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Hospital Waste Management During COVID-19

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ABSTRACT

Any solid, liquid, or gas substance used will be immediately discarded. The substance waste dumped is conducted in every place, including hospitals. The hospital management system covers hospital waste management. This management allows the hospital to monitor the amount and variants of waste produced, which minimizes the harmful effects of waste. However, in this topic, systematic analytical mapping studies still have a lot of research limitations. This study aims to analyze Hospital Waste Management during the peak of COVID-19 which is presented as a systematic review. This research applied the qualitative method with a literature study approach. The hospital waste management articles identified from 2011-2021 amounted to 686 publication articles that Scopus indexed, indicating that hospital waste management studies have increased in recent years. The expansion in the study mainly was research on hospital waste management from the inner side of hospital management. Many studies on hospital waste management from processing, environmental impact, and the risk of spreading infections have been studied from the COVID-19 side since 2019. This finding has implications for further research by analyzing the problems related to the rapidly growing field of hospital waste management in detail or using a different perspective.

Keywords: Hospital Waste, Waste Management, Hospital Waste Management, COVID-19, Systematic Review.

1. INTRODUCTION

The hospital management system includes all existing management in the hospital, such as waste management. [1] Hospital waste has greatly increased recently. [2] According to one hospital in Iran reported that waste increased from 80 kg/day to 205 kg/day. [3] Hospital waste is any waste or material produced as by-products of all activities that take place in hospitals. [4]

Every year, Hospital activities can generate more than 2.4 million tons of waste. [5] The previous studies results showed that at the beginning of 2021, the average percent of waste increased to 102.2% in personal, private, and public hospitals used during the COVID-19 pandemic. [3] It affects the generation of medical waste in some countries with high Covid-19 transmission rates, including Iran, China, Indonesia, Brazil, and India. This increase shows that the waste ratio ranges from 0.82 to 3.5 kg/bed/day. [3]

Hospitals based on tertiary care delivery in India reported that they produced more waste during the pandemic, with an average amount of 900kg/day. [6] The first country infected, China, is experiencing a tremendous daily waste surge. China has 240 metric tons of waste, with hospital medical waste increasing sixfold. It impacts establishing of new waste factories and deploying 46 mobile waste treatment facilities (mobile waste treatment facilities). [7] A significant number of cases occur

daily in Africa. [8] As a result, waste becomes one of the impacts of the increased use of masks and drugs. As this issue arises, the government needs to disseminate new regulations and solutions to develop sustainable waste management strategies using environmentally friendly technology. [9]

Some technical knowledge related to hospital waste management can be applied, given the potential for a significant increase in waste volume in a short time. [10] The concept of a waste management system consists of a series of separation activities, collection, transportation, processing, and recycling. [11] This series of activities allows for better medical waste management and disposal implementation. However, according to the Indonesia Ministry of Health report in November 2019, 2,685 hospitals produced 296 tons of medical waste per day. [12] Out of 2,685 hospitals, only 96 hospitals have incinerators to process waste independently. [12]

The dynamics of waste generation have changed because to the COVID-19 epidemic, particularly regarding the waste produced by hospitals. A previous study by Sharma *et al.* [10] Highlighted the difficulties encountered in solid waste management during the pandemic and the essential opportunities to close any implementation gaps that may develop. These concerns were supported by the issue on waste management issues for biomedical waste, plastic waste, and food waste in hospitals related to the spread of infection, which are discussed in detail. Based on the background explanation, this study will analyze hospital waste management. The study will focus on what has happened in the last ten years. With a specific focus on those related to the COVID-19 pandemic, this study aims to investigate the dominance of research topics in the scientific community regarding the emerging phenomena in the discussion of hospital waste management, with an explicit focus on those related to the COVID-19 pandemic.

