrating sustainability into healthcare education has also been highlighted as important, with efforts to include sustainable healthcare learning

objectives in medical curricula [12]. In addition, the role of medical devices in contributing to sustainability in healthcare delivery is being explored[13].

Efforts to incorporate sustainability into healthcare practice extend to community-based healthcare [14], postgraduate medical education[15], and undergraduate medical education through frameworks such as Sustainability in Quality Improvement (SusQI) [16]; [17]. Collaborative healthcare approaches are advocated to enhance social sustainability in healthcare systems [18]. Overall, there is consensus among healthcare professionals that addressing environmental sustainability is a moral imperative, necessitating a shift to more sustainable practices in healthcare delivery[19].

In the context of nursing and health sciences, green innovation includes practices that reduce medical waste, save energy, use environmentally friendly materials, and apply green technology to improve the quality of health services.

In the context of green innovation research in nursing and health sciences, several problem formulations that can be identified are:

1) How has the development of publications related to green innovation in nursing and health sciences been over the past few years?
2) What are the trends that can be identified in research on green innovation in nursing and health sciences?
3) What aspects of green innovation are the focus of research in the context of nursing and health sciences?
4) To what extent has the implementation of green innovation had an impact on daily health practices and the environment in health facilities?
5) What are the research needs that have not been met in understanding and implementing green innovation in nursing and health sciences?

Based on the problem formulation above, the research objectives that can be determined are:

1) To analyze the development of the number of publications related to green innovation in nursing and health sciences over a certain period.
2) To identify research trends related to green innovation in nursing and health sciences.
3) To evaluate the existing research focus in the context of green innovation, including the aspects emphasized and topics of concern.
4) To evaluate the impact of green innovation implementation on daily health practices and the environment in health facilities.
5) To identify research needs that still need to be met to improve the understanding and application of green innovation in nursing and health sciences.

Writing a research article on "Bibliometric Analysis of Green Innovation in Nursing and Health Sciences" has several practical benefits that can make important contributions to the field of nursing and health sciences and overall health practice, including:

1) This article can increase the awareness and understanding of academics, researchers, and health practitioners about the importance of green innovation in building sustainable and environmentally friendly health practices.
2) The findings of the bibliometric analysis can provide a basis for developing policies that support the implementation of green innovation in health services, both at the institutional and government levels.
3) The results of this study can be used to develop educational and training curricula for health professionals so that they can gain the knowledge and skills needed to implement sustainable practices.
4) This article can encourage innovation in clinical practice, such as the use of green technology, reducing medical waste, and increasing energy efficiency in health facilities.
5) Implementing green innovation practices is expected to improve the quality of health services as a whole, both in terms of operational efficiency and positive impacts on the environment.
6) This article can be a guide for researchers to determine the direction of further research that is more in-depth and specific in the field of green innovation in nursing and health sciences.

Thus, the writing of this research article not only provides academic contributions but also has a significant

practical impact on improving the quality of health services and environmental sustainability.

Research Method

Data Collection

1) Searching the Scopus, Web of Science, and Google Scholar databases to find indexed journals relevant to the topic of green innovation in nursing and health sciences.
2) Selecting publications published in the period 2014-2024 to get a comprehensive picture of recent developments[20].
3) Use of Keywords, namely by filtering publications with relevant keywords such as "Bibliometric Analysis", "Green Innovation", "Information System", "Nursing", "Health Sciences", "Hospital", sustainable healthcare", and "environmentally friendly healthcare practices, to ensure relevance to the research topic.
4) Determining the number of samples, by selecting 400 publications that meet these criteria as research samples.

Bibliometric Analysis

1) The Publish or Perish application is used in the analysis to access bibliometric data from publications indexed in Google Scholar, including information on the number of citations, journal impact factors, and author profiles[21].

2) Use of VOS Viewer as software to analyze citation networks between publications, identify dominant citation patterns, and visualize the relationship between keywords and main topics that appear in publications.

