Trends and hotspots in environmental education research: Insights from a comparison of Indonesia and USA

Wisnu Prayogo[1]*, Riansyah Putra[2], Liana Atika[2], Trimailuzi[2], Laili Fitria[3], Al Fatahillah[2], Abentin Estim[4], Sarwa[2], Darwin[2], Moondra Zubir[5], Dion Awfa[6], Januar Parlaungan Siregar[7], Muh. Ilham Anggamulia[8], Rifka Noor Azizah[6]

[1]Department of Environmental Engineering, Chung Yuan Christian University, Taoyuan, 32023, Taiwan

[2]Department of Building Engineering Education, Universitas Negeri Medan, William Iskandar Street, Medan, 20221, Indonesia

[3]Department of Environmental Engineering, Universitas Tanjungpura, Profesor Dokter H. Hadari Nawawi Street, Pontianak, 78124, Indonesia

[4]Borneo Marine Research Institute, Universiti Malaysia Sabah, UMS Street, Sabah, 88400, Malaysia

[5]Department of Chemistry, Universitas Negeri Medan, William Iskandar Street, Medan, 20221, Indonesia

[6]Department of Environmental Engineering, Institut Teknologi Sumatera, Terusan Ryacudu Street, Lampung, 35365, Indonesia

[7]Faculty of Mechanical and Automotive Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, Pahang, 26600, Malaysia

[8]Department of Environmental Engineering, Universitas Muslim Indonesia, Makassar, 90231, Indonesia

*Corresponding author, email: wisnuprayogo@unimed.ac.id

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Abstract
Environmental education plays a critical role in shaping awareness, sustainable behavior, and civic responsibility. Despite the global growth of environmental education research, comparative analyses between countries with different socio-political and academic contexts remain limited. This study aims to examine the research landscape and thematic evolution of environmental education in Indonesia and the USA. A systematic bibliometric and thematic analysis was conducted on WoS publications from 1975–2025. The study integrates PRISMA-based systematic screening with bibliometric mapping using VOSviewer, enabling transparent article selection while revealing structural relationships among keywords, institutions, and research themes. A total of 812 articles were included after screening and eligibility assessment. The results reveal clear contrasts in research focus and collaboration structures. In the USA, dominant themes include pro-environmental behavior, science education, and urban green spaces, supported by dense institutional collaboration networks led by the University of Florida, Stanford, and Cornell. In contrast, Indonesian environmental education research emphasizes health, sanitation, education, and slum communities, with relatively limited inter-institutional collaboration. Keyword co-occurrence analysis indicates that while global clusters center on "environmental education" and "students," Indonesian studies integrate context-specific topics such as "COVID-19," "slums," and "coastal communities." This study contributes to environmental education knowledge mapping by providing a systematic cross-national bibliometric comparison that clarifies thematic priorities, collaboration patterns, and emerging research directions. The findings also support SDG-aligned research and policy development, particularly SDG 4.7 (education for sustainable development) and SDG 13 (climate action), by identifying opportunities to strengthen international collaboration and diversify thematic research agendas in environmental education.

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1. Introduction

Environmental education has become a cornerstone in fostering environmental awareness, sustainability values, and pro-environmental behaviors across the globe. Since the Intergovernmental Conference on Environmental Education in Tbilisi (Hoffmann, 1977), the discourse surrounding environmental education has evolved to encompass formal, informal, and non-formal learning sectors. Over the past four decades, global environmental challenges; including climate change, biodiversity loss, and environmental inequality; have intensified scholarly and policy interest in environmental education. This expansion is reflected in the increasing

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number of publications indexed in the Web of Science (WoS). A bibliometric analysis by Tian et al. (2024) reported that environmental education publications increased from approximately 100 articles during 2013–2017 to around 285 in 2018 and continued to rise through 2022. Beyond this numerical growth, the literature demonstrates diversification of research themes, including climate change education, environmental justice, curriculum integration, teacher professional development, and public participation. These developments indicate that environmental education has become an increasingly interdisciplinary field that integrates pedagogical innovation with broader sustainability and governance agendas. Although environmental education research has expanded globally, the development of this field varies significantly across national contexts. Previous studies suggest that environmental education scholarship is strongly shaped by differences in policy frameworks, institutional capacity, research funding, and socio-cultural contexts. For example, research environments in highly developed academic systems tend to emphasize behavioral change, environmental literacy, and participatory learning models, while studies from developing regions frequently focus on localized environmental challenges and community-based education initiatives. Despite these differences, the global literature remains dominated by single-country case studies. Existing research has examined environmental education within specific national contexts, such as China (Li et al., 2021), Kenya (Gitonga et al., 2025), and South Africa (Damoah & Omodan, 2022), or has focused on particular thematic areas including climate change education (Mehmood, 2021), outdoor learning (Evans & Acton, 2022), and environmental literacy (Yusup, 2021). While these studies provide valuable insights into particular educational contexts or thematic domains, they rarely synthesize cross-national patterns or systematically examine how research priorities evolve across different geopolitical environments.

Several recent bibliometric studies have attempted to map the global development of environmental education research. For instance, a global publication network analysis by Zong et al (2024) provides a broad overview of collaboration structures and thematic clusters within outdoor and environmental education scholarship. However, these studies typically focus on global publication networks without conducting detailed country-level comparisons or examining the temporal evolution of research themes within specific national contexts. As a result, the literature still lacks systematic cross-national analyses that can reveal how environmental education research develops under different institutional, policy, and socio-environmental conditions. Comparative bibliometric investigations therefore offer an important opportunity to identify differences in research trajectories, thematic priorities, and collaboration structures across countries. Within this context, comparing Indonesia and USA provides a particularly informative analytical contrast. In USA, environmental education has benefited from long-standing governmental and philanthropic support, particularly following the enactment of the National Environmental Education Act, which institutionalized national programs for environmental literacy and education initiatives. This policy support has contributed to the development of a mature environmental education research ecosystem characterized by strong institutional collaboration networks and high publication output. In contrast, environmental education in Indonesia was formally integrated into policy frameworks through Law No. 32 of 2009 on Environmental Protection and Management, which mandates the incorporation of environmental awareness and sustainability principles into education systems. Despite this policy commitment, environmental education research in Indonesia remains relatively limited and fragmented, often influenced by disparities in institutional capacity, research funding, and international collaboration. From a bibliometric perspective, the contrast between these two countries offers a valuable opportunity to examine how environmental education scholarship evolves under different research infrastructures, governance structures, and socio-environmental priorities (Prayogo et al., 2024; DeVille et al., 2021; Li et al., 2021; Gitonga et al., 2025).

