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Global Trends in Mercury and Its Impact on Pregnancy and Newborn Health: A Bibliometric Analysis from 2014-2023

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Abstract

Mercury (Hg) exposure remains a major environmental health concern because of its persistence, bioaccumulation potential, and adverse effects on vulnerable populations, particularly pregnant women, fetuses, and newborns. Although bibliometric studies on Hg have been conducted in several domains, the research landscape specifically addressing Hg exposure in relation to pregnancy, fetal development, and newborn health has not been clearly mapped. This study aimed to provide a global bibliometric overview of scientific publications on this topic indexed in the Scopus database from 2014 to 2023. Literature retrieval was conducted using the Publish or Perish (PoP) application, and bibliometric mapping was performed using VOSviewer. A total of 200 publications were included in the final analysis, yielding 23,458 citations, an H-index of 87, and a G-index of 141. The United States and China were the leading contributing countries, while Environment International, Environmental Research, and Environmental Health *Perspectives* were the major journals publishing studies in this field. Keyword mapping showed that the literature was mainly concentrated around pregnancy-related mercury exposure, methylmercury, neurodevelopmental outcomes, and endocrine or metabolic themes. In contrast, fetus- and newborn-specific outcomes appeared less densely represented, indicating the need for more targeted bibliometric investigations. However, the analysis did not systematically classify studies by pregnancy trimester, gestational age, specific clinical outcomes, or regional subsets.

Major Findings: Overall, this study provides a global map of the bibliometric structure of Hg research in maternal and early-life health and highlights the need for more targeted bibliometric investigations using outcome-specific and mechanism-oriented search terms.

Keywords: Bibliometric Analysis, Fetal Development, Mercury, Newborn Health, Pregnancy, Toxicology

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1. Introduction

Heavy metal pollution is a critical global issue, particularly in regions with intensive industrial and agricultural activities. Hg, one of the most toxic heavy metals, poses severe risks to human health and ecosystems due to its bioaccumulation and biomagnification[1–3]. Globally, Hg contamination is exacerbated by mining and industrial agriculture, making it a priority for environmental health studies[4–8]. Understanding its impact, especially on vulnerable populations like pregnant women and developing fetuses, underscores the importance of this research for public health and policy development worldwide[9].

Hg exists in elemental, inorganic, and organic forms, each with distinct toxicological characteristics. Among these, methylmercury is generally considered the most hazardous to human exposure because of its high bioavailability and its ability to accumulate in aquatic organisms and subsequently enter the human food chain. This issue is especially important for pregnant women, fetuses, and newborns, who represent highly vulnerable populations. Maternal exposure to Hg during pregnancy has been associated with a range of adverse outcomes, including impaired fetal growth, neurodevelopmental abnormalities, placental dysfunction, and long-term cognitive and behavioural disturbances in children. These concerns have made Hg exposure during pregnancy an increasingly important focus in toxicology, environmental epidemiology, and maternal–child health research[10,11].

Indonesia, including resource-intensive regions such as Kalimantan, illustrates how environmental contamination may emerge alongside economic development driven by mining and plantation activities[12,13]. In this context, Hg pollution has become an important environmental concern in several settings. However, in the present study, such regional contexts are used only to illustrate the broader relevance of mercury-related environmental health problems. They are not treated as separate units of bibliometric analysis. Accordingly, this study does not aim to provide a region-specific bibliometric assessment, but rather to position the topic within the wider global research landscape[6–8,14].

Bibliometric analysis is a common quantitative method used to evaluate scientific literature, track research productivity, map collaboration networks, and identify thematic trends. Previous studies have examined Hg-related research in areas like water contamination, food safety, phytoremediation, and environmental health[2,15–21]. However, the specific literature on Hg exposure during pregnancy, fetal development, and neonatal health remains underexplored. There is limited bibliometric data on publication growth, leading countries and journals, highly cited works, and key thematic clusters in this specific research area.

This gap is important because the topic of Hg exposure during pregnancy spans several interconnected domains, including environmental toxicology, developmental biology, public health, obstetrics, and paediatrics. Without a focused bibliometric overview, it is difficult to determine how research attention has evolved, which themes have received the greatest emphasis, and which areas remain relatively underexplored. A clearer mapping of the literature may help researchers and policymakers identify research priorities more effectively and foster meaningful progress in protecting maternal and child health.

