A Bibliometric Review on Air Pollution, Health, and Safety Within Factories and Mills

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ABSTRACT

This bibliometric review presents a comprehensive analysis of research on air pollution and its impact on health and safety, focusing on factory and mill environments. The study examined 401 documents published between 2019 and 2023, sourced from 247 distinct outlets, with an annual growth rate of 12.32%. Key research contributions come from China and the USA, with strong international collaboration evident in 35.41% of the publications. Core sources include prominent journals such as *Science of the Total Environment*, *Environment International*, and the *International Journal of Environmental Research and Public Health.* Leading authors, including Kan H. and Chen R., have made significant contributions to the literature on the health impacts of particulate matter and nitrogen dioxide. This study identifies three (3) major trending topics: (1) human; (2) particulate matter; and (3) China. A shift towards broader discussions on "sustainable development" and "climate change" is observed, influencing recent research agendas. The co-occurrence network of keywords reveals three main research clusters: (1) human–air pollution interaction; (2) clinical studies on gender and occupational health; and (3) health risks and environmental monitoring. Analyses of the aforementioned clusters have demonstrated the role of interdisciplinary collaboration in advancing research in this field. The findings emphasise the value of interdisciplinary and international collaboration, particularly between China and the USA, in addressing health risks from air pollution. These partnerships aid in policy development, support technology sharing, and foster further research opportunities. Future studies should refine methods to better link pollutant exposure with health impacts, particularly among vulnerable populations.

Keywords: Air pollution, impacts, health and safety, factory and mills, bibliometric.

1.0   INTRODUCTION

Air pollution plays a major role in human life and may induce numerous adverse health effects in humans. In recent years, several review studies have compiled and analysed the growing body of literature on air pollution,

highlighting its wide-ranging effects on human health and its health burden. Recent studies have shown that long-term exposure to fine particulate matter ($PM_{2.5}$) significantly increases the risk of premature death, particularly from cardiovascular and respiratory diseases, and lead to cognitive decline in older adults [1,2]. Most conventional review papers focus on specific research topics, while bibliometric reviews that use quantitative analysis of published literature have become increasingly popular. Bibliometric methods summarise findings by identifying the research trends, and they play a crucial role in guiding both scientific and policy development [3].

While most reviews focus on specific fields of research, this paper provides a broader overview of literature related to air pollution, health, and safety, particularly within occupational settings such as factories and mills. This study helps to identify major literature, the most influential authors, main countries in which the studies were conducted, most cited documents, most frequent words, trend topics, conceptual structure, and the global collaboration trends for future research prediction, all of which are less commonly reviewed areas of research [4-13].

This paper is organised as follows: the Introduction section presents the concept of this paper and summarises the top ten most cited studies, while the Methodology section reveals the specific advanced search query or keywords that were used as a background for data mining conducted in this paper. The Results section then identifies the "Sample Overview," which delineates the research outcomes based on the earlier methodology used, and further identifies the publication sources. Subsequently, the results demonstrate categories of the most productive authors in the related field, core institutions, and countries involved. Meanwhile, the Documents section outlines the top ten most cited documents in the related field, where "most frequent words" refers to the commonly occurring thematic terms, and "trend topics" identifies the most widely discussed and mentioned trend topics. On the other hand, the "Conceptual Structure" shows the relationship of the sampled data, where the co-occurrence network of keywords identifies keywords in distinct clusters in which it was interrelated. Additionally, the collaborating countries were also analysed. The Conclusion section elaborates on the summary of this research.

1.1   Most Cited Documents

Chen [4] investigated short-term health impacts of coarse particulate matter ($PM_{2.5–10}$) on daily mortality across 272 cities in China, while Meng [5] examine the acute health effects of nitrogen dioxide (NO_2) exposure and cardiovascular, and respiratory mortality across multiple countries with both studies employed time series analysis approach in analysing data from multiple cities [3,4]. Chen [4] found a significant association between short-term $PM_{2.5–10}$ exposure and daily nonaccidental and cardiopulmonary mortality. Similarly, Meng [5] observed that a 10 μg/m³ increase in NO_2 concentrations was significantly linked to a higher risk of cardiovascular and respiratory mortality, suggesting stricter air quality standards and emissions control.