Methodologically, most previous reviews of environmental education rely on narrative synthesis or descriptive literature reviews. While these approaches provide useful conceptual overviews, they are often limited in their ability to systematically capture large-scale research patterns, thematic evolution, and collaboration networks across time and space. Similarly, single-country bibliometric studies can identify publication trends within specific national contexts but cannot fully explain how research development differs across geopolitical environments. Cross-national bibliometric analysis provides a more comprehensive framework by combining quantitative performance indicators with thematic mapping to examine differences in knowledge production across countries. By integrating publication trends, collaboration networks, and thematic evolution, such an approach contributes both methodologically and theoretically to environmental education research by revealing how national research systems shape the development of scholarly discourse. This study addresses these gaps by conducting a comprehensive bibliometric and keyword co-occurrence analysis of environmental education research in Indonesia and USA from 1975 to 2025. Using data retrieved from WoS and analytical tools such as VOSviewer and Bibliometrix, the study examines publication trends, thematic clusters, influential authors, institutions, and journals that shape environmental education scholarship in both countries. By integrating performance analysis with thematic mapping, this research provides a longitudinal and cross-national perspective on the development of environmental education research and offers deeper empirical insights into how contextual factors such as policy orientation, institutional development, academic culture, research collaboration, knowledge diffusion, and global sustainability discourse influence scholarly trajectories (Prayogo et al., 2024; DeVille et al., 2021; Li et al., 2021; Gitonga et al., 2025).

To guide the analysis, this study addresses the following research questions: (1) How has the volume and temporal development of environmental education research evolved in Indonesia and USA from 1975 to 2025?; (2) What thematic clusters and research hotspots characterize environmental education scholarship in both countries?; (3) How do collaboration networks and institutional structures differ between Indonesian and U.S. environmental education research communities?; and (4) What similarities and divergences can be identified in the thematic evolution of environmental education research between the two countries?. By answering these questions, this study contributes to the field by providing a systematic cross-national bibliometric comparison that clarifies thematic priorities, collaboration structures, and knowledge development trajectories in environmental education. The findings also offer practical implications for policymakers, educators, and researchers by identifying research gaps, collaboration opportunities, and strategic directions for advancing environmental education in support of global sustainability initiatives, particularly Sustainable Development Goal (SDG) 4.7 on education for sustainable development and SDG 13 on climate action.

2. Method

This study employed a systematic literature review integrated with bibliometric analysis to examine the development, intellectual structure, and thematic evolution of environmental education research (Azizah et al., 2025). The methodological framework combines systematic evidence synthesis with science mapping techniques in order to provide both transparent literature selection and quantitative insights into global research patterns. Environmental education research has expanded significantly across different regions and disciplines, yet previous studies often focus on descriptive overviews or single-country analyses that provide limited understanding of how research priorities evolve across different national contexts. To address this gap, the present study adopts a cross-national bibliometric approach to compare the research trajectories of Indonesia and USA within the broader global environmental education literature. Such a comparison enables the identification of differences in research productivity, thematic development, and collaboration structures between countries with distinct educational systems, research infrastructures, and environmental policy frameworks. The study followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to ensure transparency, reproducibility, and systematic filtering of the literature. PRISMA has become a widely accepted framework for systematic evidence synthesis because it provides a structured procedure for identifying, screening, and selecting relevant publications (Prayogo et al., 2025).

In parallel, bibliometric analysis was conducted using established scientometric frameworks developed by Moed, Leydesdorff, and Van Eck and Waltman. These frameworks emphasize quantitative investigation of publication outputs, citation relationships, collaboration networks, and keyword co-occurrence patterns in order to reveal the intellectual structure and evolution of scientific knowledge. Previous methodological studies have demonstrated that bibliometric analysis can provide robust insights into research development by identifying influential publications, emerging themes, and structural relationships among research actors. Compared with narrative literature reviews, which often rely on selective interpretation and relatively small samples of publications, bibliometric analysis allows systematic examination of large publication datasets and enables objective mapping of knowledge structures across time and geographical contexts. Integrating systematic review procedures with bibliometric science mapping therefore offers a rigorous methodological approach for investigating the development of environmental education research across countries. Bibliometric mapping and network visualization were conducted using VOSviewer (version 1.6.20), while the Bibliometrix package in R was used for bibliographic data cleaning, preprocessing, and performance analysis. This combination of tools has been widely applied in scientometric studies because it allows comprehensive investigation of publication trends, collaboration networks, and thematic evolution while maintaining transparency and reproducibility in the analytical procedure (Fitria et al., 2023; Prayogo et al., 2025).

2.1. Identification

Relevant publications were retrieved from the Web of Science (WoS) Core Collection database. WoS was selected as the primary data source because it is widely recognized as one of the most reliable databases for bibliometric analysis due to its rigorous journal selection standards, structured citation indexing, and consistent metadata quality. Unlike broader academic search engines, WoS applies strict editorial evaluation criteria for journal inclusion, which ensures high reliability of citation data and minimizes indexing inconsistencies. In addition, WoS provides comprehensive citation linking that enables accurate analysis of citation networks and research impact. Importantly for the present study, WoS offers strong coverage of internationally recognized journals in environmental education and sustainability research, including Environmental Education Research, Journal of Environmental Education, Sustainability, and International Research in Geographical and Environmental Education. These characteristics make WoS particularly suitable for longitudinal bibliometric analysis and cross-national research comparisons. The literature search was conducted in July 2025 using a Boolean search strategy applied to titles, abstracts, and author keywords. The search query was designed to capture the main conceptual terms associated with environmental education research while limiting the dataset to studies focusing on Indonesia and USA. The complete Boolean search string used in the database was: TS = (“environmental education” OR “education for sustainable development” OR “environmental literacy” OR “sustainability education”) AND (“Indonesia” OR “United States” OR “USA”). This search generated an initial

dataset of 6,508 publications indexed between 1975 and 2025. The selected time span captures the expansion of environmental education scholarship following major global milestones such as the 1977 Tbilisi Declaration on Environmental Education, the 1992 Rio Earth Summit, and the international promotion of education for sustainable development. These global developments significantly influenced environmental policy frameworks, curriculum design, and research agendas in environmental education worldwide.