Thematic Analysis

Identify Themes, namely by conducting a thematic analysis of selected publications to identify the main themes that are dominant in green innovation research in nursing and health sciences. Use of Thematic Analysis, namely: analyzing publication content to identify trends, research focuses, and current developments in this field[22].

Data Interpretation

Interpretation of Results by analyzing data obtained from the "Publish or Perish" application, VOS Viewer, and thematic analysis to gain a deep understanding of the status, trends, focus, and impact of green innovation research in nursing and health sciences. Conclusion by compiling conclusions based on data interpretation to answer the problem formulation and achieve the research objectives.

Results and Discussions

Research Data Metrics from the Publish or Perish output are presented as follows:

Table 1. Research Data Metrics

Data Metrics	Information
Publication years	2014-2024
Citation years	10
Papers	370
Citations	15121
Cites/year	1512.10
Cites/paper	40.87
Cites/author	5591.85
Papers/author	132.13

Authors/paper	3.50
h-index	53
g-index	118
hI, norm	27
hI, annual	2.70
hA, index	34

Source: *Output* Publish or Perish, 2024

Table 1 presents several relevant metrics for research data conducted in the period 2014 to 2024. A total of 370 papers were published during this period, with a total of 15,121 citations. On average, each paper received 40.87 citations, and the annual citation rate was 1,512.10. Individually, a researcher had an average of 132.13 papers per study and 3.50 authors per paper. In addition, the h-index, which reflects the number of articles that have at least h number of citations, reached a value of 53, indicating a significant level of impact in this research field. The g-index, which measures researcher productivity, reached 118. H-I, norm 27 indicates that this research has a higher impact than the average in its field. H-I, annual of 2.70 indicates an annual growth in impact. Finally, the hA index of 34 indicates that several researchers have a significant influence on their contributions to this research. Overall, these data reflect a substantial history and impact of research conducted during this period.

This bibliometric analysis, as mentioned earlier, aims to analyze the existing literature patterns and also explore the potential for future research. To answer this goal, a more specific grouping is carried out and produces questions such as "How is the existing literature classified and grouped based on similar themes and topics?", "What are the research trends on the topic from year to year and which articles have the greatest impact in the period 2004 to 2024?", "What are the collaborations carried out by the authors?", and finally "What topics are potential for future research?". With the help of the VOS Viewer tool, all of these questions can be answered precisely and comprehensively. The first question related to the classification of existing literature can be answered by utilizing the Network Visualization feature. The results of this feature analysis are attached in Figure 1 below. There is a complex visualization that shows that the topic related to digital innovation in accounting and organizational financial management is a topic that has high complexity. This indicates that the topic is a topic that attracts the attention of researchers.

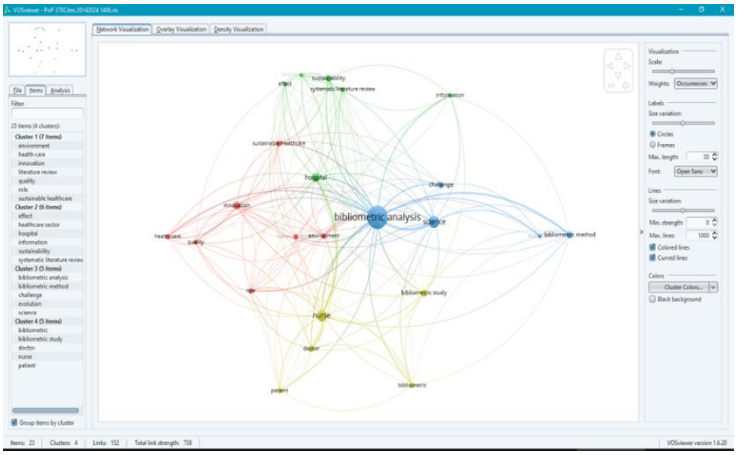

Figure 1. Network Visualization

Source: Database Analysis with VOSViewer, 2024

Figure 1 above shows that there are six different contrasting colors: red, green, blue, and yellow. These colors indicate different groups. While terms with the same color indicate that the terms are in the same group and have