Therefore, this study aimed to provide a global bibliometric overview of scientific publications on Hg exposure and its impact on pregnancy, fetal development, and newborn health indexed in the Scopus database from 2014 to 2023. Specifically, this study sought to describe publication trends, citation characteristics, leading authors, countries, and journals, and to visualise the main thematic clusters and research density using bibliometric mapping. This approach may inform future research priorities and strategic planning in the field.

2. Materials and Methods

2.1 Study Design

This study employed a bibliometric approach to evaluate the scientific literature on Hg exposure in relation to pregnancy, fetal development, and newborn health. The analysis focused on publications indexed in the Scopus database between 2014 and 2023. Scopus was selected because it is one of the largest and most widely used multidisciplinary databases for peer-reviewed scientific literature and is commonly used in bibliometric studies. The bibliometric workflow included literature retrieval, screening, and eligibility assessment, metadata export, descriptive analysis, and visualisation using bibliometric mapping tools.

2.2 Data Source and Search Strategy

Literature retrieval was conducted from the Scopus database using the PoP application. The search was

designed to capture publications on Hg exposure during pregnancy and its effects on early-life outcomes. Search terms were applied to the title, abstract, and keywords fields.

The core search concepts included terms related to Hg exposure and terms related to pregnancy or newborn outcomes. The main search terms used were: "Mercury" OR "Heavy Metal" AND "Newborn" OR "Pregnancy". The search strategy was structured broadly to capture the global literature on the topic rather than narrowly restricting the search to particular clinical stages or outcomes.

Terms such as "first trimester," "second trimester," "third trimester," "gestational age," and other highly specific obstetric descriptors were not used as mandatory search terms because the objective of this study was to generate a global bibliometric overview rather than a stage-specific clinical synthesis. Including such narrow terms may have excluded relevant publications that address maternal, fetal, or newborn effects of Hg exposure, even when they do not explicitly use trimester-specific terminology in the title, abstract, or keywords. Likewise, geographic filters were not applied intentionally, as the present study was not designed as a regional comparison but as a global mapping of the literature.

The retrieved records were exported from PoP in CSV format for descriptive analysis and in the Research Information System (RIS) format for bibliometric visualisation using VOSviewer. The exported metadata included article title, author(s), year of publication, journal, publisher, country, and citation indicators[17,22,23].

2.3 Eligibility Criteria and Data Screening

Publications were included if they met the following criteria: (1) indexed in the Scopus database; (2) published between 2014 and 2023; (3) focused on Hg exposure and its relation to pregnancy, fetal development, or newborn health; and (4) contained relevant search terms in the title, abstract, or keywords. Records were excluded after title and abstract screening if they were unrelated to the study topic, focused on Hg exposure without relevance to pregnancy or early-life outcomes, or represented duplicate records in the exported dataset. The screening process was conducted manually to ensure that only publications relevant to the bibliometric objective were retained for analysis.

Studies on specific pregnancy outcomes or trimester-related issues were not intentionally excluded as conceptual categories. However, because the search strategy relied on broad topic terms rather than highly specific obstetric descriptors, some publications focused on particular trimesters, gestational stages, or narrowly defined pregnancy outcomes may not have been captured if they did not include the core search terms used in this study. This limitation of the search design should be considered when interpreting the findings. After screening and eligibility assessment, 200 publications were retained for the final bibliometric analysis.

2.4 Data Extraction and Bibliometric Analysis

The bibliometric analysis was carried out in three main stages. First, a descriptive analysis was performed in Microsoft Excel 2019 to summarise publication trends and citation characteristics[24]. The variables analysed included annual publication output, total citations, citations per year, citations per article, author productivity, journal distribution, document type, and country contribution.

Second, bibliometric mapping was conducted using VOSviewer to visualise relationships among research items[25–28]. The visualisations included: (1) network visualisation, to identify relationships among keywords, authors, or publications; (2) overlay visualisation, to illustrate changes in research emphasis over time; and (3) density visualisation, to identify topics with higher or lower research concentration.

Third, the retrieved publications were categorised descriptively based on publication type, leading journals, productive countries, major topics, and citation performance. The overall workflow of the study, from database retrieval through analysis and visualisation, is summarised in Figure 1.