2. LITERATURE REVIEW

Any liquid, solid, or gas substance that cannot be directly used is permanently disposed of and is therefore considered waste. The waste is categorized as hazardous waste if it is combustible, reactive, explosive, corrosive, radioactive, infectious, irritating, sensitizing, or bio-accumulative. [13] All hospital waste abandoned and not intended for future use is considered waste. [14] These days, efficient biological waste management has become a global humanitarian issue. [15] The concept of hospital-waste management requires more awareness as it concerns potential risks to human health, animals, plants, and the surrounding environment. [5,16]

The different types of medical waste amount has been increasing [2] ; this is due to the increased population and medicinal products waste, especially during the Corona-19 Virus (COVID-19) pandemic. [9] The exponential growth in the amount of waste produced by hospital health service operations associated with the spread of the infectious outbreak and the subsequent increase in the number of COVID-19 patients. Additionally, the frequency of replacement of personal protective equipment, such as medical staff's use of masks also plays a role. [17]

The waste sorting, characterization, minimization, separation, transportation, and processing until it is ready for disposal or reuse. [18] According to Changizi, Badeenezhad and Alidosti, (2021) explains that in the application of hospital waste management is not only the responsibility of hospital administration, but also every part of health care provider personnel and individuals in the hospital. When carrying out waste management activities produced by hospitals, it is necessary to think about who contributes to the production of waste, so that it can help to streamline the amount of waste. [15] The share of hospital services carried out by doctors and nurses was found to be the largest contributor to the number of wastes in hospitals. [20]

3. RESEARCH METHOD

This research uses a qualitative approach with a literature review study to achieve objective scientific publications. Initially, the researcher conducted a library review taken from a central database (https://www.scopus.com/) which provides globally indexed journals with peer-reviewed journals concept. A systematic review approach is utilized in this research to identify, collect, classify, and consolidate knowledge in previously published scientific publications on the selected topic, namely hospital waste management. Then a thorough screening is carried out based on aspects related to the topic. [21] This study develops an iterative search strategy. It is a strategy starting with the search terms used in the literature that are familiar to the researcher.

Data retrieval was carried out by utilizing the largest database source, Scopus, which currently has around 81 million documents indexed in all scientific fields. [8] The researcher entered a series of searches with the main keywords "hospital AND waste AND management" then continued by limiting the year of publication of the article from 2011 to 2021, selecting English language articles, and combining several keyword choices with Boolean operators (Table 1).

Theme	Keywords
Types of waste	Hazardous Waste, Hospital Waste, Infectious Waste, Medical Waste, Medical Waste Disposal, Wastewater, Solid Waste, Wastewater, Water Pollutant, Water Pollutants, Chemical, Drug, Healthcare Waste, Hospital Wastewater, Waste
Waste Management	Education, Disinfection, Recycling, Sewage, Efficiency, Organizational, Training, Hospital Management, Waste Management, Waste Disposal, Wastewater Management, Waste Treatment, Wastewater Treatment, Wastewater Treatment Plant, Solid Waste Management Incineration, Water Management, Municipal Solid Waste, Total Quality Management Protective Equipment
Things related to waste	Cost Benefit Analysis, Cost Control, Coronavirus Disease 2019, COVID-19, Coronavirus Infections, Disease Outbreaks, Disease Transmission, Epidemic, Environment, Environmental Monitoring, Environmental Impact, Environmental Protection, Health Care Cost, Sanitation, SARS-CoV-2, Severe Acute Respiratory, Hospital Sector, Hospital Infection, Infection Control, Hand Washing, Health Knowledge, Attitudes, Practice, Hospital Patient, Health Facilities, Public Hospital, Quality Improvement, Health Care Policy, Syndrome Coronavirus 2, Pandemics, Prevention and Control, Intensive Care Unit

Table 1. Keywords used in Studies

This study used 686 published articles that have been found. The same period was used to collect all the data, January 2022, to eliminate biases caused by database upgrades. The steps taken in this study are depicted in Figure 1 to clearly show how the research was carried out. The data collection step is based on the research of Ulfa *et al.* [22] RIS and CSV file formats were used to export the data and then processed to display a map of the information presented in the study. This bibliometric map was formed using three analysis variants: analysis of search results directly from the Scopus menu, analysis using the VOSviewer software application, and analysis using the NVivo 12 Plus software application.