Similarly, Xue [6] uses a spatiotemporal model to assess the rising trend of ground-level ozone (O_3) concentrations and their contribution to the disease burden. This study has found that there was an increase in O_3 concentrations from 86 μg/m³ in 2013 to 95 μg/m³ in 2017, with a national annual growth rate of 2.07 μg/m³ (95% CI: 1.65, 2.48). This rising trend indicates that O_3 is becoming an increasingly significant contributor to the disease burden associated with air pollution in China. This is similar to findings in Chen [4], Turner [7], and Liu [8], which also explored the health risks of particulate matter, underscoring the global implications of air pollution on respiratory and cardiovascular health. Liu [8] found an association between short-term exposure to PM_{10} and $PM_{2.5}$ and daily all-cause, cardiovascular, and respiratory mortality in more than 600 cities across the globe, while Turner [7] reported a causal link between outdoor air pollution—particularly particulate matter and lung cancer, and it was estimated that particulate matter air pollution would cause hundreds of thousands of lung cancer deaths each year globally.

Vos [9] and Murray [10] provided comprehensive reviews of global health risks, focusing on the burden of communicable and non-communicable diseases and injuries. Meanwhile, Vos [9] estimated the incidence, prevalence, mortality, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs) for 369 diseases and injuries across 204 countries. The study found that in 2019, non-communicable diseases and injuries made up more than half of the total disease burden in 11 countries. Using a similar Bayesian meta-regression modelling tool, Murray [10] quantified attributable deaths and DALYs linked to each risk factor. The greatest increases in risk exposure were observed for ambient particulate matter pollution, drug use, high fasting plasma glucose, and elevated body mass index [10]. Additionally, Thompson & Darwish [11] examined environmental contamination, specifically the infiltration of chemicals into food systems and their adverse effects on human health. This review suggests improved global

cooperation, stricter regulations, and enhanced public awareness to address the growing issue of chemical contamination in the food supply [11].

A recurring methodological approach across these works is using meta-analytical and hierarchical models. Vos [9], Murray [10], and Meng [5] pooled city-specific data using such models, which enhances the generalisability of their findings. Chen [4] and Xue [6] incorporated spatiotemporal models and Bayesian hierarchical frameworks to evaluate trends in air pollution, reflecting the growing trend toward integrating large-scale environmental data. Furthermore, Tcharkhtchi [12] focused on mask and filtration mechanisms, where the author then drew simulation models and extensive literature reviews to provide a better understanding on how environmental factors can influence health risks.

Moreover, public policy and mitigation strategies emerge as critical themes throughout the texts. Carmona [13] developed a book on urban design which emphasises the importance of environmental management for human well-being, while Turner et al. [7] provided recommendations on public health and policy, and Thompson & Darwish [11] addressed the health risks posed by pollution.

2.0   METHODOLOGY

2.1   Document Selection Criteria

(ALL ("air pollut*" AND "health * safety" AND "occupation*") AND ALL ("factory" OR "factories" OR "mill*")) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (PUBSTAGE , "final"))

Figure 1. Scopus advanced search query

Figure 1 illustrates the advanced search query conducted using the Scopus indexing service. The term "air pollutant*" is applied with a wildcard to capture variations such as "air pollution," "air pollutant," and their plural forms. Another wildcard is inserted between "health" and "safety" to encompass both variations of "and" and its symbol, "&." The terms "factory" and "mills" are included to refine the document selection further. These were to ensure that the sampled documents captured studies related to the keywords: "health," "safety," and "occupation" within factories and mill settings. The sample comprises papers published within the five-year period from 2019 to 2023, up to the time of writing, with only those in the final stages of publication included for consideration.

This study employed Biblioshiny, a web-based interface for the Bibliometrix R package, to conduct a comprehensive bibliometric analysis [14]. Bibliographic data were extracted from reputable databases and subsequently cleaned to ensure consistency in author names, keywords, and sources. Descriptive analyses were performed to identify key authors, institutions, and citation patterns. Network analyses, including co-authorship and keyword co-occurrence, were used to map research collaborations and thematic linkages. Thematic evolution and trend analyses further enabled the identification of emerging topics and research gaps within the domain of air pollution in occupational health and safety.

