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Research Article

Analysis of Global Scientific Production on Health Service Waste through Bibliometric and Scientometric Indicators

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Abstract

Inadequate management of healthcare waste represents a significant challenge to public health and the environment. This study aims to analyze global scientific production on healthcare waste using bibliometric and scientometric indicators, providing a comprehensive overview of research trends and areas of interest. Data from academic databases were used to map the temporal distribution of publications, identify the leading countries, institutions,

and researchers involved, and evaluate collaboration networks and journals with the highest impact in the area. The results indicate a continuous increase in publications, reflecting a growing awareness of the risks associated with healthcare waste and the importance of research in this area. Developing countries have stood out in scientific production, which reflects their critical needs regarding management. It is concluded that research on this type of waste is expanding, with international and interdisciplinary collaborations playing a central role in advancing knowledge and implementing safer and more sustainable practices.

Keywords
Hospital waste; public health; health service waste; waste management

1. Introduction

Human activities related to healthcare provision for humans or animals generate waste with characteristics that differ from typical urban solid waste, which is why it is classified as healthcare waste [1]. This type of waste is produced in various healthcare settings, such as hospitals, clinics, and laboratories, as well as in activities related to body piercings and tattoos, aesthetic and beauty treatments, veterinary services, and even home visits for patient or client care. It also includes waste generated by healthcare supply laboratories, forensic medicine practices, drugstores, pharmacies, research and teaching institutions in healthcare, and zoonotic disease control centers, among others.

Some researchers highlight that healthcare waste is a significant component of overall waste, not because of its quantity, but because of its specific nature. Depending on the activities that produce it, healthcare waste can pose biological, chemical, and/or radiological risks to people and the environment [2, 3]. These risks arise due to the pathological, infectious, sharp, chemical, and other hazardous characteristics, such as cytostatic and radioactive materials.

Despite the challenges associated with managing this type of waste, the development of waste management practices in Brazil has been marked by significant gaps and inefficiencies, particularly concerning the establishment and enforcement of legal frameworks, which are often outdated [4, 5].

Research indicates that the effectiveness of healthcare waste management can be enhanced through initiatives such as educational programs, stronger laws, and improved oversight, emphasizing holding public authorities accountable for their regulatory and supervisory roles [6, 7].

Healthcare waste management should be treated as a collective responsibility. Poor management affects not only society at large but also individuals, particularly in the disposal of pharmaceuticals at home [8].

This study aims to analyze the global scientific literature on healthcare waste management using bibliometric and scientometric indicators, providing a comprehensive overview of research trends and areas of interest.

2. Methods

This study was based on a systematic literature review through bibliometric analysis of Healthcare Service Waste, focusing on global scientific production on the topic published in journals

indexed in the Scopus database (Elsevier). Scopus is one of the largest citation and abstract databases of peer-reviewed scientific literature, offering tools to track, analyze, and visualize research across a wide range of disciplines, providing a comprehensive view of global research trends [9].

Initially, during the data collection phase, the research followed the methodological recommendations outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement for systematic reviews. The PRISMA guidelines [10] are widely used for analyzing studies across various scientific fields (Figure 1).