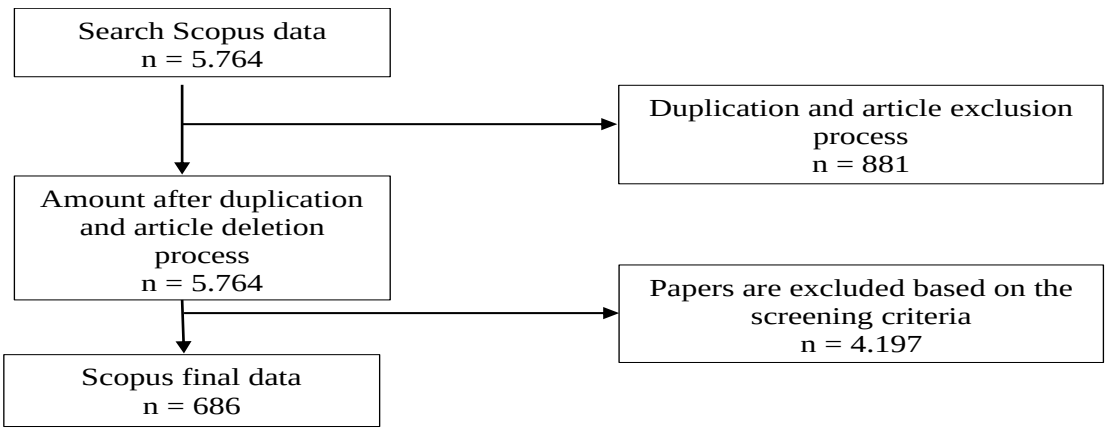

Figure 1. Data Search Flow

4. RESULTS AND DISCUSSIONS

4.1 Publication by Year

The development of the number of articles observed regarding hospital waste management can be seen in Figure 2. An overview of the research curve that tends to increase yearly is shown. The number of studies with the most topics found in 2021 amounted to 127 published articles. From 2019 to 2020, the highest increase was 31 articles, more than the increase in the previous year. The end of 2019 was the initial era of the development of a worldwide pandemic regarding the outbreak of coronavirus disease 2019 (COVID-19). [23] According to estimates, one of the factors contributing to the rise in recent years in the number of research on waste management in hospitals is the necessity for the management of waste materials and items used to treat COVID-19 patients. [24]

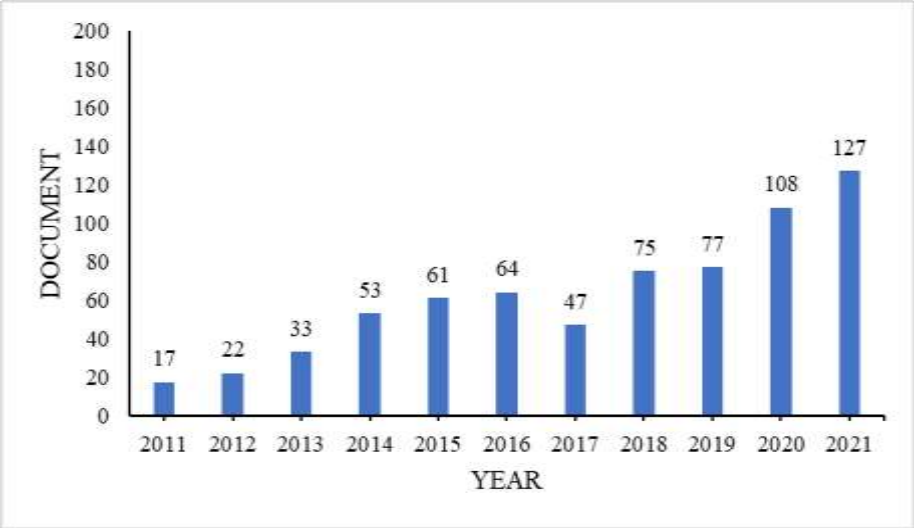

Figure 2. Distribution by Year

The analysis based on the period obtained using the VOSviewer software showed in Figure 3. It displays the visualization of the trend of the theme of publications related to hospital waste management that have been published based on a specific period. In the last five years, there have been studies on hospital waste management, including pandemics, healthcare waste, knowledge, training, environmental impact, and coronavirus disease.