3. Results and Discussion

A total of 200 publications on Hg exposure during pregnancy and fetal/newborn health were retrieved from the Scopus database for the period 2014–2023. As summarised in Table 1, these publications accumulated 23,458 citations, averaging 2,345.8 per year and 117.29 per paper. The dataset also yielded an H-index of 87 and a G-index of 141, underscoring the sustained scholarly interest and influence in this field over the past decade. Overall, these metrics suggest that research on Hg exposure during pregnancy and early life has remained scientifically relevant over the last decade.

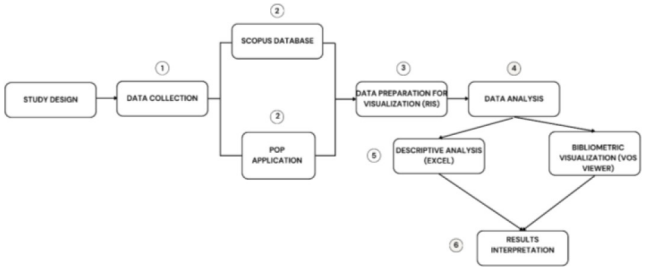


Figure 1. Data collection and bibliometric analysis workflow for publications on mercury exposure in pregnancy, fetal development, and newborn health (2014–2023).

Table 1. Citation metrics of publications on the topic of Hg and its impact on pregnancy and fetus using PoP

Description	Metric
Publication years	2014-2023
Citation years	10
Number of papers	200
Citations	23,458
Cites/year	2345.8
Cites/paper	117.29
H index	87
G index	141

The distribution of publication types, shown in Figure 2, indicates that original research articles dominate the field, whereas reviews and other document types are less frequent. This pattern suggests that the evidence base has largely developed through primary investigations rather than through a high volume of synthesis papers. In bibliometric terms, this may indicate a field that is still expanding its empirical foundation, particularly in relation to maternal exposure, fetal vulnerability, and newborn outcomes. However, the distribution of document types should not be interpreted as a direct indicator of evidentiary strength; rather, it reflects how knowledge on this topic has been disseminated across the indexed literature.

The annual publication trend, shown in Figure 3, fluctuated over the observation period, with fewer publications toward the end of the study window. This pattern should be interpreted with caution. A decline in annual counts does not necessarily indicate decreasing scientific importance of Hg-related reproductive toxicity[27]. Publication volume in bibliometric datasets can be influenced by many factors, including indexing time

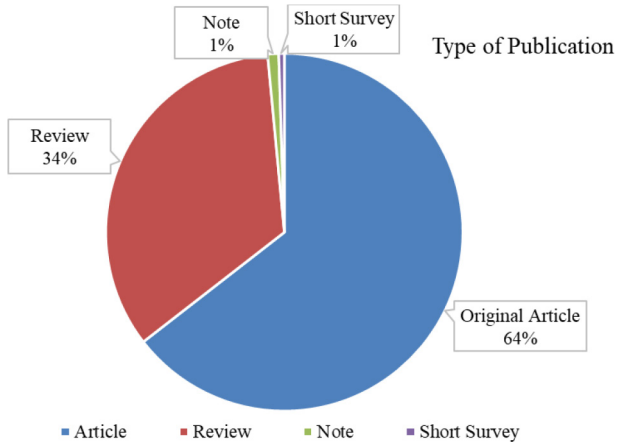


Figure 2. Types of publications on mercury exposure in pregnancy, fetal development, and newborn health (2014–2023).

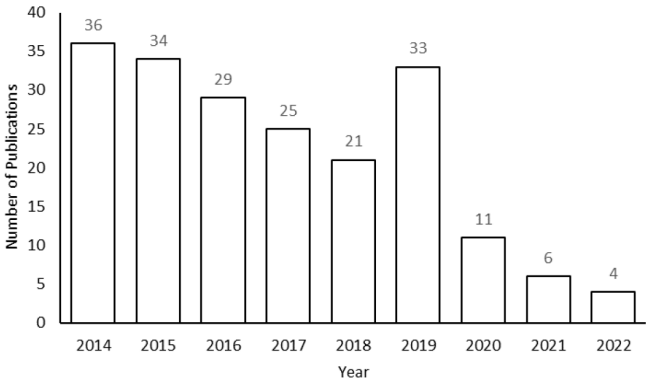


Figure 3. Annual publication trends in studies on mercury exposure in pregnancy, fetal development, and newborn health (2014–2023).

lag, changes in keyword usage, shifts in environmental health priorities, and competition from adjacent topics such as Cd, Pb, As, or mixed-metal exposure research. Therefore, the temporal pattern observed here is better interpreted as a change in indexed publication output rather than as evidence of reduced relevance of Hg exposure in pregnancy-related research[29].