2.2. Screening

Following the identification stage, duplicate records were removed using the deduplication function implemented in the Bibliometrix package. This function identifies duplicate entries by comparing combinations of article title, author names, publication year, and digital object identifiers. A total of 127 duplicate records were detected and removed from the dataset. The remaining 6,381 publications were subsequently screened based on titles and abstracts in order to determine their relevance to environmental education research. During the screening process, several exclusion criteria were applied to ensure the relevance and quality of the dataset. Studies were excluded if they focused exclusively on environmental science or ecological topics without an educational component, if the document type corresponded to conference abstracts, editorial notes, or other non-peer-reviewed publications, or if the article was written in languages other than English or Indonesian. Applying these criteria resulted in the exclusion of 6,352 publications during the screening stage, leaving a smaller subset of studies for further evaluation.

2.3. Eligibility

A full-text assessment was conducted on the remaining publications to verify their eligibility for inclusion in the study. Each article was evaluated based on three inclusion criteria. First, the article had to explicitly address environmental education as the primary research topic. Second, the study needed to focus on Indonesia, USA, or both countries as the geographical context of the research. Third, the article had to be published in a peer-reviewed journal in order to ensure scientific quality and methodological rigor. After applying these criteria, 1,900 publications met the eligibility requirements. Additional manual verification was performed to ensure that articles from key environmental education journals were not unintentionally excluded due to indexing inconsistencies or variations in metadata classification. Particular attention was given to journals that frequently publish environmental education research, including Environmental Education Research, Journal of Environmental Education, Jurnal Ilmiah Pendidikan Lingkungan dan Pembangunan, and Jurnal Pendidikan Lingkungan Hidup.

2.4. Inclusion and Data Extraction

Following the PRISMA procedure, a final dataset of 812 articles was included in the bibliometric and thematic analysis. Bibliographic metadata extracted from each publication included article title, authors, author affiliations, keywords, journal source, abstract, country of origin, publication year, and citation counts. These data were subsequently imported into VOSviewer to perform bibliometric performance analysis and science mapping. Prior to constructing the bibliometric networks, keyword normalization was conducted in order to ensure analytical consistency and avoid fragmentation of conceptually identical terms. Keyword normalization is a standard procedure in bibliometric analysis that merges synonymous expressions and standardizes variations in terminology. In the present study, the normalization process involved three main procedures: merging synonymous terms, standardizing spelling variations, and unifying conceptually equivalent expressions. For example, the terms “USA” and “United States” were merged into a single standardized label, spelling variations such as “behavior” and “behaviour” were standardized to a single form, and abbreviations such as “ESD” were unified with their full expression “education for sustainable development.” This normalization process was implemented using the thesaurus file function in VOSviewer in order to ensure consistent keyword representation and prevent fragmentation of thematic clusters. To ensure methodological transparency and reproducibility, several parameter settings were applied in the bibliometric network construction. The minimum keyword occurrence threshold was set to five occurrences in order to include only conceptually significant terms in the co-occurrence analysis. The full counting method was applied to calculate keyword co-occurrence relationships, and clustering was generated using the default VOSviewer resolution parameter to identify thematic groupings within the dataset. Network visualization and overlay visualization were used to examine both structural relationships among research topics and the temporal evolution of environmental education themes.

2.5. Ethical Considerations and Limitations

Because the analysis relied exclusively on publicly available bibliographic data obtained from the Web of Science database, no ethical approval was required for this study. Nevertheless, several methodological limitations should be acknowledged. First, reliance on a single bibliographic database may result in the exclusion of relevant publications indexed in other databases such as Scopus or Google Scholar. Second, the restriction to English and Indonesian publications may introduce language bias by excluding studies published in other languages. Third, grey literature such as policy reports, institutional documents, and non-indexed publications

were not included in the dataset, which may result in the omission of practice-oriented environmental education initiatives that are not formally published in academic journals.

2.6. Justification of Method

The integration of PRISMA-based systematic review procedures with bibliometric science mapping provides a robust methodological framework for examining the development of environmental education research. PRISMA ensures transparent and reproducible literature selection, while bibliometric analysis enables quantitative exploration of structural patterns in scientific knowledge production. By combining these approaches, the present study provides a comprehensive methodological framework for investigating publication trends, thematic evolution, and collaboration networks within environmental education scholarship. This methodological design is particularly suitable for cross-national research comparison because it allows systematic examination of differences in research trajectories between countries with distinct academic infrastructures and policy contexts. Through bibliometric mapping and network analysis, the study contributes to the global environmental education literature by revealing how national research systems influence the development of sustainability education scholarship and by identifying emerging research directions that may inform future environmental education research and policy development.

3. Results and Discussion

3.1. Global Number of Publication in Environmental Education Research

Figure 1a illustrates the global publication trend in environmental education research from 1975 to 2025. The results indicate a substantial increase in scholarly output over the past five decades. In the early stage of the field, fewer than 50 articles were published annually during the mid-1970s. The publication volume gradually increased during the 1990s and accelerated significantly after the early 2000s, eventually exceeding 1,200 publications per year in 2022. This trajectory represents nearly a 25-fold increase in annual publications, reflecting the rapid expansion of environmental education as an interdisciplinary research domain. The temporal pattern suggests three identifiable phases of development: an early formative period prior to the 1990s characterized by relatively limited publication activity, a consolidation period between the 1990s and early 2010s marked by steady growth, and a rapid expansion phase after approximately 2015. The sharp increase during the last decade indicates the growing global prominence of environmental education research across multiple academic disciplines. Several structural drivers help explain this growth pattern. First, major global environmental governance milestones have played a critical role in shaping research agendas. International policy frameworks such as the 1992 Rio Earth Summit, the United Nations Decade of Education for Sustainable Development (2005–2014), and the adoption of the Sustainable Development Goals in 2015 have significantly strengthened the institutional recognition of environmental education worldwide. In particular, SDG 4.7 explicitly emphasizes education for sustainable development, environmental awareness, and global citizenship, which has stimulated both academic research and policy-oriented educational initiatives. Second, increased research funding and international collaboration programs related to climate change, sustainability transitions, and environmental governance have encouraged interdisciplinary scholarship linking environmental science, social sciences, and educational studies. Third, evolving research agendas have expanded the scope of environmental education beyond traditional conservation education toward themes such as climate literacy, environmental citizenship, community resilience, and participatory learning models (Ardoin et al., 2023). More recently, global crises such as the COVID-19 pandemic have further stimulated research addressing environmental health, resilience education, and socio-ecological vulnerability, contributing to the continued expansion of the field (Husamah et al., 2023; Cruz et al., 2021).