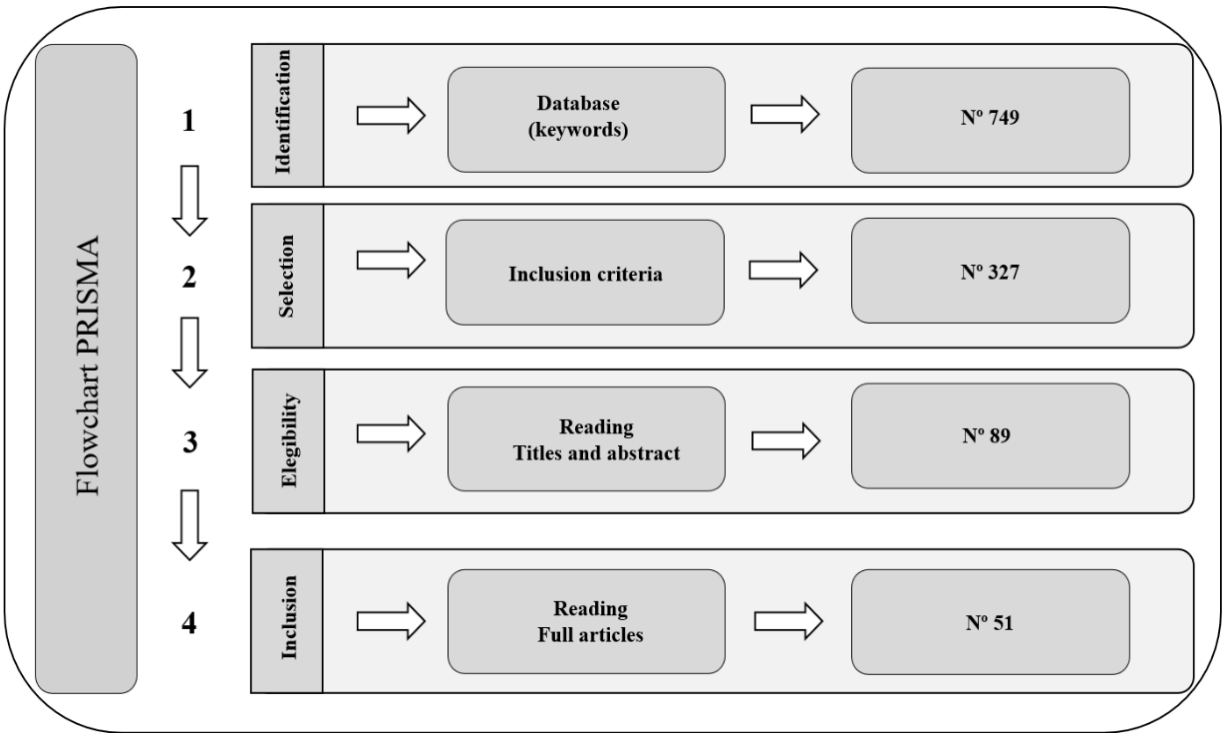

Figure 1 Schematic representation of the identification, selection, eligibility, and inclusion methods for the review, adapted according to PRISMA.

The document search was conducted in September 2024, using the following keywords in the identification criteria: "Hospital Waste," "Public Health," "Healthcare Service Waste," and "Waste Management" within the Scopus database (Elsevier). The search was performed on article titles, abstracts, and keywords, yielding 749 documents.

Next, in the selection phase, documents were chosen based on the following inclusion criteria: publications from the past 10 years (2013 to 2023), types of documents accepted were scientific articles and conference papers, and publications must be in English. This process led to the screening of 327 articles.

In the eligibility phase, scientific papers were selected by evaluating the titles and abstracts to ensure alignment with the research objective. After reviewing the titles and abstracts, 89 papers were selected. Of these, 51 were included after a complete reading and the application of exclusion criteria. Finally, after critically analyzing the chosen papers, the studies were categorized by author, year of publication, research location, objectives, methodology used, and results presented.

In the second stage of the research, during the bibliometric analysis phase, after applying the PRISMA methodology, the data were processed using the free software tools VOSviewer and R Studio (Bibliometrix package). Bibliometric indicators derived from the research materials were analyzed (Figure 2). This methodology is widely recognized in information science as a robust research tool, utilizing quantitative, qualitative, and statistical methods to analyze data from large sets of information [11].