a similar theme or relationship with each other[23]. Thus, the literature on this topic is divided into four groups. The first group is represented by the color red with a total of 7 terms, the second group is represented by the color green with a composition of 6 terms, the third group is represented by the color blue with a total of 5 terms, the fourth group is represented by the color yellow with a total of 5 terms. These groups are hereinafter referred to as clusters. Specifically, Table 2 below explains the composition of each cluster with the most relevant terms.

Table 2. Clusters and Items

Clusters	Cluster Composition
1	Environment, health care, innovation, literature review, quality, role, sustainable healthcare
2	Effect, healthcare sector, hospital, information, sustainability, systematic literature review
3	Bibliometric analysis, bibliometric method, challenge, evolution, science
4	Bibliometric, bibliometric study, doctor, nurse, patient

Source: Database Analysis with VOSViewer, 2024

After successfully identifying the existing literature classification, further analysis was continued using the Overlay Visualization feature in the VOSViewer application. This feature can identify research trends from 2021 to 2022 by referring to the timeline bar in Figure 2 below.

Figure 2. Overlay Visualization, VOSViewer, 2024

From Figure 2 above, we can conclude that terms such as environment, sustainability, and bibliometric method have a dark color (purple) which indicates that these terms are research trends around 2021. Meanwhile, terms such as bibliometric analysis, nurse, doctor, patient, and sustainable healthcare emerged and became trends in 2021 to 2022. Terms such as information, systematic literature review, and challenge are terms that have become research trends in 2022 to date. This research trend can also be examined by identifying the main literature or the most influential literature in this field[24]. The indicator of the impact of existing literature is by identifying the

number of citations so that it can be said that the article with the highest number of citations is the article that has the most impact on scientific developments[25][26] in the field of green innovation in nursing and health science. Table 3 below illustrates the 5 studies with the highest number of citations spread across various journals and scientific article databases.

Table 3. Most Cited Articles

Citations	Author	Title
6 10	Li, Y	Li, Y, Pan, X, Han, Y, Taylor, JE. Sustainable healthcare facilities: A scoping review. Journal of Construction Engineering …. ascelibrary.org; 2021;. Available from: https://doi.org/10.1061/(ASCE)CO.1943-7862.0002170 Li, Y, Abdul-Rashid, SH, Ghazilla, RA Raja. Design methods for the elderly in Web of Science, Scopus, and China National Knowledge Infrastructure databases: A scientometric analysis in cite space. Sustainability. mdpi.com; 2022;. Available from: https://www.mdpi.com/2071-1050/14/5/2545
18	Wang, Y	Wang, Y, Wang, Z, Liu, G, Wang, Z, Wang, Q, ... Application of serious games in health care: scoping review and bibliometric analysis. … in Public Health. frontiersin.org; 2022;. Available from: https://doi.org/10.3389/fpubh.2022.896974
3 1	Li, J	Zhang, Y, Yao, J, Li, W, Wang, H. Global research trends and hotspots in pharmaceutical care: a bibliometric analysis and visualization using CiteSpace and VOSviewer. European Journal of Hospital …. ejhp.bmj.com; 2023;. Available from: https://ejhp.bmj.com/content/early/2023/06/20/ejhpharm-2022-003617.abstract Zhu, H, Li, J, Yuan, Z, Li, J. Bibliometric Analysis of Spatial Accessibility from 1999–2022. Sustainability. mdpi.com; 2023;. Available from: https://www.mdpi.com/2071-1050/15/18/13399
17 23	Liu, Z	Liu, Z, Yang, Z, Osmani, M. The relationship between sustainable built environment, art therapy, and therapeutic design in promoting health and well-being. … of Environmental Research and Public Health. mdpi.com; 2021;. Available from: https://www.mdpi.com/1660-4601/18/20/10906 Liu, Z, Yang, Z, Xiao, C, Zhang, K, Osmani, M. An investigation into art therapy aided health and well-being research: a 75-year bibliometric analysis. … Journal of Environmental …. mdpi.com; 2021;. Available from: https://www.mdpi.com/1660-4601/19/1/232
11 3	Wu, Y	Luo, X, Wu, Y, Niu, L, Huang, L. Bibliometric analysis of health technology research: 1990~ 2020. … Environmental Research and Public Health. mdpi.com; 2022;. Available from: https://www.mdpi.com/1660-4601/19/15/9044 Chen, J, Hao, S, Wu, Y. Housing and health in vulnerable social groups: an overview and bibliometric analysis. Reviews on Environmental Health. degruyter.com; 2022;. Available from: https://doi.org/10.1515/reveh-2020-0167