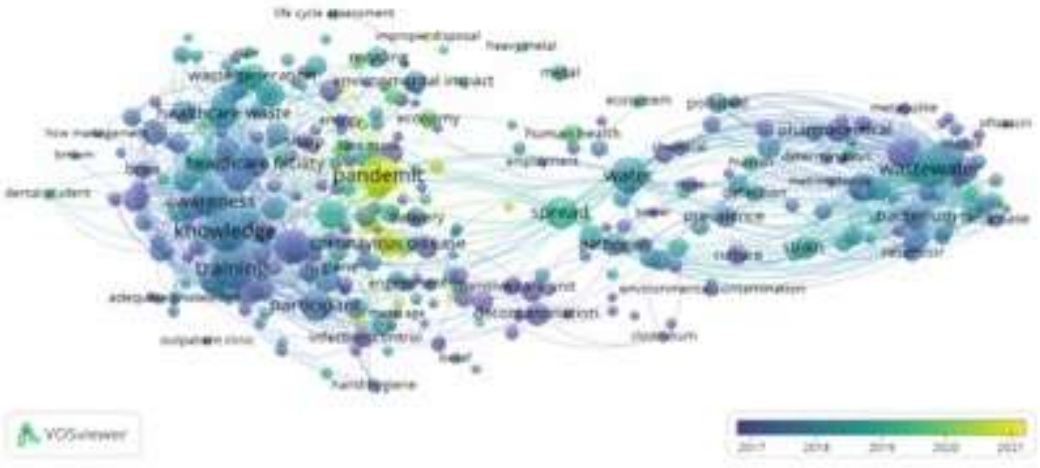

Figure 3. Overlay publication by year using VOSviewer

In addition, the development of research themes and trends involving hospital waste management from 2019 to 2021 is also investigated in this study. Before 2019, most research on hospital waste management only explored problems from the inner side of hospital management, which involves knowledge, practice, awareness, training, and participants. [25] New publication themes were raised starting in 2019, namely the themes of pandemics and coronavirus disease [2] . One of the themes of the pandemic was found in a publication article published in Bangladesh in the Sarkodie and Owusu study, entitled "Challenges in medical waste management amid COVID-19 pandemic in a megacity Dhaka." [7]

4.2 Geographical distributions

Several previous publications studied the realization of implementing independent hospital waste management in the region. [26] Based on the search results for articles on waste management from 2011-2021, 686 Scopus-indexed publication articles were identified based on the main keywords ("hospital AND waste AND management"). The articles number consists of several countries' distributions, namely the US (100), India (82), UK (75), China (67), Brazil (38), Italy (35), Iran (34), France (29), Canada (26), Sweden (23), Australia (22), Spain (22), Pakistan (20), Netherlands (18), Ethiopia (17), Switzerland (16), Poland (15), Malaysia (14), and Portugal (14). Also, several other countries can be observed (Figure 4).

Figure 4. Distribution based on Countries using (software Mapchart) (https://www. mapchart.net/world.html, accessed on 22 September 2022)

In Figure 4, the United States and India dominated the published articles on hospital waste management. It is possible because the United States is one of the countries that have the best education system in the world. [27] This country's researchers have the freedom to do research and develop innovations. It attracts researchers in the United States to continue to discover new findings. The second ranking of countries with the highest publications comes from India. Early manuscripts were found in India around 700 BC. [28] The Indian government has begun to support the idea of research as a career path that has affected the country's rapid development of literacy rates. [29] This idea certainly has encouraged researchers in India to continue to grow and improve and find research results with quality.

According to the quantity of citations, researchers categorized the articles. The categorization was used to map the research papers on the issue of hospital waste management. The citations articles listed as a research sample were based on international sources. The countries with the most cited publications globally from 2011 to 2021 (Table 2). It is essential to mention that the rankings are based on local citations. Based on this ranking, the United Kingdom ranks first in the study.

Country	Number of Document	Citations	Rank
United Kingdom	75	2427	1
United States	99	1712	2
Italy	35	687	3
China	67	1087	4
India	82	1301	5
Australia	21	883	6
France	29	608	7
Malaysia	14	337	8
Pakistan	20	205	9
Netherlands	18	520	10

Table 2. Documents Citation by Country

4.3 Document Citation

The published articles are sorted by the number of citations they have received (Table 3). Ranking the number of cited articles can also be seen by subject area. The ranking was made to map out the study of published articles most relevant to hospital waste management.