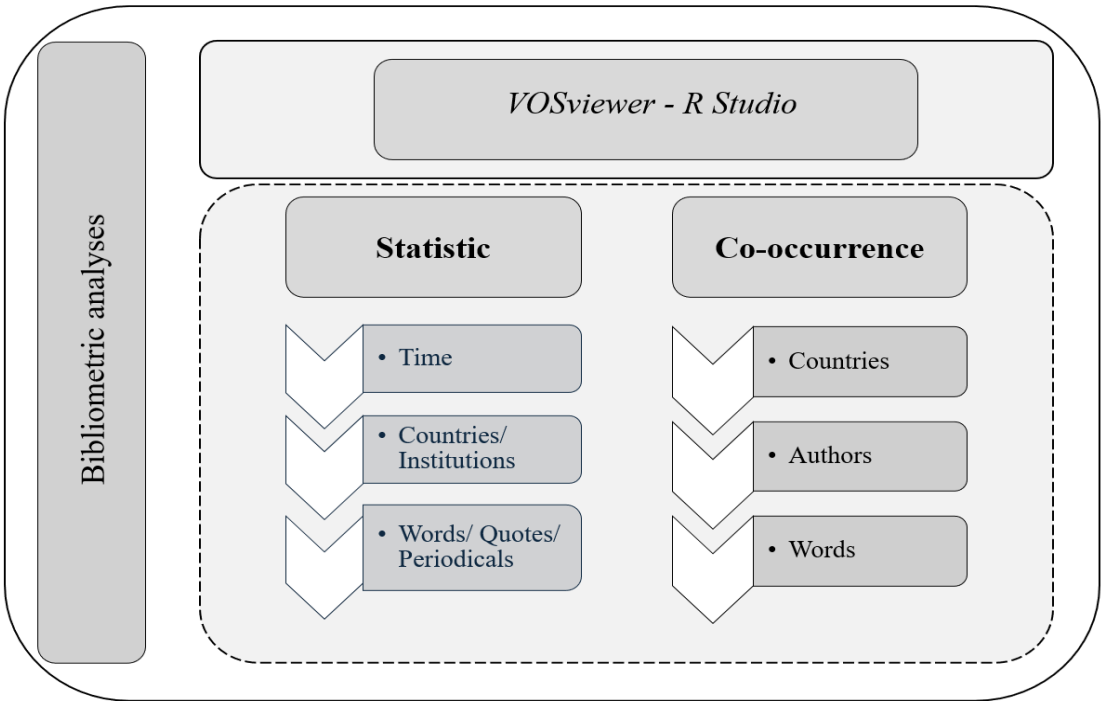

Figure 2 Schematic representation of the bibliometric analysis flowchart.

3. Results and Discussion

3.1 Annual Production

The increase in scientific publications on healthcare waste between 2020 and 2021, as shown in the bibliometric graph (Figure 3a), can be directly attributed to the COVID-19 pandemic. This period was marked by a significant surge in demand for healthcare services worldwide, leading to a greater generation of hospital and medical waste, including masks, gloves, personal protective equipment (PPE), and disposables used in treatments and tests. The rise in citations of these publications during the same period can be explained by the immediate relevance of the topic (Figure 3b). During the pandemic, healthcare managers, legislators, and professionals faced unprecedented challenges related to safety and sustainability in healthcare waste management. The search for solutions and scientific information to guide public policies and practices in the sector made research on healthcare waste particularly important.

