Teaching and Learning in Nursing 20 (2025) 189–196

Contents lists available at ScienceDirect

Teaching and Learning in Nursing

journal homepage: www.journals.elsevier.com/teaching-and-learning-in-nursing

Full Length Article

Climate change in nursing education: A bibliometric analysis of scholarly outputs 2002-2024

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ARTICLE INFO

Article History:
Accepted 10 February 2025

Keywords:
Climate change
nursing education
bibliometrics
climate health
planetary health

ABSTRACT

Background: Climate change poses a critical threat to individual and population health, highlighting the need for integration of this content into nursing education.
Aim: This bibliometric analysis explores the scholarly output on climate change in nursing education (2002-2024), examining the field's intellectual, conceptual, and social structures to identify strengths, gaps, and future directions.
Methods: About 121 relevant articles were analyzed using Scopus, following Donthu and colleagues' methodological guidance. Bibliometrix (R Studio) facilitated performance analysis, keyword co-occurrence mapping, and collaboration network assessment.
Results: The annual growth rate of publications in this field is 13.43%, which indicates an expansion of scholarly interest. However, the results revealed limited integration of climate adaptation within the nursing literature, a lack of health equity focus, and minimal transdisciplinary collaboration. Few institutions beyond Western regions have contributed significantly to the literature, highlighting a need for more global perspectives.
Conclusions: Further studies reporting on the integration of climate adaptation, health equity, transdisciplinary collaboration, and international collaboration are essential to strengthen nursing education's role in climate response. This study highlights the need for increased literature on climate-responsive nursing education.

Introduction

The impact of climate change is ever-present. One needs only to turn on the television or open a social media app to see the devastating outcomes of recent floods, tropical storms, hurricanes, heatwaves, and wildfires. According to the World Health Organization (WHO), these types of climate-driven disasters are increasing in frequency and severity and directly impacting the health of individuals and societies (WHO, 2024). The Intergovernmental Panel on Climate Change (IPCC), a subgroup of the United Nations, has identified several health risks related to climate change. They include but are not limited to, an increase in infectious diseases from contaminated water caused by flooding and hurricanes, harm from extreme weather events, malnutrition, respiratory illness, and threats to mental health (IPCC, 2023; WHO, 2024). In addition, climate change undermines the social determinants for healthy living, such as equality and access to health care. These effects are experienced disproportionately by the most vulnerable societal groups (women, children, ethnic minorities, older adults, migrants, financially disadvantaged, and people with underlying conditions) (WHO, 2024).

The nursing profession has often underestimated the significance of environmental issues and the interconnections between health, social justice, and the natural world (Lokmic-Tomkins, Strus, et al., 2023). However, as climate change poses a severe threat to the health of individuals and communities, current and future nurses must be equipped to address its impacts and practice sustainably. Education programs play a critical role in preparing nurses to mitigate the effects of climate change and in caring for people who have suffered the health impacts of climate change.

Disclaimer: Editors Justin Fontenot and Melissa Mastorovich did not participate in the review process for this manuscript.

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https://doi.org/10.1016/j.teln.2025.02.014

The purpose of this bibliometric study was to explore and analyze the literature regarding climate change and nursing education. Since the topic of climate change is relatively new to nursing education literature, no limits were set on the time frame of search strategy. The search yielded articles from 2002 to 2024 and represent the first published study to the most recent. Conceptual, intellectual, and social structures were examined to identify strengths and gaps in the literature, which can inform future research and advance nursing education related to climate change.

Background

Climate change is described as a “change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods” (United Nations, 2023). Human activities, including the heavy reliance on and continued investment in fossil fuels, along with deforestation and animal agriculture, have significantly influenced climate change (IPCC, 2022). Escalating emissions of greenhouse gasses resulting from climate change have increased global temperatures, causing significant and, in some cases, irreversible impacts. The most recent Lancet Countdown Report stated, "Despite the initial hope inspired by the 2015 Paris Agreement, the world is now dangerously close to breaching its target of limiting global multiyear mean heating to 1.5° C. The annual mean surface temperature reached a record high of 1.45°C above the preindustrial baseline in 2023, and new temperature highs were recorded throughout 2024. The resulting climatic extremes increasingly claim lives and livelihoods worldwide” (Romanello et al., 2024).