3.0   RESULTS

3.1   Sample Overview

Following the earlier selection criteria, 401 documents from 247 sources were chosen. The documents exhibit an annual growth rate of 12.32%. A total of 3,983 authors contributed to these publications, with 31 authors producing single-authored documents. International co-authorship accounts for 35.41% of the total contributions. On average, each document has 14.4 co-authors. The dataset includes 1,367 author keywords and references and 39,651 sources. The average document age is 2.74 years, with each document receiving an average of 57.07 citations. From the selected sample, 195 papers are open access. The number of publications per year is as follows: 71 in 2019, 63 in 2020, 70 in 2021, 84 in 2022, and 113 in 2023. Figure 2 shows the annual scientific production. The sample comprises 254 journal articles, 70 review papers, 43 books, 26 book chapters, and 8 conference papers. Regarding sources, 324 articles are derived from journals, 65 from books, 7 from conference proceedings, and 5 from book series.
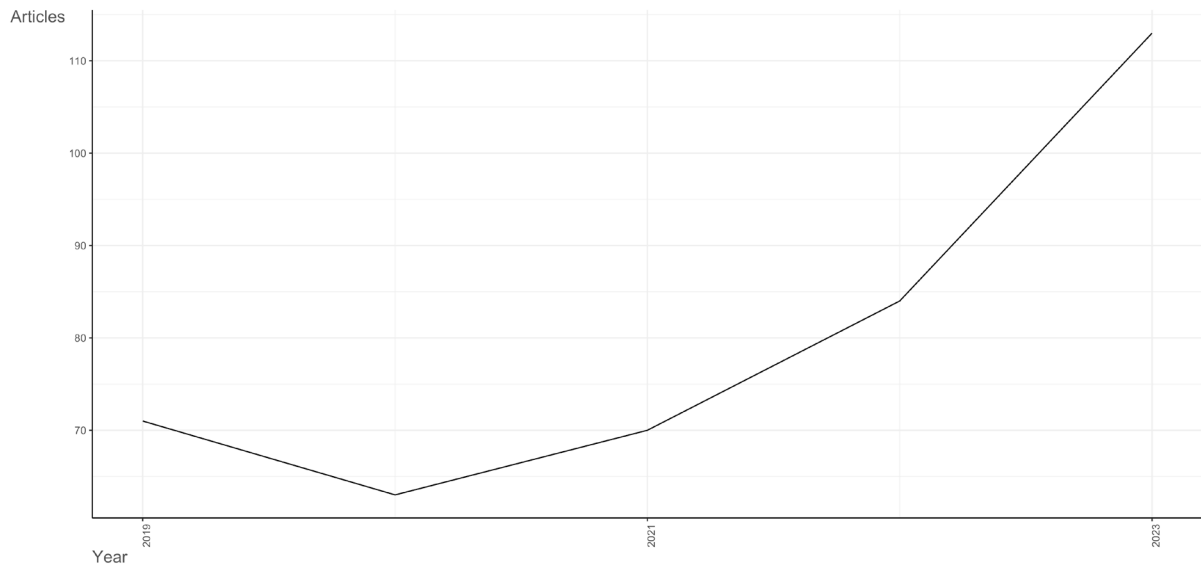
Figure 2. Annual scientific production

3.2 Publication Sources

Figure 3 presents the core sources of the documents, as identified using Bradford's Law. According to this law, a few sources produce a large proportion of publications, while the majority contribute only a few. The top-ranked sources are listed, with the core sources highlighted in the grey box. The leading source in the field is "Science of the Total Environment," with 19 documents, followed by "Environment International" with 14 papers. The "International Journal of Environmental Research and Public Health" ranked third place with 12 publications, and "Chemosphere" ranked fourth with 10 documents.
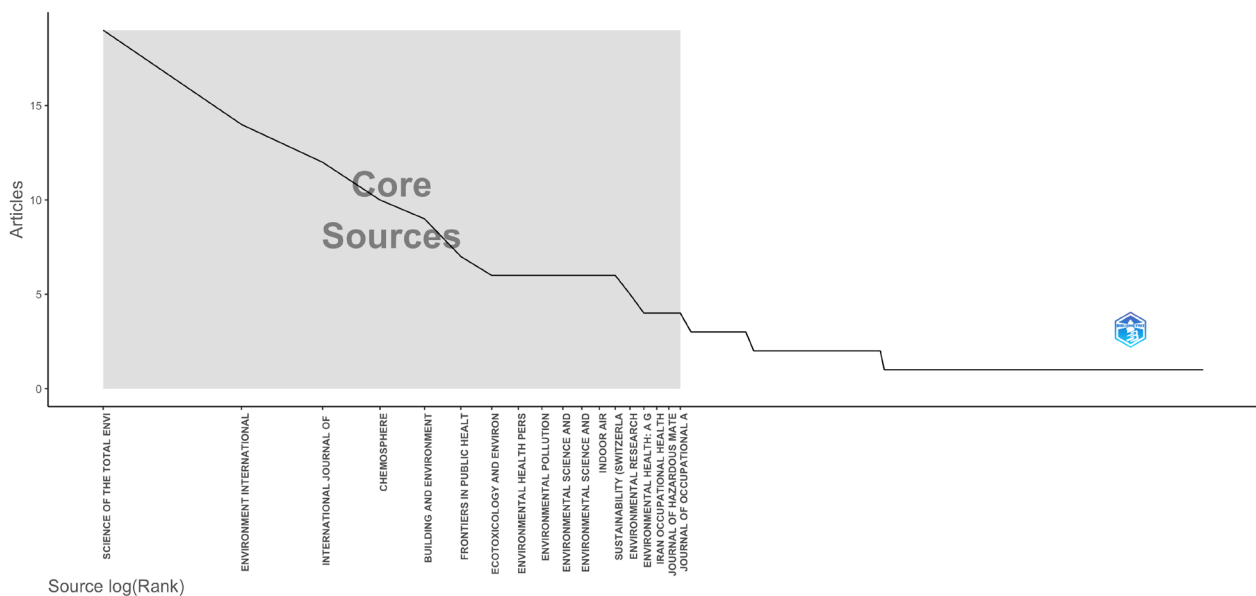