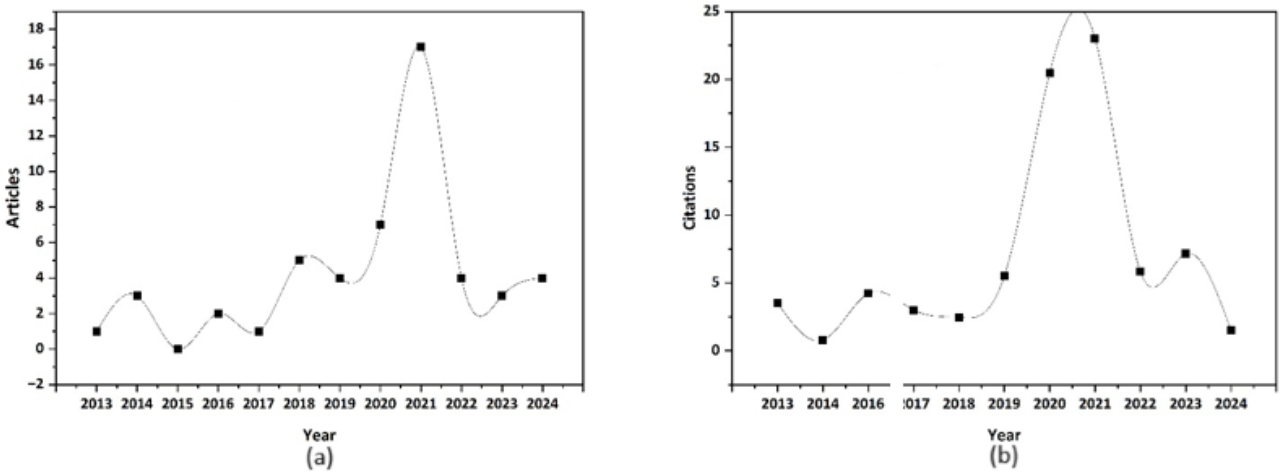

Figure 3 (a) and (b) – Annual production and citations per year.

With the global increase in COVID-19 cases, the management of protective measures and waste became highly relevant [12, 13]. The large volume of waste generated during the treatment and prevention of COVID-19, due to its rapid spread, posed risks of contamination from discarded materials [14]. Research conducted during the pandemic indicated that the increase in healthcare waste was primarily due to the care protocols used for treating COVID-19 patients [15].

3.2 Country Scientific Production

An analysis of scientific production related to COVID-19 by country reveals a clear correlation between the volume of research and the severity of the pandemic in terms of infections and deaths (Figure 4a and 4b). China, as the first epicenter of the crisis, initially led scientific production focusing on the virus's origin, control measures, and vaccines. In the United States, the country with the highest number of cases and deaths at various times, there was a large volume of research on vaccines, treatments, and hospital response. These two countries continued to drive research efforts, standing out in terms of strategies to combat the pandemic, with incentives for further studies. At the same time, other nations also began to focus on research related to countries with the highest number of cases.

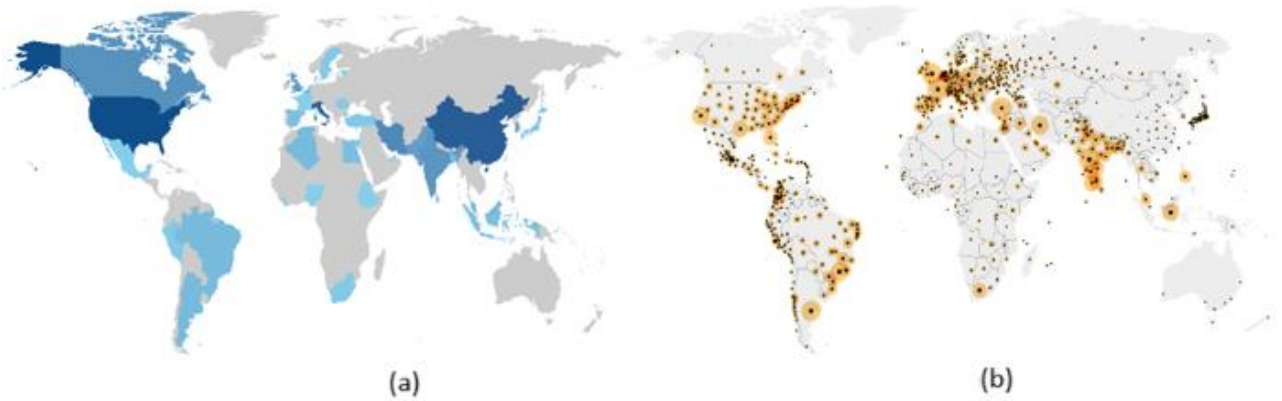

Figure 4 (a) and (b) – Country scientific production x Confirmed cases of COVID-19 and deaths caused by the virus, by country.