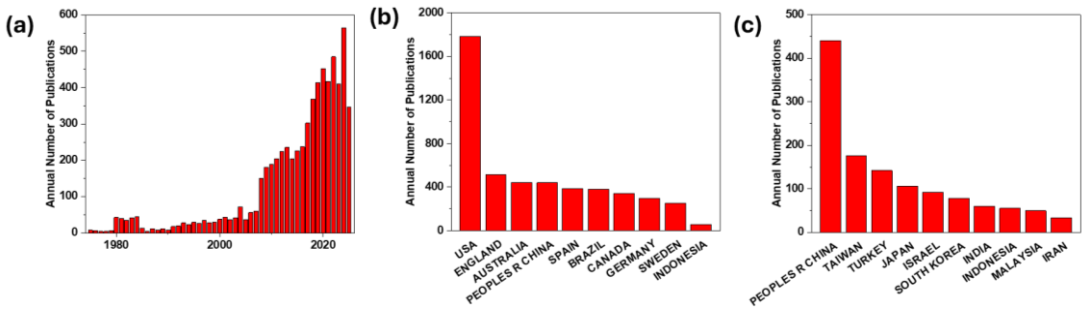


Figure 1. (a) Global number of publications in environmental education, (b) Comparison of the number of environmental education publications between Indonesia and the top 9 publishing countries globally and (c) in Asia

The cross-national comparison presented in Figure 1b reveals substantial disparities in publication output among countries. USA dominates global environmental education research with more than 1,500 publications

indexed in the dataset, followed by the United Kingdom, Australia, Canada, and China. In contrast, Indonesia ranks tenth globally, contributing fewer than 150 publications during the same period. While this comparison initially appears to reflect differences in publication volume, the pattern also indicates broader differences in research maturity and institutional capacity. Countries with long-established environmental education traditions, such as USA and the United Kingdom, typically demonstrate higher levels of research specialization, theoretical development, and methodological diversity. Their research portfolios frequently include longitudinal behavioral studies, large-scale educational interventions, and interdisciplinary collaborations involving environmental psychology, policy studies, and sustainability science. In contrast, environmental education research in emerging research systems often remains more fragmented and context-specific, focusing primarily on local environmental issues and applied educational programs rather than broader theoretical development. When the comparison is narrowed to the Asian context (Figure 1c), Indonesia remains relatively underrepresented compared with countries such as China, Japan, South Korea, and India. China, for example, has produced more than 700 environmental education publications during the same period, reflecting strong governmental investment in sustainability education and environmental governance research. The comparatively lower output from Indonesia highlights structural challenges that commonly affect research development in the Global South, including limited research funding, weaker international collaboration networks, restricted access to high-impact publication outlets, and language barriers in global scientific communication (Vasques et al., 2022). However, this disparity does not necessarily indicate a lack of research relevance. Instead, it suggests that environmental education research in Indonesia remains at an earlier stage of institutional and theoretical development. Existing studies are often strongly grounded in community-based environmental challenges such as sanitation, biodiversity conservation, disaster risk reduction, and environmental awareness programs. While these themes provide important locally contextualized knowledge, expanding the methodological diversity and international collaboration of Indonesian environmental education research may help strengthen its visibility and theoretical contribution within the global research landscape (Debrah et al., 2021; Prayogo et al., 2024). **Figure** 2 shown a global (a) macro and (b) micro citation in environmental education research.



Figure 2. Global (a) Macro and (b) Micro citation in Environmental Education Research

3.2. Global Micro and Macro-citation in Environmental Education Research

Citation analysis offers a valuable lens through which the intellectual structure and thematic impact of environmental education research can be understood. The macro citation map (**Figure** 2a) displays the broader disciplinary fields in which environmental education research is embedded, while the micro citation map (Figure 2b) reveals more granular subtopics with concentrated scholarly attention. At the macro level, environmental education is highly interlinked with social psychology (n = 2,116), education and educational research (n = 584), and hospitality, leisure, sport, and tourism (n = 430). These fields reflect the interdisciplinary nature of environmental education, where cognitive, behavioral, and experiential domains intersect (Mann et al., 2022; Pirchio et al., 2021; Hoover, 2021; DeVille et al., 2021). Notably, environmental education also receives significant citations in management (n = 296) and climate change studies (n = 213), indicating its relevance to sustainability governance and climate literacy initiatives. The prominence of forestry (n = 368) and zoology & animal ecology (n = 293) further suggests that environmental education research is often grounded in conservation biology and field-based environmental science. At the micro level, as shown in Figure 2b, the most cited topic is pro-environmental behavior (n = 2,091), a concept central to environmental education's mission to shape values and actions toward sustainability. Other highly cited themes include science education (n = 341), urban green spaces (n = 321), and corporate social responsibility (n = 196). These hotspots indicate a thematic shift toward urban environmentalism, individual agency, and institutional accountability in environmental education research. The inclusion of posthumanism (n = 169) and climate change adaptation (n = 85) signals growing attention to post-anthropocentric ethics and resilience-focused pedagogy. Such developments reflect how environmental education is expanding beyond traditional environmental knowledge transmission to incorporate critical, affective, and transformative educational paradigms.