The IPCC (2022) report describes the profound effects on human health from climate change, including increased frequency and severity of heatwaves and heat-related illnesses; storms and changing rainfall patterns resulting in injuries, death, dislocation, contaminated water supplies; changes in the prevalence of vector-borne diseases such as malaria and dengue fever; more frequent wildfires and dust storms impacting air quality and exacerbating respiratory and cardiovascular conditions; and droughts and food insecurity leading to malnutrition and increased mortality, particularly in children and babies. While people worldwide face unprecedented health threats due to climate change (Romanello et al., 2024), marginalized communities and vulnerable populations face disproportionate impacts, making climate change an urgent social justice issue.

Healthcare systems contribute significantly to climate change, with greenhouse gas emissions from healthcare organizations increasing by 36% since 2016 (Romanello et al., 2024). This is driving healthcare away from its guiding principle of doing no harm and making achieving net zero targets increasingly unlikely. Paradoxically, healthcare professionals ethically committed to protecting and promoting healthcare both contributors to and frontline responders in managing the health impacts of climate change (Ward et al., 2022).

Many healthcare professionals are ill-prepared for their critical role in promoting adaptation and mitigation interventions (Ward et al., 2024). The 2024 Lancet Countdown Report identified that 70% of the 279 global education institutions surveyed provided education on climate and health in 2023. Yet, this was rarely mandated and mostly occurred only in master’s degree programs.

The International Council of Nurses [ICN] (2018) advocates that nurses can contribute to building climate-resilient healthcare systems, mitigating climate change, and supporting people and communities to adapt to its impacts. To enhance the capacity of the nursing profession to respond to the challenges of climate change, leadership from nurses is critical. This requires integration of climate change into both prelicensure and postgraduate nursing education programs (ICN, 2018). There should be a particular focus on how to reduce the health sector’s environmental and ecological footprints, learning to practice sustainably to mitigate greenhouse gas emissions and address its root causes; and adapting healthcare systems to respond to the climate’s uncertain future and minimize the adverse effects of climate change on human health (Levett-Jones et al., 2024).

To date, little is known about the extent of literature pertaining to nursing education and climate change. For this reason, a bibliometric analysis of this field of study was thought to be beneficial so as to highlight historical trends and support future pedagogy and research on climate change education. Bibliometrics, first introduced by Prichard in 1969, uses mathematics and statistical methods to investigate the volume and scope of literature in a given field. As the body of nursing literature increases, the need for this type of analysis has become evident. Indeed, a recent review of studies using or discussing bibliometric analyses in nursing identified over 500 publications with a significant increase in number over the last two decades (Kokol & Vosner, 2019).

For this bibliometric analysis, the research questions were:

- What is the volume and scope of scholarly output of contemporary literature on climate change in nursing education?
- What are the intellectual, conceptual, and social structures of the identified corpus of data on climate change in nursing education?

Methods

The research team followed the updated methodological guidance provided by Donthu et al. (2021) to conduct this bibliometric analysis focusing on the research output and performance of a corpus of data related to nursing education and climate change. This method was selected because a large amount of bibliometric data can be analyzed. This analysis yields both quantitative (key citations) and qualitative (thematic trends) results. Donthu and colleagues (2021) suggest four steps to conducting such an analysis: 1) define the aims and scope of the bibliometric study, 2) choose the techniques for analysis, 3) collect the data for analysis, and 4) run the analysis and report the findings.

This study aimed to explore the existing literature on climate change in nursing education, analyze the scholarly output, and determine the data’s intellectual, conceptual, and social structures using performance analysis, science mapping, and network analysis (Donthu et al.,2021). No time limits were set for the inclusion of articles found. The data collection, analysis, and results are reported in the following sections.

Search Procedure

The research team used the Scopus database to conduct the search for this analysis. Before performing the search, the team met to discuss the search terms to ensure a comprehensive search. Shortly after the meeting, the search strategy was trialed. The results from the pilot search did not provide an extensive data set, leaving out known seminal work. After another meeting and adjustment to the search strategy, a more comprehensive search of the database was completed. Following an initial review of the updated search, the team agreed that the current search captured a detailed dataset of the research topic. The pilot search was conducted on April 22, 2024. The extended and updated search occurred on April 30, 2024. The final search strategy is available in Table 1 below.

Data Collection

After the final search, the research team downloaded the entire dataset into an Excel spreadsheet. After meeting remotely, data

Table 1
Final search strategy for the Scopus database.