The most highly cited authors and publications, shown in Figure 4, were led by influential papers published in high-impact journals. The prominence of works such as those by Landrigan *et al.* likely reflects the broad relevance of pollution and environmental health to global public health, as well as the visibility of publications appearing in journals with wide interdisciplinary readership[30]. Likewise, highly cited articles related to autism, epigenetics, and exposure-associated developmental effects suggest that Hg-related

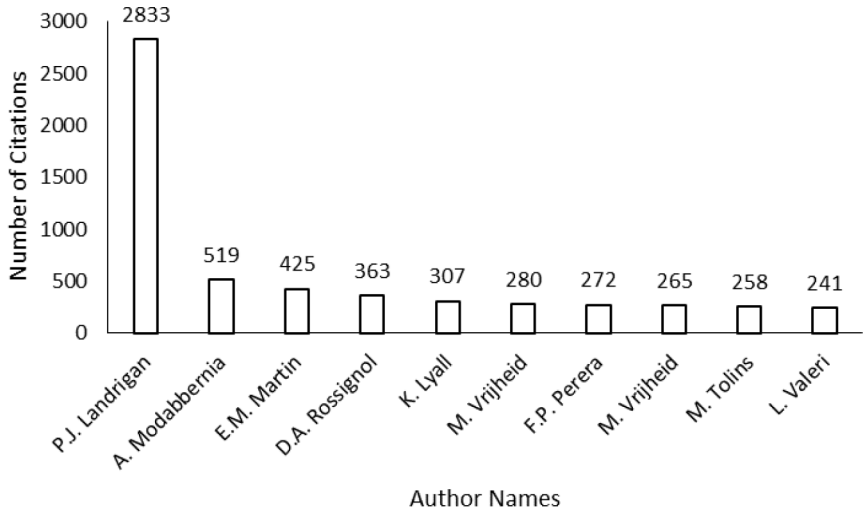


Figure 4. Top 10 most cited publications on mercury and its impact on pregnancy and fetal/newborn health between 2014 and 2023.

pregnancy research is embedded within wider discussions on developmental toxicology, environmental epidemiology, and child health. In this context, citation prominence reflects not only topic importance but also journal reach, interdisciplinarity, and the centrality of the cited papers to broader environmental health discourse [31–33].

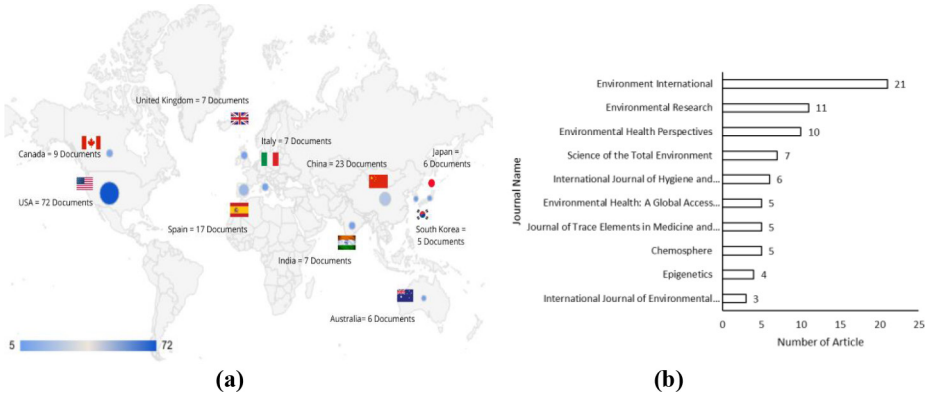
The results in Figure 4 also show that the second author with the highest number of citations is Modabbernia *et al.*, with their article entitled "Environmental Risk Factors for Autism: An Evidence-Based Review of Systematic Reviews and Meta-Analyses"[34]. This article provides a comprehensive review of the environmental risk factors for autism, a significant health issue, and its high citation count indicates its influence in the field. It is published by BioMed Central and indexed by Scopus. In addition, the third author, with the highest number of citations, is Martin and Fry's article, "Environmental Influences on the Epigenome: Exposure-Associated DNA Methylation in Human Populations." This article explores environmental influences on the epigenome, particularly exposure-associated DNA methylation in human populations, and has received high citations, reflecting its impact. It is published in the journal Annual Review of Public Health by the publisher Annual Reviews, Inc.[35]. Apart from these three articles, seven others have citations ranging from 241 to 363, underscoring their significance in environmental health and epigenetics research. Some of these articles also have in common that they are published in reputable international journals with reputable publishers and are all indexed by Scopus.