3.3. Comparison of Environmental Education Research between Indonesia and the USA

The comparative annual publication trends between Indonesia and USA in environmental education research reveal substantial differences in both research output and temporal dynamics. As illustrated in Figure 3, USA consistently dominates the field, producing an average of more than 150 publications annually during the last decade and reaching a peak of over 180 articles in 2022. In contrast, Indonesia's publication output remains significantly lower, fluctuating between 10 and 30 publications per year over the same period despite recent improvements in national education and research policies. This disparity reflects broader structural differences in research infrastructure, funding availability, academic publishing capacity, and international collaboration networks (Debrah et al., 2021; Prayogo et al., 2024). The strong position of USA is closely associated with long-standing institutional support for environmental education research, particularly through policy instruments such as the National Environmental Education Act and funding programs supported by federal agencies including the Environmental Protection Agency (EPA). These initiatives have enabled large-scale empirical research, curriculum innovation, and longitudinal studies on environmental behavior and sustainability education. Furthermore, the presence of highly productive research universities, such as the University of Florida and Stanford University, has strengthened the institutional capacity for interdisciplinary research and high-impact scholarly output. In contrast, environmental education research in Indonesia has developed more recently and has grown gradually following the enactment of Law No. 32 of 2009 on Environmental Protection and Management, which formally integrated environmental education into national policy frameworks. Although this policy milestone stimulated academic interest in environmental education, the research landscape remains relatively fragmented. Limited research funding, language barriers in international publishing, and relatively low levels of international co-authorship continue to constrain Indonesia's visibility within the global environmental education literature. Consequently, many studies remain locally oriented and practice-driven, focusing on environmental awareness programs, sanitation education, or community-based environmental initiatives. While these contributions are important for addressing national environmental challenges, expanding international collaboration and increasing methodological diversity may enhance the global visibility and theoretical contribution of Indonesian environmental education research (Perea et al., 2025).

Collaboration networks further illustrate the structural differences between the two countries. Visualization results generated using VOSviewer show clear contrasts in the organization of research communities. In Figure 3a, the Indonesian author collaboration network appears fragmented into several relatively small clusters, with limited connections between research groups. Authors such as Taruc, Ruzka R., Tela, Autiko, and Barker, S. Fiona appear as central nodes within individual clusters; however, collaboration across clusters remains weak. Similarly, the institutional collaboration network shown in Figure 3b indicates that only a limited number of Indonesian universities such as Universitas Gadjah Mada and Universitas Pendidikan Indonesia appear in the network, and even these institutions show relatively weak interconnections. This pattern suggests that environmental education research in Indonesia is still characterized by relatively isolated research groups with limited cross-institutional integration. In contrast, the collaboration networks observed in USA demonstrate a far more integrated and dense research structure. As shown in Figure 4a, prominent scholars such as Nicole M. Ardoin, Marc J. Stern, and Martha C. Monroe are embedded within extensive co-authorship networks that connect multiple universities and research centers. The institutional

collaboration map (Figure 4b) further highlights the presence of strong research hubs, including the University of Florida, Stanford University, Cornell University, and Clemson University, which are interconnected with more than 50 collaborating institutions. Such dense collaboration networks facilitate frequent joint publications, interdisciplinary research, and large-scale research projects supported by national funding programs.

Importantly, these collaboration structures are closely associated with differences in research impact and knowledge innovation capacity. Previous bibliometric studies have shown that highly interconnected collaboration networks tend to produce publications with higher citation impact and broader international visibility because collaborative research often integrates diverse expertise, methodologies, and institutional resources (Thier et al., 2021). The dense collaboration structure observed in USA therefore contributes not only to higher publication volume but also to stronger citation performance and greater theoretical influence within the environmental education literature. In contrast, fragmented collaboration patterns may limit knowledge diffusion and reduce the potential for high-impact publications, as research groups operate within relatively isolated academic environments. The structural contrast between Indonesia and USA thus reflects broader disparities in research infrastructure, funding mechanisms, and academic culture. Many environmental education researchers in Indonesia are based in teaching-oriented universities with limited research mandates or financial resources, which constrains their ability to conduct large-scale empirical studies or long-term interdisciplinary projects. Furthermore, the absence of dedicated national funding programs specifically targeting environmental education research may limit opportunities for building strong domestic research networks. Strengthening collaboration at both national and international levels therefore represents a critical pathway for improving research impact and innovation capacity. Strategic investments in joint research centers, collaborative doctoral training programs, international research grants, and co-authored publication incentives could significantly enhance the integration of Indonesian environmental education scholars within global research networks (Wang et al., 2024). Enhancing such collaboration is not only important for increasing Indonesia's research visibility but also for enriching global environmental education scholarship by incorporating diverse ecological, cultural, and socio-environmental perspectives.

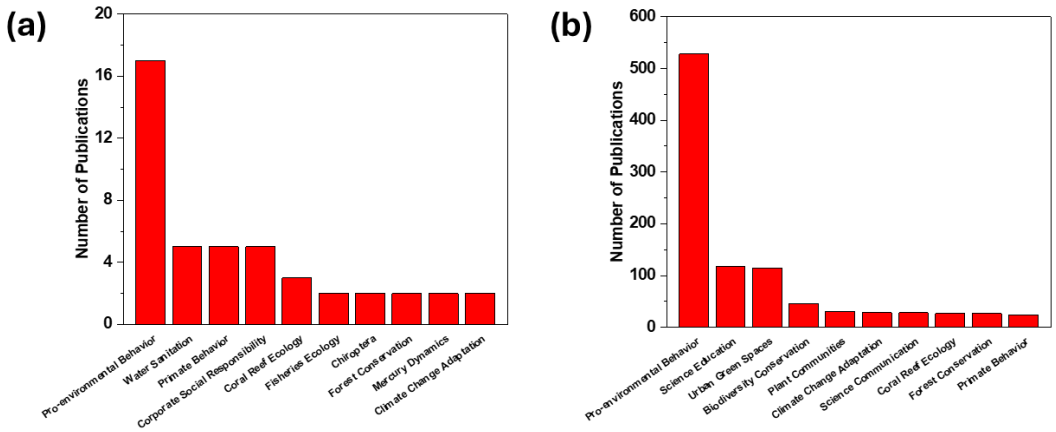


Figure 3. Most frequently studied research topics in environmental education in (a) Indonesia and (b) USA