	Syntax	Filters
Scopus search strategy:	(TITLE-ABS-KEY (“greenhouse gas” OR “carbon mitigation” OR “mitigating carbon” OR “emission mitigation” OR “carbon dioxide” OR “CO2” OR “fossil fuels” OR “methane” OR “chlorofluorocarbons”) OR TITLE-ABS-KEY (“climate change” OR “global warming” OR “environmental impact” OR “impact on environment”) OR TITLE-ABS-KEY (“emission reduction” OR “emissions reduction” OR “greenhouse gas reduction” OR “greenhouse gas reduction” OR “planetary health” OR “climate health” OR “sustainability” "Emissions reduction” OR “anthropocene”) AND TITLE-ABS-KEY (“curriculum” OR “nursing education” OR “training”)	Language: English Subject: Nursing Source types: Articles and reviews only

cleaning was performed manually. The initial dataset included 270 entries. Of these, 52 duplicates were removed, and 97 erroneous entries were removed because they did not pertain to the topic. After the manual data-cleaning process, the final dataset included 121 entries. The final dataset went through five versions. During the data analysis process, errors in the spelling of author names were noted and corrected in version 6 of the dataset. Versions 5 and 6 of the datasets are published openly and can be found through this link: https://doi.org/10.17632/gvw2zwscxm.2. The final version was uploaded to Bibliometrix by R for analysis.

Data Analysis

The research team used the open-source software provided by R Studio, Bibliometrix, to analyze the dataset. Several analyses were completed to uncover intellectual structures (performance metrics), conceptual structures (keyword analysis), and social structures (collaboration networks). According to Donthu et al. (2021) all of these structures must be evaluated. The analysis was added to a report, downloaded, and shared between the research team for interpretation. The team worked together to ensure the accuracy of the analysis and to interpret the data. Any disagreements were discussed via e-mail and resolved collaboratively.

Ethical Considerations

The research team did not seek institutional board approval for this work, as it used freely and publicly available data to analyze it. While each research team member is interested in this topic, we have no conflicts of interest to share. Additionally, regarding publishing ethics, we would like to disclose that the authors of this work are editors and guest editors for the journal and the special issue on climate change. As such, the journal manager anonymized the manuscript from the editors, handled by an outside editor not affiliated with the journal. Please see the acknowledgments for more information on the handling editor for this work.

Results

This bibliometric study on integrating climate change in nursing education analyzed the field’s intellectual, conceptual, and social structures. The analysis revealed significant patterns in authorship, collaboration, and thematic trends within the body of research. Key citations and influential works define the intellectual structure, while thematic networks and keyword co-occurrences represent the conceptual structure. Social structures are mapped through collaboration networks, showing inter-country connections and author networks.

General Overview

The dataset used in this bibliometric study spans from 2002 to 2024. No time limits were set for this search strategy. The dates included represent the first published article to the latest. The dataset includes $n = 121$ documents sourced from $n = 46$ journals. The annual growth rate of publications in this field is 13.43%, indicating a steady increase in interest over time. However, the average age of the documents is 3.44 years, which suggests that much of the research is relatively recent. On average, each document has been cited 11.43 times, reflecting a moderate citation impact for work in this area. The dataset contains $n = 2{,}685$ references, highlighting the extensive research foundation for these publications. Single-authored documents account for $n = 15$ publications, while co-authorship is prevalent, with an average of 4.08 authors per document. Furthermore, 22.5 % of the papers involve international co-authorship, showcasing the global collaboration efforts in addressing climate change within nursing education. This dataset demonstrates the growing scholarly attention to climate change in the context of nursing education and highlights the collaborative nature of this research.

Intellectual Structure

The intellectual structure of the research in climate change and nursing education is characterized by key contributors, influential publications and the journals that have shaped the discourse. Leading scholars in this field include Richardson J., with $n = 17$ published articles, Grose J., with $n = 12$ articles, and Nicholas P.K., who contributed $n = 11$ articles. These authors have played a pivotal role in advancing the integration of climate change concepts into nursing education, particularly regarding sustainability and climate resilience. The high productivity of these authors is matched by their academic influence, as indicated by Richardson J’s h-index of 14, which suggests significant citation counts and academic recognition. See Table 2 for more information on the top ten relevant authors. Please note that Fractionalization is the process of distributing citation credit proportionally among co-authors to avoid overestimation of the author’s scientific impact.

The most prominent journals in this field are *Nurse Education Today*, which has published $n = 18$ articles; *Journal of Nursing Education,* with $n = 12$ articles; and *Creative Nursing*, which contributed $n = 9$ articles. These journals serve as essential platforms for disseminating research on climate change and nursing education, reaching a broad audience of educators, policymakers, and practitioners. The body of literature published in these journals has laid the foundation for understanding how nursing education can adapt to address the challenges posed by climate change. Table 3 provide additional information about journal sources.