India, which was severely affected by a second wave in 2021, concentrated on research concerning the management of the health crisis and the variants of the virus. Canada, with its more effective response, focused on public policies and the social impacts of the pandemic. Brazil, also heavily impacted, produced significant studies on hospital responses and immunization strategies, addressing the urgent need for solutions in light of the high rates of infection and death in the country.

The word cloud shown in Figure 5 presents a visual representation of the most frequent terms found in the publications [16]. In the context of healthcare waste studies, the term "COVID-19" appears prominently, reflecting the massive impact of the pandemic on the generation and management of medical waste. The substantial increase in waste, such as masks, gloves, and PPE, raised significant concerns about safe and proper disposal. As a result, "medical waste" stands out as a central term, emphasizing the focus on addressing healthcare waste generated during the pandemic.

Figure 5 Word clouds.

Additionally, terms like "waste management" and "recycling" are prominent in the word cloud, indicating discussions about improving waste management systems to cope with the increased volume of waste. "Waste management" refers to the practices necessary to ensure the safe and efficient handling of healthcare waste, particularly in a pandemic. The term "recycling" reflects the growing interest in finding more sustainable solutions, such as reusing or recycling some of this waste to reduce environmental impact. Together, these terms in the word cloud highlight the primary areas of concern and research on healthcare waste.

3.3 Cluster Analysis

The similarity cluster analysis revealed two distinct clusters within the selected articles, each representing a thematic domain related to healthcare waste management (Figure 6). The green and red circles within each cluster indicate the most frequently used keywords, while the lines connecting the terms show the frequency of their co-occurrence in the literature. Cluster 1 (red) is associated with managing healthcare waste in hospitals and the public sector. This cluster includes topics like solid waste disposal, recycling, and waste treatment, all of which contribute to quality of

life and minimize environmental impact. Keywords like municipal solid waste, hospital waste, and public health are essential for driving discussions in this domain.