Title	Author and Publication's year	Source	Subject Area	Frequency of Citation
Epic3: National evidence-based guidelines for preventing healthcare-associated infections in nhs hospitals in England	Loveday *et al.*, 2014 [30]	Journal of Hospital Infection 86(S1), pp. S1-S70	Medicine	617
Controlling hospital-acquired infection: Focus on the role of the environment and new technologies for decontamination	Dancer, 2014 [31]	Clinical Microbiology Reviews 27(4), pp. 665-690		288
Knowledge, awareness, and practices regarding biomedical waste management among undergraduate dental students	Santhosh Kumar and Rahman, 2017 [32]	Asian Journal of Pharmaceutical and Clinical Research 10(8), pp. 341-345		248
An evaluation of environmental decontamination with hydrogen peroxide vapor for reducing the risk of patient acquisition of multidrug-resistant organisms	Passaretti *et al.*, 2013 [33]	Clinical Infectious Diseases 56(1), pp. 27-35		147
Contribution of hospital effluents to the load of pharmaceuticals in urban wastewaters: Identification of ecologically relevant pharmaceuticals	Santos *et al.*, 2013 [34]	Science of the Total Environment 461-462, pp. 302-316	Environmental Science	346
Environmental toxicology and risk assessment of pharmaceuticals from hospital wastewater	Escher *et al.*, 2011 [35]	Water Research 45(1), pp. 75-92		335
Hospital wastewater treatment by membrane bioreactor: Performance and efficiency for organic micropollutant elimination	Kovalova *et al.*, 2012 [36]	Environmental Science and Technology 46(3), pp. 1536-1545		294
Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic	Bhakta *et al.*, 2020 [37]	Resources, Conservation and Recycling 162,105052		140
Multiresistance, beta-lactamase-encoding genes and bacterial diversity in hospital wastewater in Rio de Janeiro, Brazil	Chagas *et al.*, 2011 [38]	Journal of Applied Microbiology 111(3), pp. 572-581	Biochemistry, Genetics and Molecular Biology	98
Microbial removal of the pharmaceutical compounds ibuprofen and diclofenac from wastewater	Langenhoff *et al.*, 2013 [39]	BioMed Research International 2013,325806		85
Impact of China's public hospital reform on healthcare expenditures and utilization: A case study in ZJ province	Zhang *et al.*, 2015 [40]	PLoS ONE 10(11),e0143130		29
Continuous fungal treatment of non-sterile veterinary hospital effluent: pharmaceuticals removal and microbial community assessment	Badia-Fabregat *et al.*, 2016 [41]	Applied Microbiology and Biotechnology 100(5), pp. 2401-2415		28
Controlling hospital-acquired infection: Focus on the role of the environment and new technologies for decontamination	Dancer, 2014 [31]	Clinical Microbiology Reviews 27(4), pp. 665-690	Immunology and Microbiology	288
Quantitative and qualitative impact of hospital effluent on the dissemination of the integron pool	Stalder *et al.*, 2014 [42]	ISME Journal 8(4), pp. 768-777		125
Multi-resistance, beta-lactamase-encoding genes and bacterial diversity in hospital wastewater in Rio de Janeiro, Brazil	Chagas *et al.*, 2011 [38]	Journal of Applied Microbiology 111(3), pp. 572-581		98
Microbial removal of the pharmaceutical compounds ibuprofen and diclofenac from wastewater	Langenhoff *et al.*, 2013 [39]	BioMed Research International 2013,325806		85

Table 3. Citation of publications by subject area

The analysis of the article's global citations by the researcher is shown in Table 3. The quantity of article citations extracted from the Scopus database represents the number of international sources. The two articles that get mentioned the most are, "Epic3: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England," written by Loveday *et al.*, 2014, were cited 617 times. [30] Followed by the article "Contribution of hospital effluents to the load of pharmaceuticals in urban wastewaters: Identification of ecologically relevant pharmaceuticals," written by Santos *et al.*, 2013, cited 346 times. [34]

4.4 Subject Area

This study also identifies journals that have been published based on their field of study. Medicine and environmental science dominated most hospital waste management studies. Additional areas of study with a lower percentage included in this study were presented in Figure 5.