At the country level, Figure 5a shows that the United States contributed the most publications (72 documents), highlighting its prominent role in environmental health research[36]. This distribution is consistent with the major scientific output of these countries in environmental health, toxicology, epidemiology, and maternal-child health. It may also reflect stronger research infrastructure, broader database representation, and higher publication capacity in these settings. However, the present study did not perform a region-specific bibliometric breakdown for Indonesia, Kalimantan, or other subnational settings. Accordingly, although regional contexts such as Kalimantan are relevant as environmental background, they were not analysed as separate bibliometric units in the current study. The country analysis reported here should therefore be understood strictly as a global country-level overview based on the retrieved Scopus dataset.

(a) Top 10 countries by publication count, illustrating significant research contributions.

(b) Top 10 journals that published studies on this topic, showcasing the leading platforms for disseminating research findings.

The journal distribution shown in Figure 5b indicates that Environment International published the most papers on this topic (21), followed by Environmental Research (11) and Environmental Health Perspectives (10). These journals are widely recognised in environmental health and toxicology and are appropriate publication outlets for research linking contaminant exposure with maternal and developmental outcomes. Their prominence in



(a) (b)

Figure 5. Global publication patterns on mercury exposure in pregnancy, fetal development, and newborn health.

the present dataset suggests that Hg-related pregnancy research is situated within mainstream environmental health scholarship rather than in a narrow or isolated speciality niche. Understanding these publication patterns can help researchers identify influential outlets and inform policymakers about the dissemination channels for environmental health research, ultimately guiding evidence-based decision-making.

As shown in Table 2, most of the leading journals were classified as Q1, with the International Journal of Environmental Research and Public Health as the only Q2 journal among the top ten. Science of the Total Environment had the highest citation count, whereas Environment International showed the highest SCImago Journal Rank (SJR) value (3.02) among the listed journals. These indicators suggest that the topic has achieved visibility in well-established journals with strong bibliometric performance[37], which can be indicative of their influence and reach within the scientific community. Nevertheless, journal-level indicators should be interpreted cautiously. A high citation count or SJR score reflects journal influence and visibility rather than the methodological superiority of every individual article within that journal. Thus, the current results are more appropriately interpreted as evidence of the field's publication in reputable environmental and public health journals, rather than as a direct measure of article quality[38].

Table 2 reveals an intriguing finding: The International Journal of Environmental Research and Public Health is the sole journal in the Q2 category, distinguishing itself from the other Q1 journals. The Science of the Total Environment journal stands out with the highest number of citations, a remarkable 228,353. Furthermore, the Environment International journal boasts the highest SJR value, a significant 3.02. These results, as shown in Table 1, suggest that the Environment International journal is the premier quality journal for the topic of Hg and its impact on pregnancy and fetuses. This is evidenced by its high number of scientific papers compared to other journals and its inclusion in the Q1 classification with the highest SJR value of 3.02.

The network visualisation in Figure 6 revealed four main thematic clusters within the retrieved literature. One cluster linked Hg with related exposure forms such as MeHg and with neurodevelopment-related terms, including autism spectrum disorder. Another cluster was associated with environmental exposure, endocrine effects, and the risk of gestational diabetes mellitus. Additional clusters reflected themes related to pregnancy and children. From a bibliometric perspective, these clusters represent the co-occurrence structure of terms in the literature, illustrating how research topics are interconnected. In other words, terms that appear closer together and are connected by stronger links are terms that tend to be discussed together within the same body of publications. The network, therefore, maps how the research field is conceptually organised; it does not demonstrate causal biological pathways or quantify toxicological risk directly.