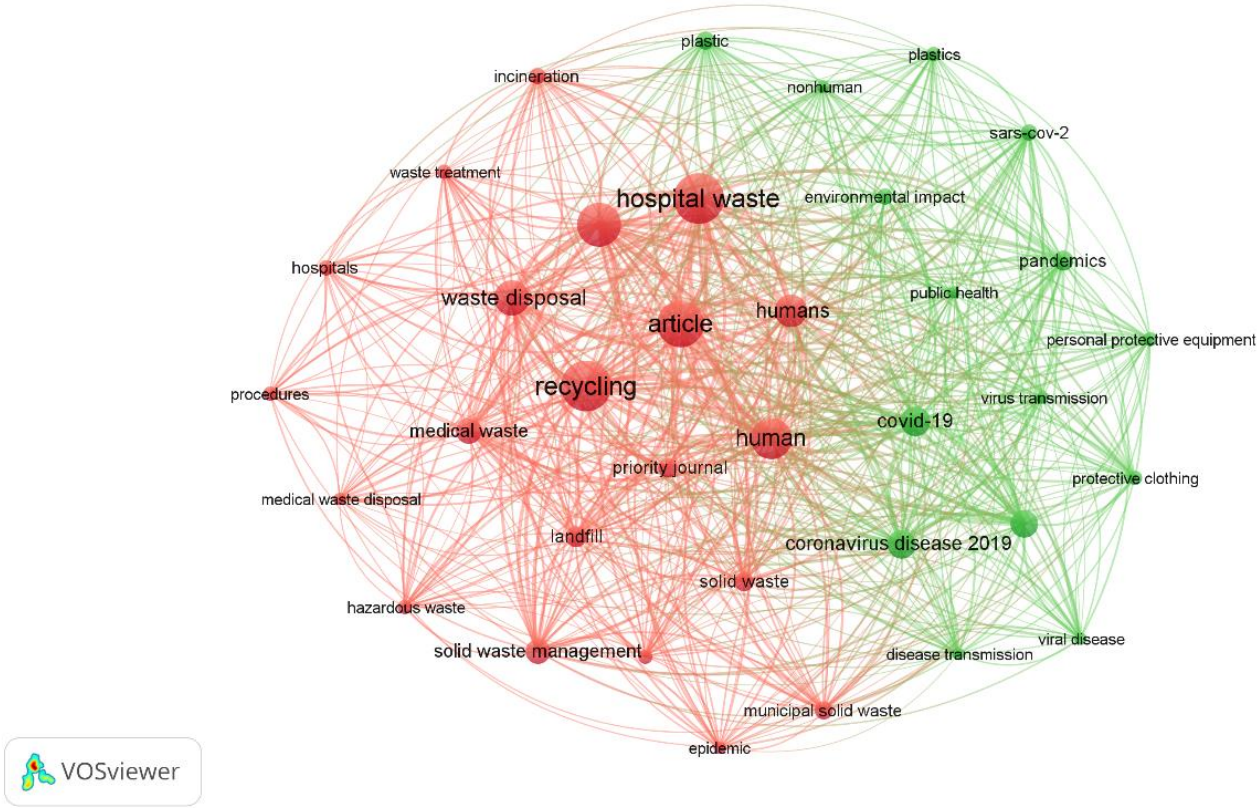

Figure 6 Grouping of studies associated with the theme of health service waste.

Cluster 2 (green) focuses on issues related to viral transmission, such as spreading diseases through contact with contaminated waste. This cluster emphasizes the growing importance of measuring and implementing actions to minimize the transmission of communicable diseases, such as COVID-19, and their effects on public health and the environment.

Analyzing the articles from a scientometric perspective, it is evident that studies focused on hospital waste, recycling, human resources, and waste disposal gained more relevance (Figure 7). In the first half of 2019, the main themes for academic discussions centered around incineration, hospitals, and the disposal of medical waste. As the year progressed, these topics expanded to include other relevant subjects, such as health and the environment.