The researcher chose the subject to be more precise in selecting articles. These fields of study, including medicine and environmental science, are related to this research topic. The articles in the chosen field of study have been selected through a gradual screening stage and are related. The study of biochemistry, genetics, molecular biology, immunology and microbiology, pharmacology, toxicology, and pharmaceutics can potentially be affected when waste management is not carried out correctly. The background of the area used in the study occurs in a hospital. The highest subject of discussion found in this study was medicine, which saw 380 articles out of the total published articles used.

Figure 5. Documents based on the area subject

4.5 Trending Topics

Additionally, researchers also present searches related to popular topics. The size or diameter represents the frequency of the author-provided phrase. This finding was obtained using keywords based on periodicity parameters with five words per year minimum. For the period of 2011 to 2021, words like waste (n=10,840), health (n=9,137), management (n=6604), hospital (n=5203), and medical (n=3611) can be regard in Table 4. recent studies show that, in the face of this research, the researcher's experience found that individual health in this context includes health workers, [43] the environment, [44] and the incidence of infection. [45]

Word	Length	Count	Weighted Percentage (%)	Word	Length	Count	Weighted Percentage (%)
Waste	5	10840	1,29	Wastewater	10	2270	0,27
Health	6	9137	1,09	Control	7	2189	0,26
Management	10	6604	0,79	Infection	9	1880	0,22
Hospital	8	5203	0,62	department	10	1839	0,22
Medical	7	3611	0,43	infect	6	1669	0,20
Water	5	3110	0,37	hospitals	9	1653	0,20
Environmental	13	2845	0,34	environment	11	1411	0,17
Covid	5	2369	0,28	assessment	10	1350	0,16
Healthcare	10	2356	0,28	disposal	8	1255	0,15
Treatment	9	2290	0,27	clinical	8	1244	0,15

Table 4. Trending topic based on keywords

4.6 Keyword Analysis

Analysis using VOSviewer was carried out to support translating Scopus data and reading the themes. It will make the study easier to understand in the visualization form. Research related to hospital waste management can be seen in the visualization of the data mapping results collected in Figure 6. An image with different color variations was applied to distinguish each list of concepts that dominates from the clusters found. Different colors were used to obtain trends in finding themes often discussed in selected articles.

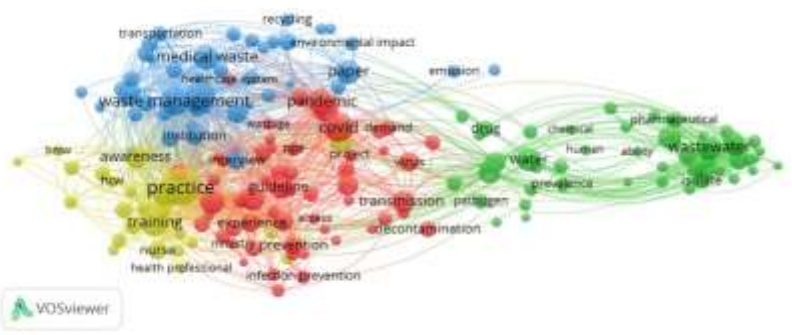

Figure 6. Visualization of Network Hospital Waste Management using VOSviewer

From the analysis using VOSviewer in Figure 6, it has been found that four main clusters map the research topics of hospital waste management. The colors of each cluster from clusters 1 to 4 are red, green, blue, and yellow. Each cluster consists of several items belonging to the same category. Based on the visualization displayed, the dominant topics from each cluster are related to the topics of covid, wastewater, practice, and medical waste.