The table above presents a summary of some important scientific works in the field of environment and its impact on the business world. A study titled “An investigation into art therapy aided health and well-being research: a 75-year bibliometric analysis” by [27] stands out with 23 citations, while other studies, such as “Application of serious games in health care: scoping review and bibliometric analysis “ by [28] with 18 citations, and " The

relationship between sustainable built environment, art therapy and therapeutic design in promoting health and well-being " by [29], also make important contributions with 17 citations.

Furthermore, to answer questions related to topics that are less researched, creating research gaps and potentially becoming interesting topics in the future, we can use the Density Visualization feature[30]. Figure 3 below shows the results of the analysis with some conditions having dim color intensity and some having brighter color intensity. The level of light intensity shows how often the term is used by researchers. The higher the intensity, the more articles use the term and vice versa[31].

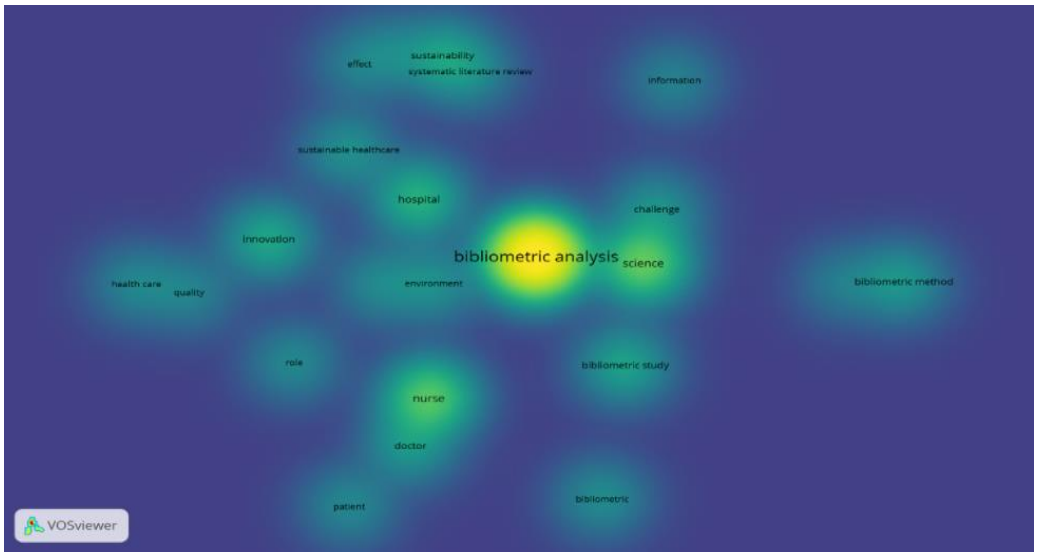

Figure 3. Density Visualization

Source: Database Analysis with VOSViewer, 2024

Based on Figure 3 above, it is known that terms such as bibliometric analysis, nurse, science, and hospital have a fairly high light intensity compared to other terms. This shows that these terms are very often used in previous studies and have the potential to have high saturation so they are not recommended for use in further research[32][33]. Meanwhile, terms such as role, quality, patient, and information have a dim intensity indicating that these terms are still rarely used so they have the potential to be interesting topics for future research[34].