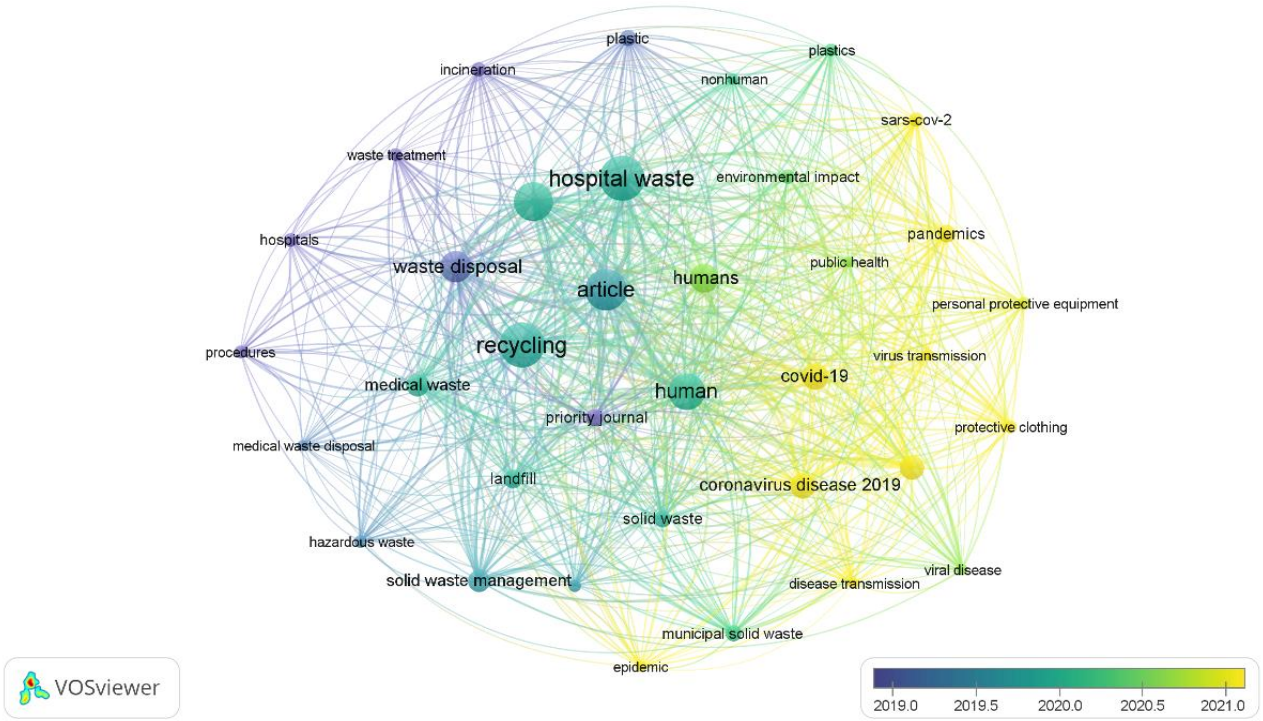

Figure 7 Analysis of temporality associated with the theme of health service waste.

In the first half of 2020, the focus of academic publications shifted towards COVID-19, emphasizing the environment, solid waste, and public health. This shift highlights the importance of these topics in the educational community, despite the relatively low number of published articles. By the second half of 2020, discussions broadened to include the management of municipal solid waste within the context of public health and the proper disposal of healthcare waste.

In the first quarter of 2021, there was a notable increase in publications on waste management and hospital waste (medical waste), reflecting the growing importance of personal protective equipment (PPE) in public health services. This academic interest was anticipated due to the rising number of COVID-19 cases, which led to increased hospital waste generated by the virus's transmission [17]. Furthermore, the COVID-19 pandemic imposed significant limitations in many countries, resulting in major changes and increased storage of various types of waste, creating a challenge for properly disposing of these materials [18].

Although there was insufficient research addressing the societal impacts of waste generation and management during the pandemic, there were discussions on these topics, particularly with solid waste [19].

4. Conclusions

The study demonstrates that research on healthcare waste has experienced significant growth over the years, reflecting an increasing awareness of the risks this waste poses to public health and the environment. The bibliometric and scientometric analysis revealed a notable rise in publications, particularly since the COVID-19 pandemic. During this global health crisis, scientific production surged, driven by the urgent need to address the massive volume of waste generated, such as masks, gloves, disposable testing materials, and other items related to controlling the virus's spread. This surge in publications underscores the pivotal role of the pandemic in amplifying discussions about

the proper management of healthcare waste and adopting safer, more effective practices in both developed and developing countries.

The findings also indicate that developing countries emerged as key contributors to scientific production during this period, reflecting their urgent needs in waste management, which were exacerbated by the pandemic's impact on infrastructure and socioeconomic conditions. International and interdisciplinary collaborations have been crucial in advancing knowledge during the crisis, enabling exchanging experiences and developing innovative solutions for healthcare waste management.

Additionally, the global network of scientific collaboration has grown substantially, with institutions and researchers from various regions of the world coming together to mitigate the impacts of the pandemic on healthcare waste management. Leading journals have also reported a significant increase in articles on the topic, highlighting the issue's importance within the global health context.

In conclusion, research on healthcare waste is rapidly expanding, with an even more critical role during global health crises such as COVID-19. The pandemic has emphasized the need for safer and more sustainable practices, and science will continue to play an essential role in guiding improvements in healthcare waste management, ultimately contributing to the protection of public health and the preservation of the environment.

Author Contributions

Italcy, Flávio, Alana, Thamyris, Rhaldney: Conceptualization, methodology, writing – original draft, formal analysis, writing – review and editing, and also, final control of the draft. Marcone, Clezianny: Translation, conceptualization, methodology, writing – review and editing. All authors read and approved the published version of the article.

Competing Interests

The authors have declared that there are no competing interests.

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