CLUSTER	THEME	QUANTITY	PERCENTAGE
CLUSTER 1	Access, admission, age, availability, barrier, best practice, clinician, compliance, coronavirus, coronavirus disease, cost, covid, decontamination, demand, education, equipment, experience, guideline, health care facility, health facility, healthcare, healthcare provider, healthcare system, hygiene, infection control, infection prevention, infectious disease, infectious disease, infrastructure, intensive care unit, interest, laboratory, literature, ministry, mortality, operating room, outbreak, pandemic, patient safety, perception, personal protective equipment, physician, ppe (personal protective equipment), prevention, procedure, project, provision, room, safety, sanitation, sars cov (Severe acute respiratory syndrome coronavirus), staff, surgery, team, transmission, understanding, virus, wastage.	57	38%
CLUSTER 2	Ability, antibiotic, antibiotic resistance, antibiotic resistance gene, antimicrobial resistance, aquatic environment, bacterium, chemical, ciprofloxacin, community, concentration, contamination, culture, degradation, degree, discharge, dissemination, drug, effluent, environmental contamination, Escherichia coli, hospital effluent, hospital wastewater, human, human health, isolate, municipal sewage, nosocomial infection, occurrence, pathogen, pharmaceutical, pollutant, prevalence, public health, release, removal, resistance, selection, spread, surface, surface water, surveillance, wastewater, wastewater sample, wastewater treatment plant, water, wwtp (wastewater treatment plant).	50	27,7%
CLUSTER 3	Climate change, clinic, current practice, disposal, emission, employee, environmental impact, future, general waste, government, hazardous waste, health care waste, healthcare facility, healthcare waste, hospital waste management, incineration, infectious waste, institution, interview, landfill, medical waste, medical waste management, metal, paper, plastic, policy, private hospital, proper management, public hospital, recycling, segregation, sharp, society, solid waste, stakeholder, storage, sustainability, transport, transportation, waste disposal, waste generation, waste management, waste management practice, waste management system, waste segregation.	45	25%
CLUSTER 4	Adherence, attitude, awareness, biomedical waste, biomedical waste management, blood, bmw (bio-medical waste), bmw management, doctor, hcw (health care worker), health care, health care worker, health professional, health worker, healthcare professional, healthcare waste management, healthcare worker, hospital staff, injury, knowledge, nurse, practice, professional, teaching hospital, tertiary care hospital, training, worker.	28	9,3%

Table 5. Cluster Classification

Furthermore, from a total of 4 clusters found, a total of 180 items are shown in Table 5. Three clusters have a percentage above 20%, namely cluster 1 with 57 items (38%) and cluster 2 with 50 items (27.7%), and cluster 3 with 45 items (25%). Meanwhile, cluster 4 was the only cluster with subject items that are still rarely researched. There are still very few studies conducted on 28 subject items that are part of cluster 4, which can be used as opportunities for other researchers to conduct research.

Cluster Themes	Author	Purpose(s)	Finding(s)
Factors that affect hospital waste management	Wei *et al.*, 2021 [24]	This study investigated how medical waste and contaminants were disposed of in China following the SARS outbreak. It also analyzes the driving factors for medical waste change, measures the impact of socioeconomic factors during the SARS outbreak based on the STIRPAT model, and predicts future changes in medical waste without the influence of a pandemic.	The results showed China's medical system and economic development, such as increasing personal income and popularizing universal health care. Also, the number of seeking medical care increased rapidly, leading to explosive growth in medical waste (~240%) and pollutants (260%), and Major hospitals are the primary source.
Parameter hospital waste management	Mousazadeh *et al.*, 2021 [46]	This study describes the background, current conditions, future potential, and WBE (Wastewater-based Epidemiology) detection and quantification procedures for SARS-CoV-2 in wastewater.	The results showed that human feces from wastewater samples might contain detectable SARS-CoV-2 RNA days to weeks before symptoms appear. It shows that keeping an eye on SARS-CoV-2 genetic markers in wastewater samples may be a useful strategy in advance of the COVID-19 outbreak.
Hospital waste	Cesario *et al.*, 2020 [47]	This goal was to evaluate the effects of a hospital waste management approach used in a cancer center that was based on appropriate segregation and a corresponding reduction in the mass burned.	This finding shows a decline in the percentage of waste that was incinerated. The lack of data from before the program's execution might be filled in by the examination of the stationarity of the proportion of waste burned.
Hospital practice healthcare worker	Olaifa, Govender and Ross, 2018 [48]	This study was designed to evaluate the relationships among hospital staff members' knowledge, attitudes, and behavior regarding waste management in district hospitals.	42.7% of all participants received a "poor" score, indicating that their knowledge of hospital waste management procedures is still inadequate. The rest of the participants showed good health workers' knowledge of hospital waste management procedures. However, more than half reported positive attitudes towards proper waste disposal by health workers. Knowledge and practice and attitudes and practice have a significant relationship ($p < 0.05$).