Figure 3. Core sources by Bradford's law

3.3 Authors

A bibliometric review of the authors' productivity, affiliations, and countries can identify the most influential authors, most active institutions or organisations, and the leading countries in the field of study.

3.3.1   Productivity

The most influential authors in the field can be assessed based on the sample data. Table 1 ranks the most prolific authors by the number of articles they contributed and their fractionalised articles. Article fractionalisation credits multiple authors proportionally based on the number of co-authors. The author with the highest contribution is Kan H., with 55 articles and 4.74 fractionalised articles. On average, the top ten authors contributed 25.7 articles, with 2.006 fractionalised articles.

Table 1. Most Relevant Authors

Authors	Contributed Articles	Articles Fractionalised
Kan H.	55	4.74
Chen R.	44	3.68
Zhang Y.	27	1.81
Liu C.	26	1.96
Meng X.	20	1.49
Chen Y.	19	1.23
Wang W.	18	1.50
Cai J.	16	1.52
Wang Y.	16	1.18
Liu Y.	16	0.95

3.3.2   Core Institutions

A total of 476 authors in the sample are primarily affiliated with "Fudan University," making it the institution with the most relevant affiliations. This is followed by the "London School of Hygiene and Tropical Medicine" with 57 documents. "Thomas Jefferson University" ranks third with 45 documents. The top five affiliations are rounded out by the "University of Washington" and the "Shahid Beheshti University of Medical Sciences," with 41 and 36 documents, respectively.
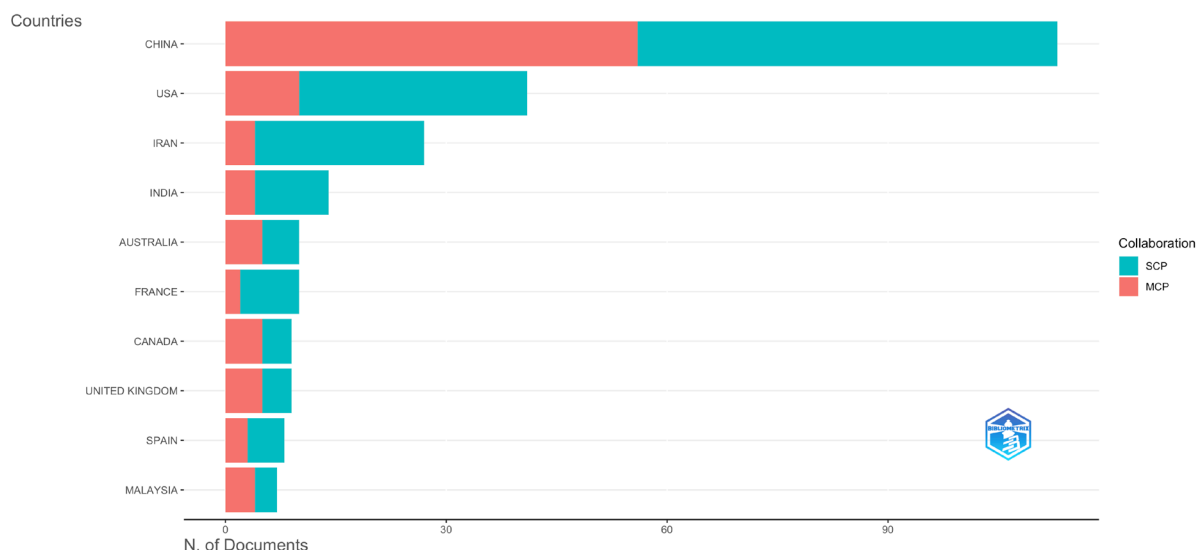
3.3.2   Countries