Finally, to find out how collaboration is established between authors, network construction is used based on bibliographic data for each article in the database that we collect. Several authors work together and collaborate while other authors are still individually conducting their research[35][36]. Figure 4 below shows the groups of each author and those who have collaborated.

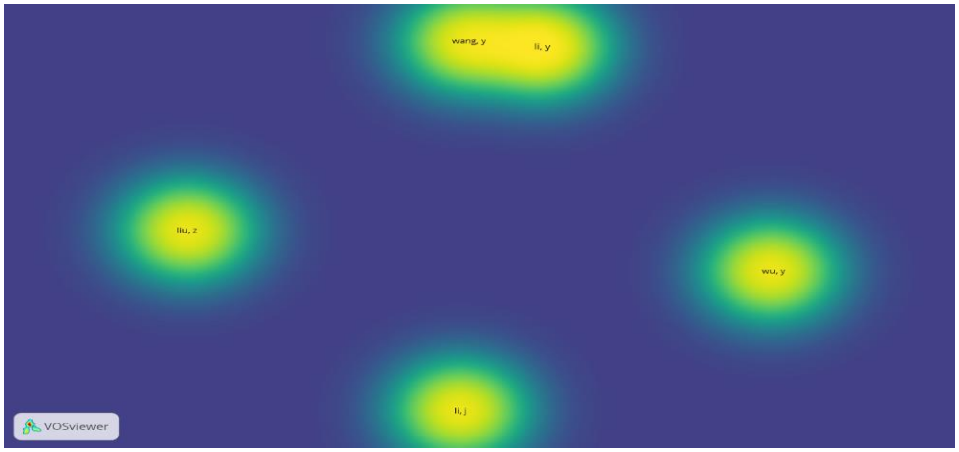

Figure 4. Density Visualization of Author Collaboration

Figure 4 above shows that four groups of authors have conducted collaborative research while the other groups are still individual. This identification is important to find key authors and to collaborate with each author[37]. This is done to enrich the discussion and perspective of research that will later be carried out or published.

Comparison with other Bibliometric Studies

The topic of bibliometric analysis of green innovation in nursing and health sciences has been carried out by several researchers in the past. These studies discuss the use of bibliometric analysis to understand research trends, the interdisciplinary nature of research, and the increasing importance of sustainability. The studies cover a variety of topics, including digital literacy, digital transformation in nursing and health sciences, and the impact of digital technology on sustainability in nursing and health sciences. These studies include those conducted by (Li, Y., 2023; Wang, Y., 2022; Li, J., 2022; Liu, Z., 2023; Wu, Y., 2023). Meanwhile, this article specifically highlights the renewal or green innovation in nursing and health sciences that have not previously been achieved by the above studies, so that this study can complement and enrich the literature on the topic.

The results of this study have an impact on various aspects. First, it provides an in-depth understanding of digital innovation in nursing and health sciences. This provides a basis for professionals to develop insights into the influence of technologies such as big data, artificial intelligence, and cloud technology in nursing and health sciences. Second, it guides further research, helping researchers identify trends and future research contributions. Third, its contribution to the development of theory and practice in nursing and health sciences includes aspects of technology, regulation, ethics, and information security. Fourth, the results of this study can help practitioners, both lecturers, and researchers, adjust to the development of digital innovation, influence the way green innovation sustainability is formulated, risk management is implemented, and decision-making at the organizational level. Fifth, it motivates interdisciplinary collaboration between researchers in the fields of nursing and health sciences learning, information technology, and educational management. Sixth, its relevance can be applied both globally and locally, helping organizations and practitioners in various countries to understand the adoption of green innovation according to local needs. Seventh, it can contribute to the development of educational and training curricula for professional lecturers, nurses, and health practitioners, ensuring that future generations have relevant knowledge and skills. Eighth, it is aware of the impact of digital innovation on information security, which encourages organizations to improve data security policies and practices. Ninth, it opens up a space for public policy discussions that support green innovation and learning in nursing and health sciences. Tenth, it provides a basis for organizations to evaluate their readiness to adopt new technologies.