The density visualisation in Figure 7 showed that terms related to pregnancy appeared in areas of higher density than terms related to the fetus, child, or newborn. Scientifically, this suggests that the literature indexed in the present dataset has placed greater emphasis on maternal exposure contexts and pregnancy-related framing than on downstream developmental outcomes in offspring. However, interpreting density visualisations

Table 2. Top 10 journals according to the number of documents, citations, scopus quartile, and SCImago Journal Ranking (SJR)

Journal name	Number of documents	Citation	Quartile	SJR
Science of the Total Environment	7	228353	Q1	2
International Journal of Environmental Research and Public Health	3	158486	Q2	0.81
Chemosphere	5	106765	Q1	1.81
Environmental Research	11	44435	Q1	1.68
Environment International	21	28335	Q1	3.02
Environmental Health Perspectives	10	4393	Q1	2.53
International Journal of Hygiene and Environmental Health	6	2667	Q1	1.21
Journal of Trace Elements in Medicine and Biology	5	2377	Q1	0.67
Environmental Health: A Global Access Science Source	5	2047	Q1	1.23
Epigenetics	4	1325	Q1	1.15

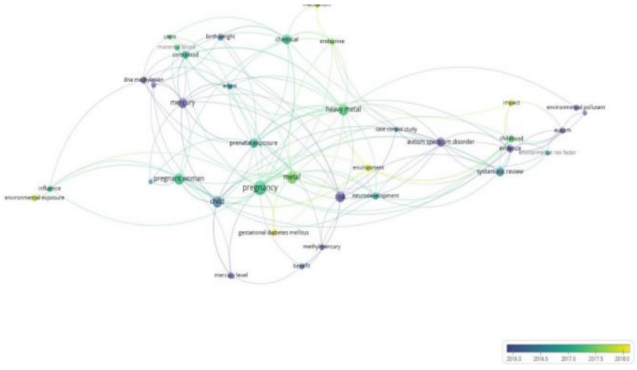


Figure 6. Network visualisation of keyword co-occurrence in publications on mercury exposure in pregnancy, fetal development, and newborn health (2014–2023).

requires caution, as the dataset may contain biases, such as publication bias or limitations in the search strategy. High-density areas indicate a greater concentration of research attention within the retrieved corpus, not greater clinical severity or toxicological importance. Likewise, low-density terms should not be automatically interpreted as biologically less important; rather, they may reflect topics that have received less bibliometric attention, were described using different terminology, or were underrepresented by the search strategy used in this study.

More targeted insights can be drawn from the thematic structure of the keyword maps. The presence of terms such as gestational diabetes mellitus, autism spectrum disorder, placental tissue, and developmental outcomes suggests that at least some studies addressed specific pregnancy-related or offspring-related outcomes. However, the present analysis did not systematically classify the retrieved studies by pregnancy trimester, gestational age, or individual clinical outcomes such as preeclampsia, fetal growth restriction, preterm birth, or neural tube defects. This omission limits understanding of how comprehensively these specific outcomes are represented, which is important for interpreting the depth of toxicological insight provided by the present bibliometric overview[37,39–41].

Taken together, the bibliometric results indicate that Hg-related pregnancy research is concentrated around several major themes: maternal exposure, Me-Hg, child and neurodevelopmental outcomes, endocrine and metabolic disruption, and broader environmental contamination. While these themes are well represented, the present study's contribution is not to establish or re-evaluate these biological mechanisms directly. Rather, its value lies in showing which themes are most visible in the literature, how they are clustered, and where research attention appears to be concentrated or comparatively sparse within the global publication landscape[42]. Identifying these disparities can guide future research to address underexplored areas.