3.4. Comparison of Micro Citations in Environmental Education Research between Indonesia and the USA

Micro-level citation analysis provides insights into the thematic structure and conceptual priorities within environmental education research. As shown in **Figure** 6a, the keyword co-occurrence network for Indonesia indicates that environmental education research is primarily oriented toward context-specific socio-environmental challenges. Dominant keywords include "education," "health," "sanitation," "behavior," "biodiversity," "slums," and "climate change," which collectively reflect the strong linkage between environmental education and public health, ecological conservation, and urban environmental issues. The co-occurrence of terms such as "COVID-19," "coastal communities," "awareness," and "perceptions" further suggests that many Indonesian studies focus on community-based environmental learning and environmental awareness initiatives targeting vulnerable populations. These patterns indicate that environmental education research in Indonesia remains strongly embedded in practical environmental problem-solving contexts rather than theoretical model development. The temporal visualization presented in Figure 6b reveals emerging attention to topics such as "climate resilience" and "urban sanitation," with brighter nodes indicating increased scholarly attention during the past three to five years. This trend suggests a gradual expansion of research interests toward climate adaptation and environmental governance issues. From a knowledge development perspective, these thematic patterns reflect an early to intermediate stage in the evolution of environmental education research. In this stage, scholarship often prioritizes applied educational interventions that address pressing environmental challenges at the local level. Such a focus is common in emerging research systems

where environmental education is closely linked to public health education, disaster risk reduction, and environmental awareness programs. The prominence of sanitation, coastal vulnerability, and environmental health topics in Indonesian studies can be interpreted in relation to national environmental priorities, including urban sanitation challenges, coastal climate vulnerability, and disaster risk management in archipelagic regions. Furthermore, the emergence of COVID-19-related themes reflects the influence of recent global crises on environmental education discourse, particularly the integration of environmental health, resilience education, and community awareness during the pandemic period, highlighting interdisciplinary connections among education policy, environmental governance, sustainability literacy, participatory learning frameworks, and community empowerment strategies.

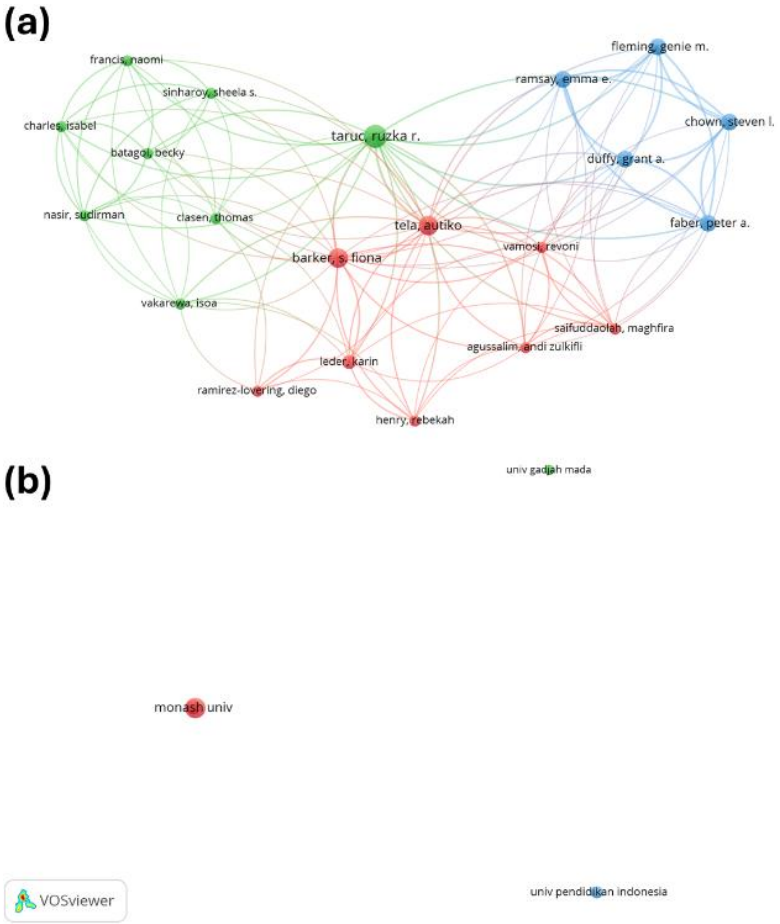


Figure 4. Research collaboration networks in environmental education between (a) Indonesia and (b) USA

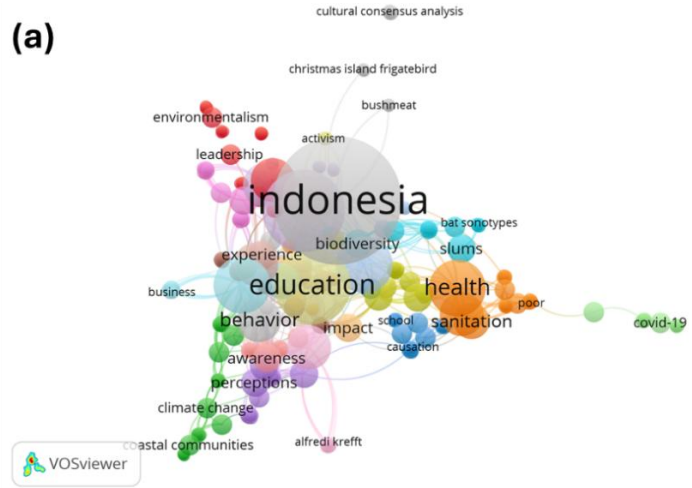
In contrast, the micro-citation network for USA (Figure 7a) displays a significantly denser and more conceptually integrated structure. Central nodes include terms such as “environmental education,” “students,” “youth attitudes,” “citizen science,” “place-based education,” and “climate literacy,” indicating a strong focus on behavioral change, participatory learning, and environmental citizenship. Additional concepts such as “connectedness to nature,” “play,” “values,” and “qualitative research” highlight the incorporation of affective, experiential, and psychological perspectives into environmental education scholarship. These thematic characteristics reflect a more mature research ecosystem in which environmental education is integrated with environmental psychology, sustainability science, and educational theory. Studies conducted in this context frequently employ diverse methodological approaches, including longitudinal behavioral analysis, experimental learning interventions, and interdisciplinary research frameworks (Chang & Kidman, 2023; Aribowo et al., 2025). The temporal overlay visualization shown in Figure 7b further demonstrates how research themes in USA have evolved in response to broader socio-political and environmental developments. Emerging keywords such as “polarization,” “hope,” “agency,” and “resilience” indicate increasing scholarly attention to the social and psychological dimensions of climate change communication and environmental engagement. This thematic shift corresponds with growing societal debates surrounding climate change policy, environmental justice movements, and the need for transformative environmental learning. For instance, the increasing focus on climate literacy and environmental citizenship aligns with international policy developments such as the Sustainable Development Goals and the expansion of climate education initiatives in formal education systems. Similarly, the appearance of terms related to resilience and agency reflects the growing recognition that

environmental education must address not only knowledge but also the social capacities needed to respond to complex environmental crises.