Limitations and Suggestions for Further Research

Although the results of this study provide valuable insights, some limitations need to be considered. First, the focus on a specific context may limit the generalizability of the findings. Therefore, future research can expand the geographical scope or industry sector to validate the general applicability of the findings. Second, this study may be affected by time factors, as digital technology continues to evolve. Therefore, future research should consider periodic updates to reflect current changes and trends in technology. Third, aspects of ethics and information security can be the focus of further research, given the importance of data integrity and privacy in the digital environment.

For future research, it is recommended that the focus be on further integration between technology and communication strategies, particularly in developing predictive models for analyzing green innovation in nursing and health sciences further regarding the potential risks and benefits of technology adoption. In addition, this study can examine the impact of regulations and policies related to data protection and ethics in the context of digital innovation in nursing and health education. The adoption of technology by organizations can also be identified through more in-depth case studies, which clarify the challenges and benefits that organizations may face in adopting digital innovation.

Similarly, future research could consider the psychological and social aspects of digital innovation adoption by teaching professionals, nurses, doctors, and health practitioners, investigating attitudes, perceptions, and other factors that influence the acceptance and use of such technologies. Finally, it is recommended to involve closer interaction between researchers and practitioners, allowing for better knowledge transfer and understanding of the

practical challenges that organizations may face in implementing digital innovation in the context of nursing and health sciences.

Conclusion

This bibliometric analysis shows that green innovation has become an increasingly important topic in nursing and health sciences. Publications in this area reflect efforts to integrate sustainability principles into everyday healthcare practices. However, further research is needed to better understand the implications of green innovation for improving the quality of health care and ameliorating the environmental impact of health care practices.

The results of the bibliometric analysis show an increase in the number of publications discussing green innovation in nursing and health sciences over the past few years. This reflects a growing awareness among academics and health practitioners of the importance of adopting sustainable practices in this field.

In addition, the analysis also identified several trends in green innovation research in nursing and health sciences, including a focus on reducing medical waste, energy efficiency in healthcare facilities, the use of green technologies in diagnosis and treatment, and a holistic approach to health and the environment

Research Implications

The implications of the results of this literature review article research with bibliometric analysis have a significant impact on academic professionals in the field of nursing and health sciences, including:

In-depth Understanding of Research Trends: The results of bibliometric analysis can provide an in-depth understanding of current research trends in the domain of green innovation in nursing and health sciences. This allows academic professionals to stay informed about the latest developments in their field and identify knowledge gaps that need to be addressed.

Development of Research Plans: Information obtained from literature reviews and bibliometric analysis can help academics in formulating relevant and meaningful research plans. They can use these insights to determine the direction of research to be taken, identify topics of interest, and plan appropriate research methodologies.

Identification of Collaborations and Academic Networks: Citation network analysis in bibliometric research can help academic professionals identify potential collaborations with colleagues and strong academic networks. This can encourage collaboration between institutions, researchers, and health practitioners to advance knowledge and practice in the field of green innovation.

Determination of Research Priorities: The results of bibliometric analysis can help academics in determining better research priorities. They can use this information to select research topics that are relevant and important for the advancement of science and health practice.

Publication and Academic Recognition: A well-written literature review article with bibliometric analysis can be a valuable source of information for the academic community. Such publications can enhance the reputation of the authors, gain academic recognition, and expand their influence in the field of nursing and health sciences. Thus, the results of literature review articles with bibliometric analysis have important implications for academic professionals in improving understanding, developing research, identifying collaborations, setting priorities, and gaining recognition in the field of nursing and health sciences.

Declaration of conflict of interest

There is no potential conflict of interest in research, authorship, or publishing articles.

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