Table 2
Most relevant authors (top 10).

Authors	Articles	Articles Fractionalized
Richardson J	17	3.524603175
Grose J	12	2.624603175
Nicholas PK	11	2.617099567
Lupez-Medina IMm	9	1.422222222
Elf M	8	1.866666667
Alvarez-Nieto C	7	1.022222222
Aronsson J	7	1.45
Breakey S	7	1.883333333
Alshammari F	6	1.138888889
Anåker A	6	1.366666667

Table 3
Most relevant sources (journals).

Sources	Articles
Nurse Education Today	18
Journal of Nursing Education	12
Creative Nursing	9
Public Health Nursing	8
Journal of Professional Nursing	5
Nurse Educator	5
Journal for Nurse Practitioners	4
Journal of Nursing Scholarship	4
Nurse Education in Practice	4
BMC Nursing	3

Several key documents, particularly those published in the early 2000s and 2010s, remain highly influential, with substantial citation counts that reflect their lasting impact on the field. For example, works published in 2011 are frequently referenced, suggesting that foundational research from that period has played a critical role in shaping academic discourse and practical applications related to climate change in nursing education. These foundational works have served as the intellectual backbone for subsequent studies, further expanding the conversation around sustainability and climate preparedness in nursing education. Fig. 1 provides an overview of the most globally cited documents, which refers to the number of times each document was cited globally (outside of this dataset [locally]).

Conceptual Structure

Critical themes and evolving trends define the conceptual structure of climate change research in nursing education. Thematic clusters identified through co-word analysis and mapping reveal the dominant topics driving this field (Fig. 4). Central to the research landscape is the theme of climate change, which holds the highest betweenness centrality, indicating that it acts as a bridge between various research areas. Betweenness centrality in bibliometric analysis, as outlined in Donthu et al. (2021), represents the ability of a node (such as an author, institution, or publication) to act as a bridge within a network. It is calculated by identifying the number of shortest paths passing through a particular node relative to the total shortest paths in the network, highlighting its role in facilitating connections between otherwise unconnected nodes.

This suggests that climate change is fundamental within nursing education and connecting research across disciplines, such as environmental science and public health. Climate change is consistently explored with its impact on healthcare systems, nursing practice, and educational curricula, making it a cornerstone of the research field. Fig. 2 provides an overview of keyword occurrences.

The sustainability theme is closely associated with climate change, another critical topic. Sustainability has gained prominence as nursing education seeks to prepare future nurses to engage in mitigation activities to prevent the environmental and health-related impacts of climate change. Integrating sustainability practices into nursing education reflects a growing awareness of the need to equip healthcare professionals with the skills necessary to promote and maintain environmental and public health in the face of climate change. While sustainability does not exhibit the same level of centrality as climate change, it remains a crucial focus of scholarly collaboration and curriculum development.

Nursing education itself forms another core thematic cluster, focusing on how to adapt nursing curricula to address climate-related health issues. The evolution of this theme has shifted from theoretical discussions of climate change to more applied research, which examines the practicalities of integrating climate-related content into nursing programs. Recent studies increasingly focus on developing pedagogical approaches to ensure that nurses are well-prepared to respond to the health impacts of climate change in clinical and community settings. However, gaps remain, particularly in exploring emerging themes such as health equity and the disproportionate effects of climate change on vulnerable populations. While gaining attention, these themes have not yet become central to the research discourse but represent areas for future exploration. Figs. 3 and 4 provide an overview of trends and keyword clusters, respectively.

The analysis indicates that the predominant focus on contemporary literature has been on sustainability and waste management. In