Comparing these thematic structures reveals clear differences in the maturity and theoretical integration of environmental education research between the two countries. The Indonesian research landscape remains relatively fragmented, with many studies addressing localized environmental problems through community-based education initiatives. While this applied orientation provides valuable insights into local environmental challenges, the limited integration of theoretical frameworks and interdisciplinary approaches may constrain the development of a cohesive research tradition. In contrast, the U.S. environmental education literature demonstrates stronger theoretical continuity and methodological diversity, enabling the development of more integrated research agendas linking environmental psychology, sustainability education, and social learning theories. From a knowledge evolution perspective, these differences illustrate how environmental education research progresses through several stages of development. Early stages are typically characterized by problem-driven research addressing immediate environmental issues, whereas later stages involve greater theoretical integration, interdisciplinary collaboration, and methodological diversification. USA appears to have progressed further toward the latter stage, where environmental education research contributes not only to educational practice but also to broader theoretical debates concerning environmental behavior, sustainability transitions, and environmental governance. Strengthening theoretical integration and expanding interdisciplinary collaboration may therefore represent an important pathway for advancing environmental education research in Indonesia and enhancing its contribution to the global environmental education knowledge base (Alam et al., 2025; Prayogo et al., 2022).

3.5. Insights for the Future of Environmental Education in Indonesia

The bibliometric results presented in the previous sections provide important insights into the future development of environmental education research in Indonesia. Overall, the findings suggest that strengthening research integration, expanding thematic scope, and improving institutional collaboration represent key priorities for advancing the field. As indicated by the collaboration network analysis, environmental education research in Indonesia remains fragmented, with many studies conducted within relatively isolated academic clusters and limited cross-institutional collaboration. Such fragmentation can hinder the accumulation of cumulative knowledge and reduce the capacity of research findings to inform national environmental policy and educational strategies. Strengthening collaboration among universities, government agencies, and civil society organizations is therefore essential to build a more cohesive and productive research ecosystem (Andrews et al., 2020). Developing interdisciplinary research platforms and national research networks dedicated to environmental education may facilitate knowledge exchange and enhance the overall impact of Indonesian scholarship in this field. Another key insight concerns the thematic orientation of environmental education research in Indonesia. The bibliometric analysis shows that many studies remain strongly focused on localized environmental issues such as sanitation education, disaster risk awareness, and school-based environmental health programs. While these topics are highly relevant within the Indonesian socio-environmental context, expanding the thematic scope of research could enhance the international relevance of Indonesian environmental education scholarship. Integrating broader global discourses; such as environmental citizenship, climate resilience, planetary health, and sustainability transitions; may help align Indonesian research agendas with global sustainability frameworks, including SDG 4.7 and SDG 13. Achieving this shift will require stronger interdisciplinary integration between environmental education, environmental psychology, sustainability science, and social learning theory. Incorporating transformative and critical pedagogical approaches may also support the development of environmental education programs that not only increase awareness but also foster long-term behavioral change and civic engagement. Figure 5 shown a micro citations in environmental education research in indonesia.