Figure 4. Corresponding author's countries

Analysis of the corresponding authors' countries highlights which nations are most active in the field under review. Figure 4 presents the distribution of corresponding author countries, including collaboration details for Single-Country Publications (SCP) and Multiple-Country Publications (MCP). China leads with 113 articles (28.2%) comprising 57 SCPs and 56 MCPs. The USA follows with 41 articles, including 31 SCPs and

10 MCPs. Iran ranks third with 27 documents, 23 SCPs, and 4 MCPs. India takes fourth place with 14 articles, while Australia and France share fifth place, each contributing 10 articles. The top ten is rounded out by Canada, the United Kingdom, Spain, and Malaysia, with 9, 9, 8, and 7 articles, respectively. It is assumed that China, the USA, Iran, India, Australia, and other leading countries were able to publish SCP journals due to their rapid industrialisation, advances in technology, and their countries' support in funding research in the related areas.

3.4   Documents

3.4.1   Most Cited Documents

The significance of a document within a research field can be evaluated by the total citations (TC) it has accumulated. Table 2 lists the ten most globally cited documents, ranked by their TC, TC per year, and normalised TC. Normalised TC adjusts citation counts to account for differences in citation practices across fields or years, enabling a fairer comparison of research impact. In brief, the top ten documents average 1,675.4 total citations, 332.819 TC per year, and 11.438 normalised TC.

Vos [9] leads the ranking, with 9,347 total citations, 1,869.40 TC per year, and 36.75 normalised TC. This systematic analysis addresses the health burden of 369 diseases and injuries in 204 countries, making it a complete and reliable source of baseline data to support research, guiding health planning, and shaping public policies [9]. The top three most globally cited documents (>1000 citations) have some similarities. These studies were funded by either government or non-governmental bodies, conducted on a larger scale, and mostly focused on the health burden of diseases, making it a popular source of citations [8-10]. Other studies focused on environmental pollution-chemical contaminants [11], only one study evaluates the mask filtration efficiency [12], one study highlights the environmental space design [13], while others similarly focused on air pollution and its effect [4-7].

In summary, most studies are related to research on air pollution and its impact on health and safety, while only one-tenth most cited publications are related to air pollution and the workplace environment [12].

Table 2. Most globally cited documents

Documents, citation by First Author	Source	DOI	Total Citations	TC per year	Normalised TC
Vos et.al (2020) [9]	The Lancet	10.1016/S0140-6736(20)30925-9	9,347	1,869.40	36.75
Murray et.al (2020) [10]	The Lancet	10.1016/S0140-6736(20)30752-2	4,792	958.40	18.84
Liu et.al (2019) [8]	The New England Journal of Medicine	10.1056/NEJMoa1817364	1,063	177.17	25.89
Turner et.al (2020) [7]	CA: A Cancer Journal for Clinicians	10.3322/caac.21632	468	93.60	1.84
Tcharkhtchi et.al (2021) [12]	Bioactive Materials	10.1016/j.bioactmat.2020.08.002	262	65.50	10.10
Thompson & Darwish (2019) [11]	Journal of Toxicology	10.1155/2019/2345283	256	42.67	6.24
Chen et.al (2019) [4]	Environmental Health Perspectives	10.1289/EHP2711	156	26.00	3.80
Carmona (2021) [13]	Taylor & Francis Group	10.4324/9781315158457	146	36.50	5.63
Xue et.al (2020) [6]	Environmental Science & Technology	10.1021/acs.est.0c03098	141	28.20	0.55
Meng et.al (2021) [5]	The BMJ	10.1136/bmj.n534	123	30.75	4.74