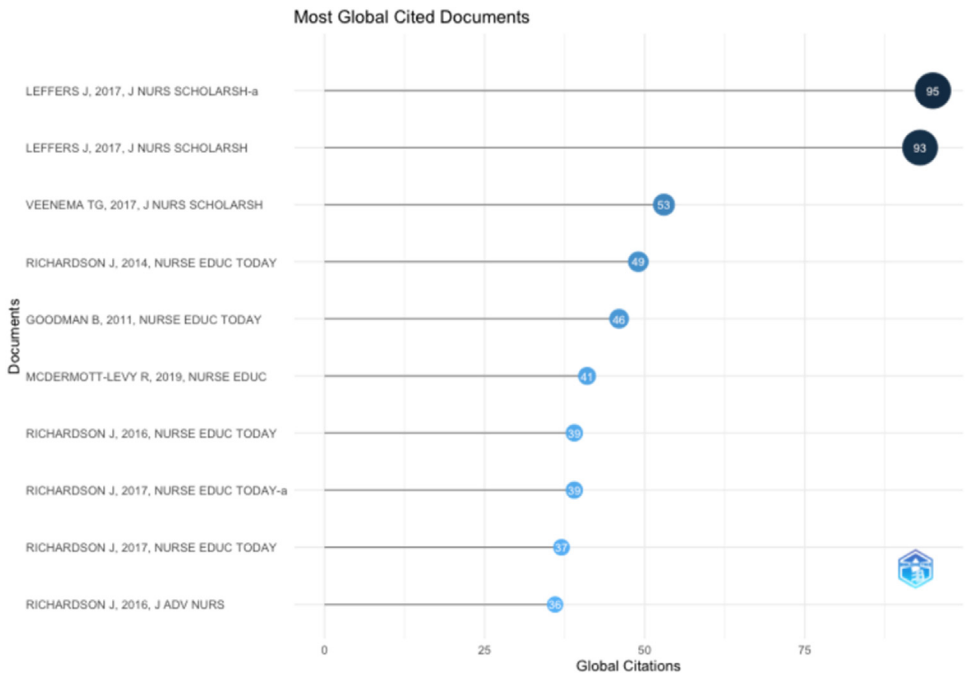

Fig. 1. Most globally cited documents.

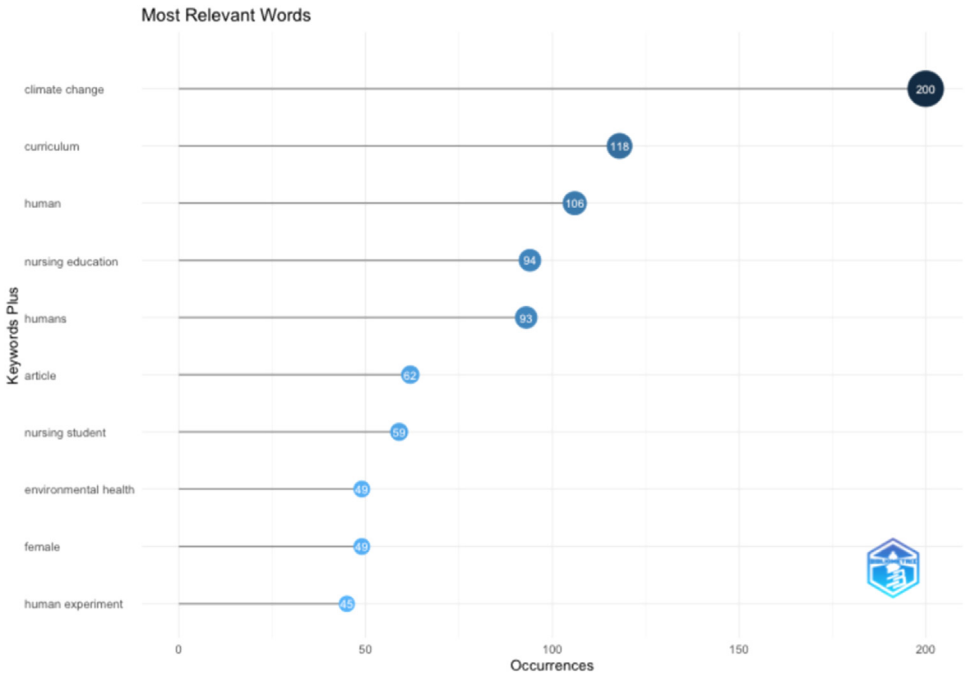

Fig. 2. Most relevant words.

contrast, less attention has been devoted to climate adaptation and to addressing climate change as a social justice concern, particularly in terms of health equity for vulnerable populations. This discrepancy suggests a potential gap in literature where the intersections of climate change, health equity, and social justice could be more comprehensively explored.

Social Structure

This field's social structure reveals collaboration patterns among authors, institutions, and countries. A small group of highly productive authors, such as Richardson J. and Grose J., collaborate frequently, contributing to a dense academic network. These authors often work within closely related institutions, fostering strong localized research communities. Their collaborative efforts have produced a significant portion of the literature on climate change and nursing education, reflecting a tight-knit group of scholars driving the field forward. Fig. 5 depicts cross-collaboration networks.