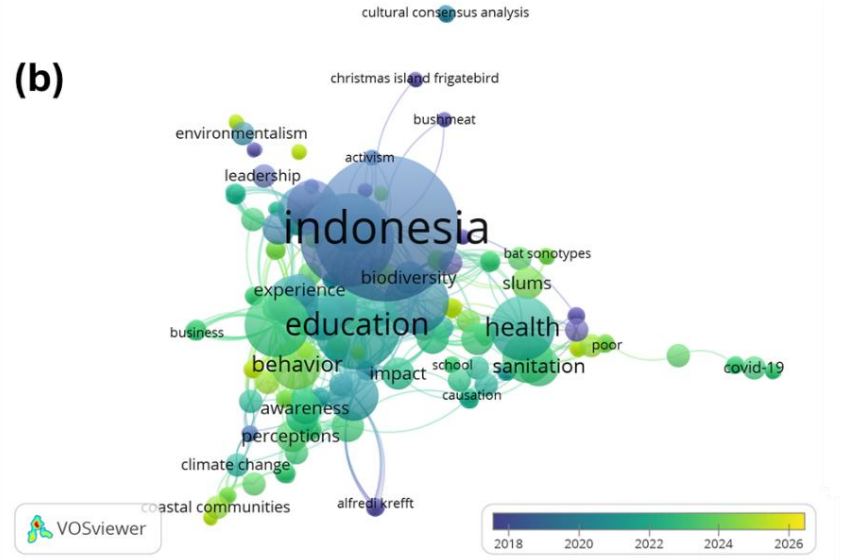


Figure 5. Micro Citations in Environmental Education Research in Indonesia

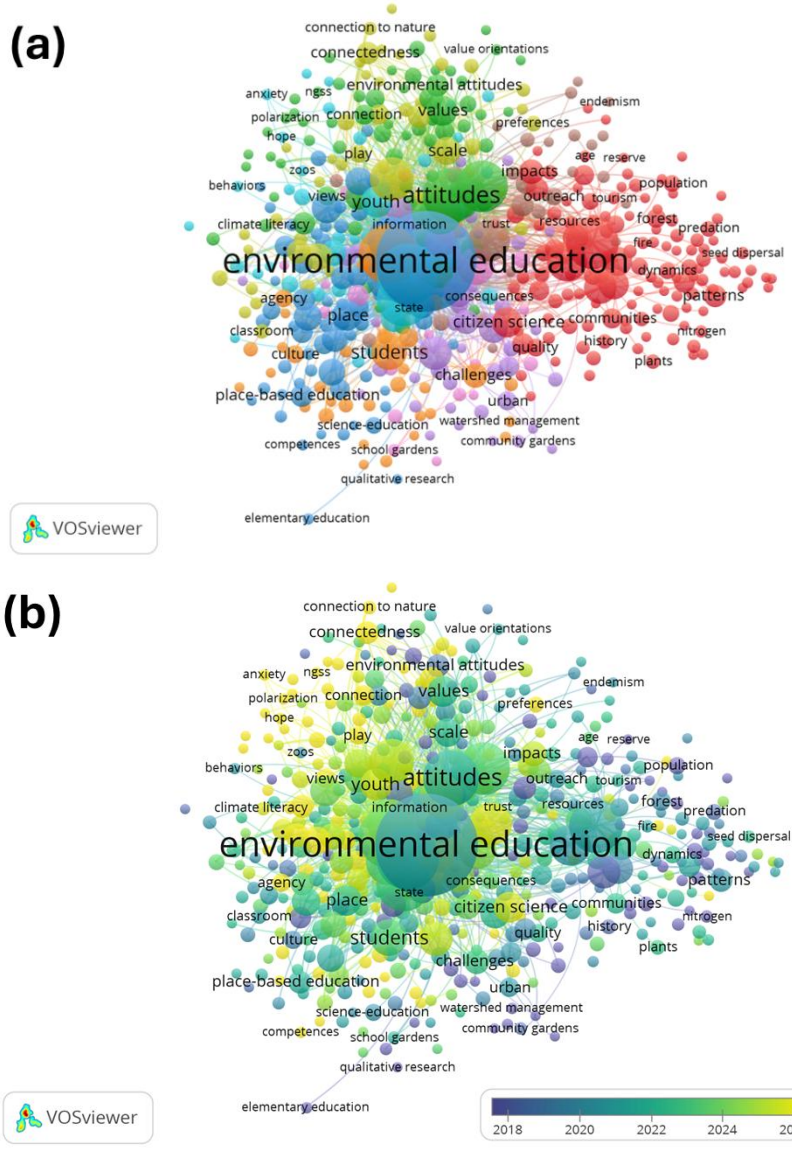


Figure 6. Micro Citations in Environmental Education Research in the USA

Improving Indonesia's participation in global scientific discourse also requires addressing structural challenges in academic publishing and research capacity. The bibliometric findings indicate that Indonesian environmental education research remains underrepresented in high-impact international journals. Language barriers, limited access to international research networks, and insufficient training in scientific writing often constrain the ability of researchers to publish in Scopus- or Web of Science-indexed journals. Addressing these barriers will require targeted capacity-building initiatives, including scientific writing workshops, journal mentoring programs, and collaborative research grants that encourage international co-authorship. Such initiatives may significantly enhance the visibility and citation impact of Indonesian environmental education research while facilitating greater integration with global research communities (Sugiharto et al., 2023). In addition to strengthening research capacity, future environmental education initiatives in Indonesia should also emphasize the integration of local knowledge and cultural context. Indonesia's rich ecological diversity and indigenous knowledge systems offer valuable perspectives that can contribute to global environmental education discourse. Incorporating place-based ecological knowledge, traditional environmental practices, and community-based learning approaches may help ensure that environmental education remains culturally relevant and socially embedded. Previous studies have shown that integrating local values and community participation into environmental education programs can significantly improve student engagement and sustainability outcomes (Aribowo et al., 2025). Approaches such as experiential learning, ecopedagogy, and community service learning may therefore provide effective pathways for linking environmental education with real-world environmental problem solving.

Finally, the rapid expansion of digital learning technologies presents new opportunities for strengthening environmental education in Indonesia. The COVID-19 pandemic accelerated the adoption of digital learning platforms and highlighted the importance of flexible educational delivery systems. Integrating digital tools with community-based learning models may help expand access to environmental education programs, particularly in rural and remote areas. Moving forward, national environmental education strategies should therefore integrate digital innovation, local knowledge systems, and global sustainability perspectives to create a more inclusive and future-oriented educational framework. Achieving this transformation will require coordinated support from educational institutions, government agencies, and research organizations, as well as sustained investment in research funding and institutional capacity development. Table 1 shown a future perspective on environmental education in indonesia.

Table 1. Future Perspectives on Environmental Education in Indonesia

Insight	Strategic Recommendation	Reference
Fragmented research network	Strengthen cross-institutional and international collaboration networks	Andrews et al (2020)
Localized research themes	Expand research focus toward global sustainability issues (climate resilience, environmental citizenship, SDGs)	UNESCO (2022)
Limited global visibility	Provide scientific writing training and international publication mentoring	Sugiharto et al (2023)
Lack of cultural contextualization	Integrate indigenous ecological knowledge and place-based environmental education	Sugiharto et al (2023)
Unequal digital access	Promote blended and digital environmental education models	Aribowo et al (2025)

4. Conclusion

This study provides a cross-national bibliometric comparison of environmental education research in Indonesia and USA from 1975 to 2025, revealing significant differences in research development, thematic structure, and collaboration patterns. While global environmental education research has expanded rapidly in response to international sustainability agendas, the results show that knowledge production remains unevenly distributed. USA exhibits a mature research ecosystem characterized by dense collaboration networks, diverse thematic development, and strong theoretical integration. In contrast, environmental education research in Indonesia remains relatively fragmented and primarily oriented toward context-specific socio-environmental challenges, with limited institutional collaboration and global visibility. Beyond differences in publication volume, the bibliometric findings highlight structural disparities in knowledge development. U.S. research demonstrates greater thematic complexity and methodological diversity, particularly in areas such as environmental behavior, climate literacy, and participatory learning, whereas Indonesian research is largely problem-driven and locally focused. These patterns suggest different stages of research maturity between the two countries and highlight the importance of strengthening research integration and collaboration in emerging research systems. This study contributes to the literature by advancing comparative bibliometric analysis in environmental education and by providing a knowledge-mapping perspective on how national research systems shape thematic evolution and collaboration structures. Future research should expand cross-national bibliometric investigations to additional regions, examine how collaboration networks influence citation impact and knowledge diffusion, and explore emerging themes such as climate resilience education, environmental citizenship, and digital environmental learning. Strengthening interdisciplinary collaboration and international research partnerships will be essential for enhancing the global contribution of environmental education scholarship.

Author Contributions

Wisnu Prayogo: Conceptualization, Methodology, Supervision, Writing – Review and Editing. Riansyah Putra: Data Curation, Formal Analysis, Writing – Original Draft Preparation. Liana Atika: Investigation, Data Curation, Writing – Original Draft Preparation. Trimailuzi: Investigation, Data Curation, Validation. Laili Fitria: Visualization, Resources, Validation. Al Fatahillah: Formal Analysis, Software, Data Processing. Abentin Estim: Methodology, Validation, Writing – Review and Editing. Sarwa: Investigation, Data Curation. Darwin: Investigation, Data Curation. Moondra Zubir: Project Administration, Resources, Validation. Dion Awfa: Methodology, Formal Analysis, Writing – Review and Editing

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Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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