3.4.2   Most Frequent Words

The most frequent terms can be extracted from the sample data and visualised using WordCloud (Figure 5). In a WordCloud, the size of each term corresponds to its frequency of occurrence in the dataset. The most frequent term is "particulate matter," appearing 194 times, followed by "human" with 191 occurrences. "China" ranks third with 181 mentions, followed by "humans" with 159 occurrences. "Air pollution" is in fifth place, appearing 145 times. The remaining top ten terms include "article," "female," "male," "environmental exposure," and "adult," with 142, 142, 137, 128, and 115 occurrences, respectively. The term "occupational exposure" is in 11th place with occurs only 89 times compared to other environmental-pollution related words. These frequent words show that air pollution related to particulate matter dominated the findings compared to studies within factories and mills ("particulate matter" vs. "occupational exposure" keywords; 194 vs. 89).

Other findings related to "occupation," "factories," and "mills" have appear at the 12th place with "Risk assessment" occurs about 85 times, "indoor air pollution" at 22nd place and occurs 43 times, while the term "Occupational Health" at 36th place and occurs only 28 times. This might be due to the higher research in the particular field since air pollution has been the major global public health issue over the last two decades [15], compared with occupational environments or exposure-related studies.

Figure 5. Most frequent words WordCloud

3.1.3   Trend Topics

Popular trend topics were analysed based on the document selection criteria. Figure 6 illustrates the trending topics derived from the sampled data, highlighting the most discussed subjects by year. The line indicates the period during which each topic was covered in the research, while the circle marks the median point when the topic was most frequently mentioned. In 2021, three terms—"human," "particulate matter," and "China"— were mentioned with high frequency, ranging from 200 to 300 occurrences. In 2023, the most frequently discussed topics were "climate change," "physical activity," and "sustainable development." This also proves that ambient air pollution and its impact on either humans or the environment (the climate change trend topic appears to show the air pollution impact on the environment) remains popular compared to pollution related to "occupation", "factories", and "mills" (trend topic: risk assessment).
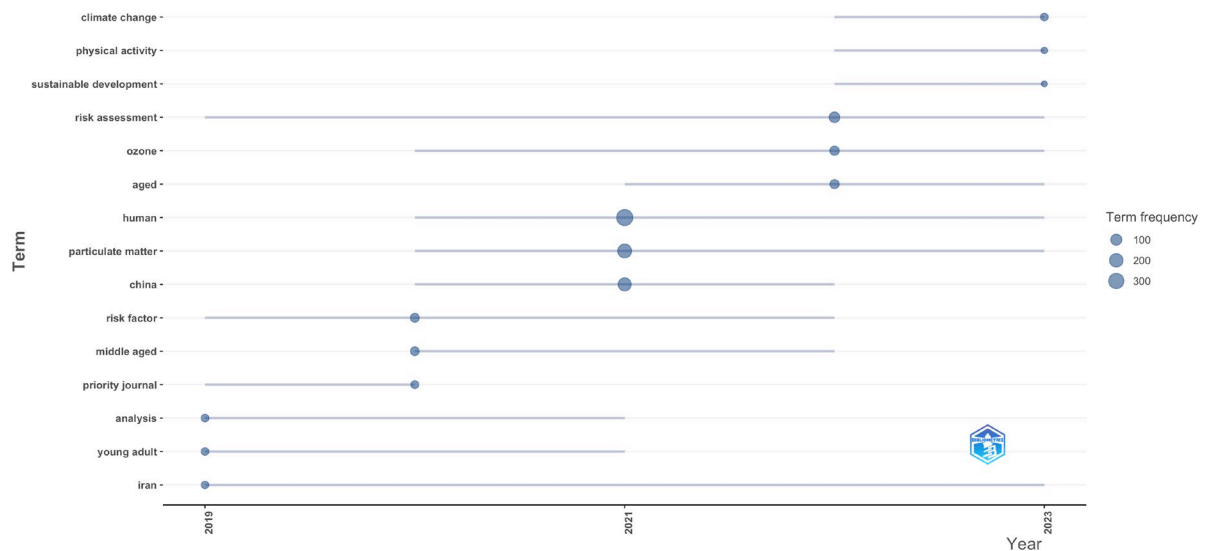
Figure 6. Trending topics
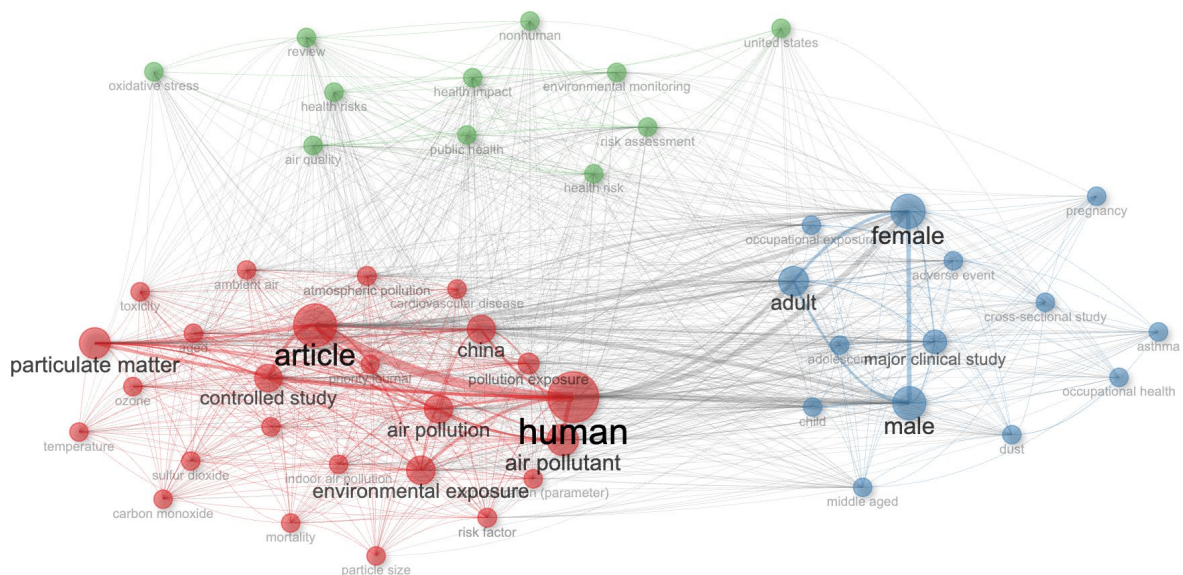
3.5 Conceptual Structure