Institutions play a central role in shaping the collaborative landscape. The University of Plymouth in the United Kingdom stands out as the most collaborative institution, contributing to $n = 47$ articles, followed by the University of Jaén, Spain, with $n = 32$, and the MGH

Fig. 3. Trend topics.

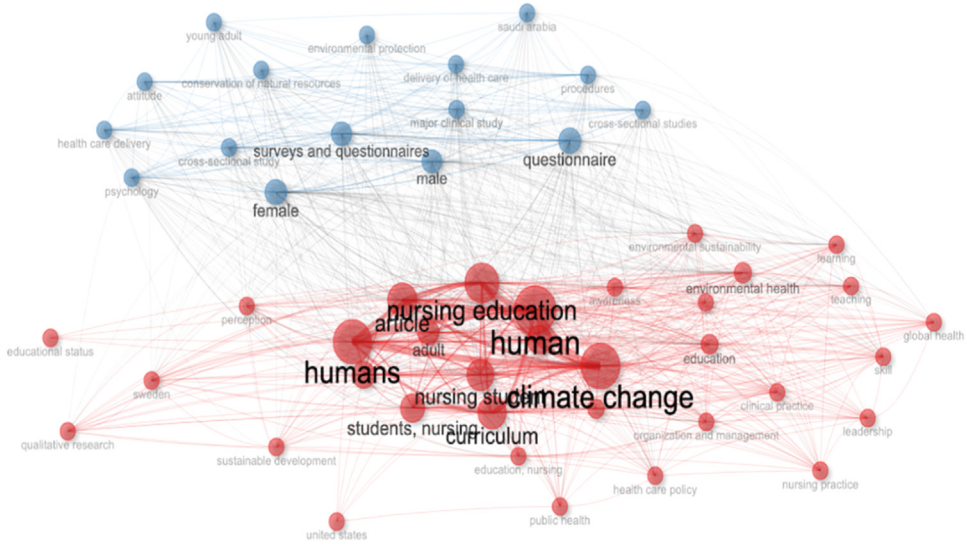

Fig. 4. Keyword clusters.

Institute of Health Professions, United States, with $n = 29$ articles. These institutions act as hubs for research, facilitating collaboration among scholars within and outside their academic networks. The solid institutional presence suggests that climate change and sustainability are prioritized within these educational and research settings, further enhancing the productivity and impact of the work emerging from these centers. Fig. 6 depicts the most relevant affiliations, while Fig. 7 provides an overview of collaboration networks by country.

However, despite robust institutional collaboration, international collaboration remains relatively limited. Countries like Australia have established research partnerships with Germany and Sweden, while Egypt collaborates frequently with neighboring countries such as Iraq and Israel. These patterns indicate regional clustering of research efforts, with collaborations often occurring within specific geographical areas rather than spanning multiple regions. This lack of extensive global collaboration highlights a potential gap in the field, as international partnerships could bring diverse perspectives and strategies to studying climate change and nursing education. Broader global collaboration could enrich the research by incorporating different regional approaches to climate change adaptation and healthcare education.

Discussion

This bibliometric analysis highlights a growing focus on climate change within nursing education, evident from a 13.43% annual growth rate in scholarly output since 2002. This growth aligns with global health mandates, such as those by WHO and IPCC, calling for healthcare professionals to be prepared to prevent and respond to climate-related health risks, encompassing social justice and environmental sustainability (IPCC, 2022; WHO, 2024). The field's intellectual foundation is shaped significantly by a few prolific authors, notably Richardson, Grose, and Nicholas, who have propelled themes of sustainability and resilience within healthcare education.