From a toxicological and public health perspective, the observed emphasis on pregnancy-related exposure terms, together with the more limited bibliometric density for fetus- and child-related terms, may suggest an imbalance in the indexed literature. Specifically, the field may be

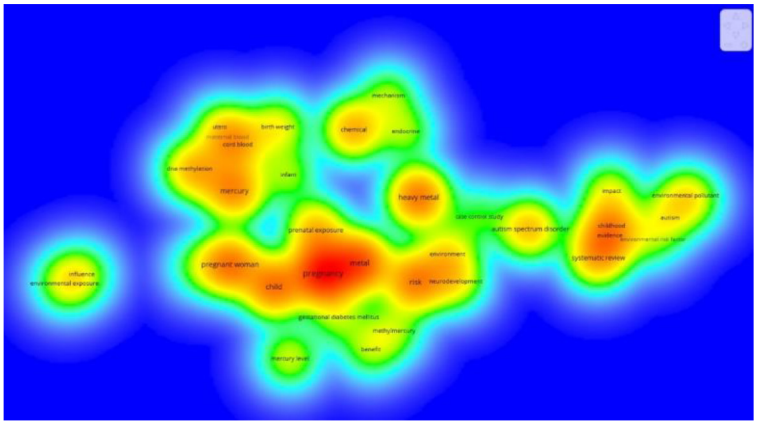


Figure 7. Density visualisation of keyword co-occurrence in publications on mercury exposure in pregnancy, fetal development, and newborn health (2014–2023).

stronger at documenting maternal exposure and general pregnancy-related risks than at systematically mapping specific developmental consequences in offspring. This interpretation is supported by the presence of outcome-related terms in the network map, but the relative lack of dense clustering around highly specific fetal and neonatal endpoints. However, this pattern may also reflect the influence of the search query and how authors label their work in titles, abstracts, and keywords, which should be considered when interpreting these bibliometric signals[43–52].

4. Conclusion

This study provides a global bibliometric overview of scientific publications on Hg exposure in relation to pregnancy, fetal development, and newborn health indexed in the Scopus database from 2014 to 2023. The findings indicate that the literature has gained substantial visibility, particularly in high-impact environmental health journals and in countries with strong research capacity. These trends indicate the growing visibility of this field within environmental health research. At the same time, the bibliometric mapping suggests greater emphasis on pregnancy-related exposure than on more specific fetal and newborn outcomes. In addition, the results of this study emphasise the need for further research on this topic, and call on the academic community to take action to fill the gaps in our understanding of this important issue, for example, the topic of other heavy metals such as Lead (Pb), Arsenic (As), Cadmium (Cd) and others.

However, several limitations should be acknowledged clearly. First, the study is based on bibliometric metadata and keyword co-occurrence, and therefore does not provide a trimester-specific analysis of Hg exposure during pregnancy. Second, the study does not offer a mechanistic synthesis of toxicological pathways because the analysis was not designed to evaluate biological mechanisms in a structured manner. Third, the study does not include a regional or subnational bibliometric breakdown, including for Indonesia or Kalimantan, and thus any mention of Kalimantan should be understood only as contextual background rather than as an analytically supported regional finding. In addition, the analysis was limited to publications retrieved from the Scopus database, which may not fully represent all relevant literature. These limitations should be considered when interpreting the findings.

Based on the observed gaps, future bibliometric studies should apply more targeted search strategies to map the literature in greater detail. These may include trimester-specific terms, outcome-specific terms, and mechanism-oriented keywords such as oxidative stress, placental dysfunction, neurodevelopmental delay, gestational hypertension, preeclampsia, and fetal growth restriction. Future work may also compare country-level or region-specific publication trends, provided that such analyses are explicitly incorporated into the study design. Overall, the present study contributes a broad global map of the field and highlights the need for more granular bibliometric analyses to improve the structure of research on Hg exposure in maternal and early-life health. This proactive approach can inspire researchers and environmental scientists to fill the current gaps and advance understanding in this critical area.

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Author Contributions

Iskandar contributed to the formal analysis, software, resources, and writing—original draft preparation. Didik Dwi Sanyoto contributed to the methodology, validation, and review and editing of the manuscript. Rizmi Yunita contributed to conceptualisation, methodology, and supervision; Isna Syauqiah contributed to the validation; analysis data; review and editing of the manuscript, and supervision; Eko Suhartono contributed to conceptualisation, methodology, validation, writing—review and editing of the manuscript, and supervision; and Hapsari Lintang Sekartaji contributed to the software, writing the manuscript, and visualisation.

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