Figure 7. Co-occurrence network of keywords

A conceptual structure can help identify relationships within the sample data. Figure 7 displays the co-occurrence network of keywords mentioned in the documents. The size of each node reflects the frequency with which a keyword appears—the larger the node, the higher the frequency, and vice versa. The keywords are grouped into three distinct clusters, represented by different colours. The red nodes represent studies on humans and air pollution, while the blue nodes highlight studies focusing on adult clinical research, gender, occupational health, and specific health impacts across age and exposure groups. The green nodes indicate studies on health risks and environmental monitoring. These topics are the current emerging trends. A keyword co-occurrence network helps identify the relationships between commonly used terms in academic publications, revealing key research themes and interdisciplinary links. Publishing in these thematic areas not only increases the likelihood of higher citation impact but also enhances opportunities for securing research grants and attracting major collaborative partnerships.
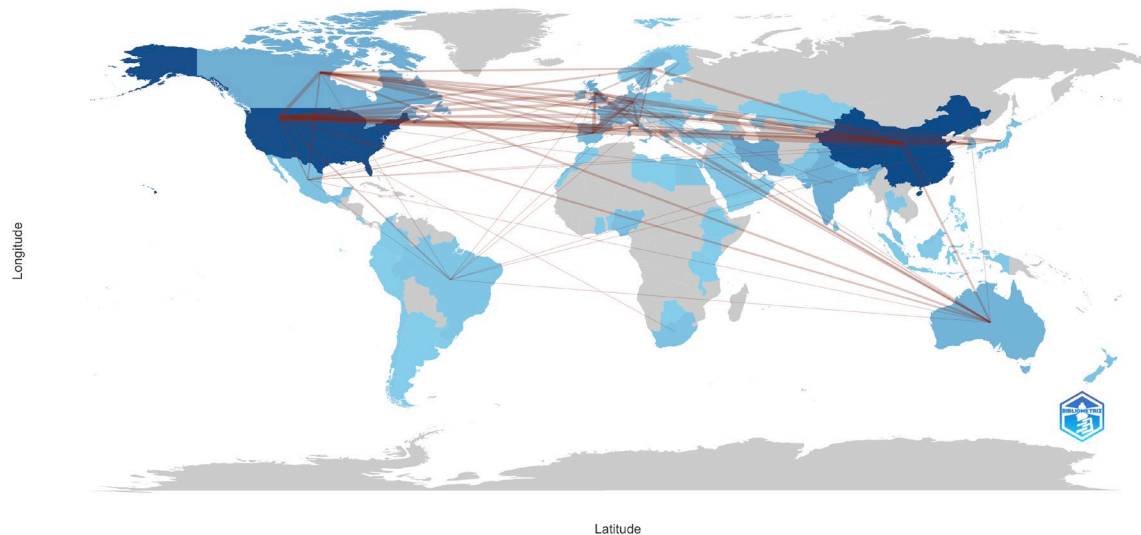
Figure 8. Country collaboration map