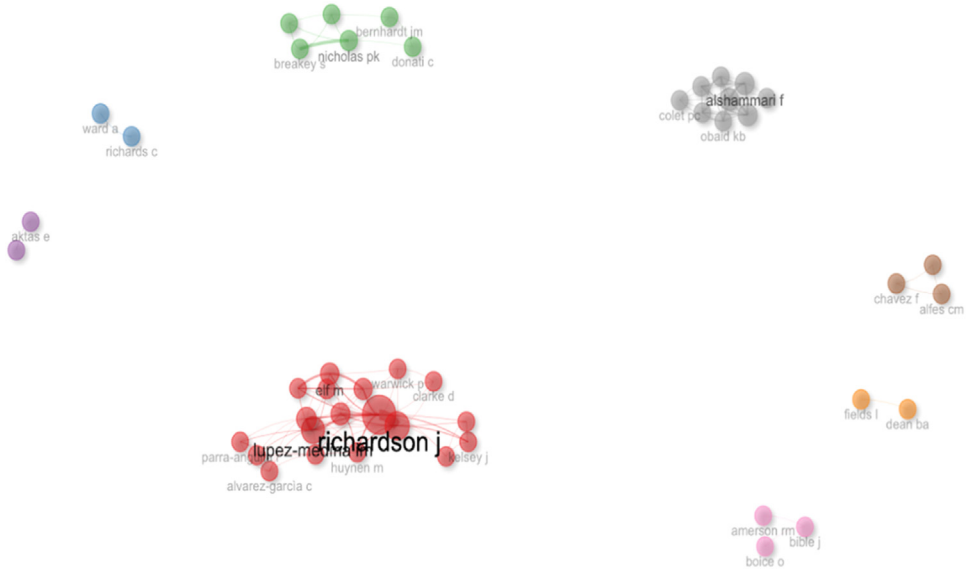

Fig. 5. Co-collaboration network.

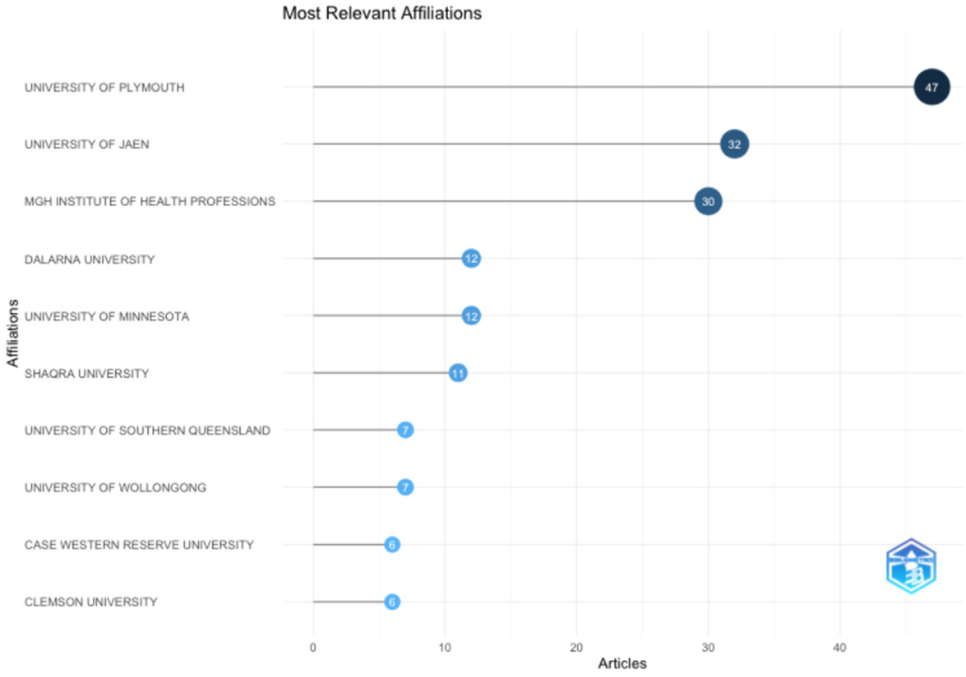

Fig. 6. Most relevant affiliations.

The evolving focus on climate change as a critical component of nursing education marks a shift from theoretical discourse toward practical integration. Yet, gaps persist, particularly in climate adaptation and health equity. Although mitigation strategies—such as waste reduction—are increasingly included, adaptation frameworks are often missing, limiting comprehensive preparedness for climate-related extreme weather events.

Key Gaps and Future Directions

The analysis highlights several areas that need further development. Firstly, the field's reliance on a few key contributors suggests limited diversity in perspectives, especially from early-career researchers and those in underrepresented regions. Expanding participation could diversify insights and foster innovative approaches to integrating climate change into nursing education.

A second notable gap lies in interdisciplinary engagement. While influential, leading journals are primarily nursing-focused, with limited integration of perspectives from environmental science, public health, or climate policy. Broadening collaborations across disciplines could enhance the depth and applicability of research and educational frameworks.

Furthermore, health equity is insufficiently addressed within the nursing education literature. Vulnerable populations, including women, ethnic minorities, and economically disadvantaged groups, face disproportionate climate impacts (Richards et al., 2023). Nursing education must expand to prepare students to meet the specific needs of these groups, linking climate change with social determinants of health.

Finally, limited international collaboration restricts the research's global relevance. While productive institutions like the University of Plymouth actively contribute to the field, cross-national partnerships remain sparse. Broadening global collaborations, especially with institutions in regions facing acute climate challenges, could enrich the research with diverse regional insights and promote more universally applicable strategies.