Figure 8 presents the country collaboration map, where the intensity of brown lines indicates the number of collaborations between countries. The most vigorous collaboration is between China and the USA, with 44 joint publications. This was followed by collaborations between the USA and Canada, which resulted in 17 partnerships. The third-highest collaborations, each with 12 instances, are between China and Canada, China and the United Kingdom, the USA and Germany, and the USA and the United Kingdom. The United Kingdom and Italy have 11 collaborations, while China and Sweden have 10. These robust collaborations demonstrate the commitment of multiple nations to supporting research in this field.

Developed countries tend to dominate research in the field of air pollution and occupational health and safety due to several interrelated factors. China and the USA established the highest joint publications basically due to their extensive industrial activities, well-established research infrastructure, and strong governmental and private support for scientific advancement. Moreover, both nations experience significant environmental and public health challenges associated with air quality, motivating urgent scientific inquiry and innovation. In China, rapid urbanisation and energy-intensive manufacturing have led to serious air pollution concerns, making it to become an urgent environmental problem to be solved [14]. Similarly, in the USA, regulatory bodies like OSHA and EPA rely heavily on scientific evidence to guide occupational and environmental health standards. Apart from that, the dominance is also influenced by greater publication output, international visibility, and collaboration networks, allowing researchers in these countries to contribute substantially to the global scientific discourse.

4.0   CONCLUSION

This bibliometric review offers a comprehensive overview of the research on air pollution, health, and safety within factory and mill settings. The analysis of 401 documents sourced from 247 outlets shows that the field has experienced steady growth, with an annual growth rate of 12.32% and a strong emphasis on international collaboration, as demonstrated by the 35.41% of publications involving co-authorship across multiple countries. Notably, China and the USA lead in contributions and collaborations, underscoring their central role in the global research landscape.

Key sources such as "Science of the Total Environment," "Environment International," and the "International Journal of Environmental Research and Public Health" have emerged as core contributors to the field, demonstrating the concentrated production of high-impact research in a small number of journals, in line with Bradford's Law. Authors like Kan H. and Chen R. have been identified as the most prolific in the domain, contributing substantially to the literature on particulate matter and nitrogen dioxide's health effects.

The top three most cited documents are studies that published an interaction of humans with air pollution and its association with health burden. These studies were funded by either governmental or non-governmental bodies. The co-occurrence network of keywords reveals that research clusters around three primary themes: human and air pollution studies, clinical studies on gender and occupational health, and

studies on health risks and environmental monitoring. Additionally, trending topics in recent years reflect a shift toward broader discussions on sustainable development and climate change, which are increasingly shaping the research agenda.

This review underscores the critical importance of international collaboration in addressing the health impacts of air pollution, both at the community level and among specific populations such as workplace-exposed groups. The analysis highlights that China, and the United States are leading contributors to research in this area, likely due to their status as developed nations with advanced technological capacity and large populations. For Malaysian policymakers and stakeholders, engaging in partnerships with these countries may offer valuable opportunities to address local air pollution challenges and deepen understanding of its health effects.

For researchers, recognizing global research trends is essential for increasing the potential for research funding from industry stakeholders and government bodies, improving citation impact, and fostering international collaborations. Future research should aim to refine methodologies that link pollutant exposure more precisely with health outcomes, especially among vulnerable populations. Such efforts not only enhance the scientific rigor of local studies but also increase their global relevance and policy impact. By aligning with international research directions, Malaysian researchers and policymakers can strengthen national capacity in environmental and occupational health, while contributing to more effective management of air pollution and its associated health risks.

Bibliometric analysis studies are useful for identifying research trends, but using a single database might lead to bias since some important studies from other sources or languages may be missed. We acknowledge this limitation and suggest future studies use multiple databases for a more complete analysis.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper.

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