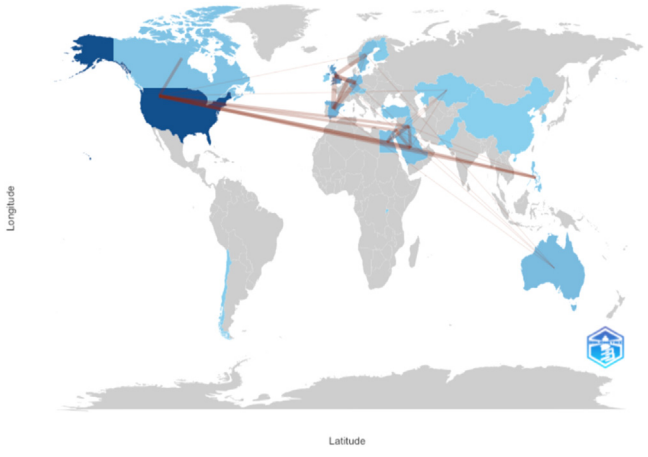

Fig. 7. Collaborations by country.

Emerging Focus on Health Equity and Climate Adaptation

Integrating health equity and climate adaptation into nursing education aligns with ICN's emphasis on social justice and equitable healthcare. This would help to address climate impacts on marginalized populations by enabling nurses to offer culturally relevant, adaptive care. Ensuring comprehensive climate adaptation frameworks within nursing education programs can empower nurses to address evolving health risks in clinical and community settings proactively.

Implications for Future Research and Curriculum Development

This study demonstrates the need for further studies that address climate change education, inclusive of climate adaptation, health equity, and sustainability. Papers focusing on experiential learning, such as simulations and community-based projects, would be beneficial in bridging the theory-practice gap and focusing attention on the need for enhanced education on climate-adaptive care. There is a need to move beyond the multidisciplinary model to transdisciplinary education regarding climate change. While

interdisciplinary education allows students to consider other perspectives, transdisciplinary teaching requires students from different disciplines to work together to solve complex problems. This method demands innovation, collaboration, and intentionality. For example, when using a transdisciplinary approach, students from different disciplines might be required to find ways to mitigate the effects of medical waste on climate change. Promoting cross-disciplinary and international collaboration within nursing education could prepare a generation of nurses better equipped to navigate the complex health challenges posed by climate change.

Limitations

This bibliometric study is subject to several limitations. First, it relies solely on data from the Scopus database, which, while comprehensive, may exclude relevant studies indexed in other databases such as Web of Science or PubMed, potentially limiting the breadth of the analysis. Additionally, the study is confined to English-language publications, which could lead to an underrepresentation of research conducted in non–English-speaking regions, particularly in low- and middle-income countries heavily affected by climate change. Citation-based metrics also have inherent limitations, as they may not fully capture a study's quality or practical impact, especially for newer publications that have not yet had time to accumulate citations. Finally, the study focuses on established research themes and collaboration patterns but may miss emerging areas that are not yet widely studied or cited. These factors should be considered when interpreting the findings.

Conclusions

This bibliometric analysis offers a comprehensive overview of the scholarly landscape surrounding climate change in nursing education, determining critical patterns, trends, and gaps in the existing literature. The steady growth in publications from 2002 to 2024 reflects an increasing recognition of climate change as an essential focus area within nursing education, aligning with global health mandates that urge healthcare professionals to be prepared for the extensive health and social impacts of environmental shifts. Despite this growing body of literature, significant gaps remain. It appears that climate adaptation, a vital concept for building resilient healthcare systems, is underrepresented in the nursing literature, suggesting that current educational initiatives may be limited in their ability to prepare nurses to respond effectively to climate-induced health challenges.

Key areas requiring further attention include papers on the integration of climate adaptation and health equity into nursing education and developing transdisciplinary frameworks that leverage insights from environmental science, public health, and policy studies. Addressing these gaps through targeted research and educational innovations could empower nursing students to deliver equitable, adaptive care, particularly to marginalized communities disproportionately affected by climate change. Additionally, fostering international collaborations would bring diverse regional insights into educational strategies, enriching the global discourse on climate-responsive nursing education.

Declaration of Competing Interest

There are no conflicts of interest undertaking this research.

CRediT authorship contribution statement

Tracy Levett-Jones: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Aletha Ward:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Melissa Mastorovich:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Justin Fontenot:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization.

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