Table 6. Themes of clusters in keyword analysis

In order to better understand the topic of this study, researchers focused on two themes namely things that affect hospital waste management and hospital waste management parameters in table 6. These two themes are the closest related to this research topic. One of the studies containing the things that affect hospital waste management has the title "Environmental challenges from the increasing medical waste since the SARS outbreak," written by Wei *et al.*, 2021. [24] It explained that the condition factor of the COVID-19 outbreaks, a new variant of SARS, played a significant role in increasing medical waste production. One study examined that the Covid-19 outbreak impacted the quantity, composition, and management of medical waste. [3] It becomes a new challenge for hospitals and researchers to find solutions for planning more efficient medical waste management. Prasetiawan, 2020 explained that the COVID-19 outbreak should be an opportunity for policymakers. [48] Namely, the government needs to improve the waste management system of health facilities, so the country will be prepared to face similar disasters in the future.

Another study discussed hospital waste management parameters on the subject item 'wastewater.' Mousazadeh *et al.*, (2021) study determined the potential for detecting and quantifying COVID-19 infection using the WBE detection (Wastewater-based Epidemiology) and quantification procedure. [46] The study showed that

human feces traced from wastewater samples could contain SARS-CoV-2 RNA as an effort to detect infection before symptoms develop. A different study by Momeni *et al.*, (2018) explained that the impact of health service waste on public health poses the most significant risk of spreading the infection to patients and the community. [49] Health service waste has various forms, one of which is wastewater. The study of Saguti *et al.*, (2021) further investigated the extent to which the virus detected in wastewater could reflect the time of the spread of infection in the community. [51] The study tested viral content in wastewater limited to patients with severe symptoms. The study found the number of SARS-CoV-2 varied with a peak approximately per four weeks; the variation in the number of newly admitted patients was early by 19-21 days. Viral peaks with consistent periodic intervals suggest that SARS-CoV-2 may have cluster spread, perhaps representing that most infected patients only spread the disease for a short period.

4.7 Keyword Relation

Table 7 reveals the Pearson correlation between the total score of Hospital waste management and hazardous waste, waste disposal, solid waste management practices, and infectious waste management. The top result showed Hospital waste management scores positively between hazardous waste and waste disposal, with a correlation value ranging from 0.888 to 0.887 determined by the point-biserial correlation coefficient. The limitation of this study is that the results are subjective, following the author's knowledge and focus on the topic the researcher wants to discuss.

	Code A	**Code B**	**Pearson correlation coefficient**
Waste management	Hospital waste management	hazardous waste	0,888764
	Hospital waste management	waste disposal	0,887829
	Hospital waste management	solid waste management practices	0,87424
	Hospital waste management	infectious waste management	0,873609
	Hospital waste management	medical waste management practices	0,872307
	Hospital waste management	human resource management	0,855535
	Hospital waste management	chemical waste	0,845818
	Hospital waste management	health care facility	0,843558

Table 7. Relations of the Hospital waste management keyword

The aspect of hazardous waste that has the most vital positive relationship with hospital waste management is in line with the focus of the previously mentioned themes regarding matters. Hospital waste management is a necessary process that must be taken seriously. Most hospital waste is medical and categorized as hazardous waste. [43] Medical waste can become a medium for infection transmission, which makes it hazardous. [52] Because of it, its management requires special knowledge and regulations handled by experts. During the Covid-19 pandemic, almost all hospitals experienced a surge in waste production. [3] Hospital waste management actions are influenced by minimizing the spread of COVID-19 and restricting business operations, travel, and the available manufacturing sector. [53] It is essential to ensure that waste does not pose a health risk to human growth, so the spread of COVID-19 can be prevented by managing hospital waste during the pandemic. [7]

The subsequent highest correlation that has a positive relationship with hospital waste management is regarding waste disposal. Hospitals have been identified as a significant source of contamination worldwide, which can risk inadvertently endangering public health. [54] Although the primary goal of hospitals is to promote human health, they must consider environmental protection. [55] The hospital management can monitor and evaluate waste disposal to achieve it. [2] Hospital waste management activities involve waste production, characterization, minimization, separation, transportation, and processing

until it is ready for disposal or reuse. [18] Changizi, Badeenezhad and Alidosti, (2021) explained that the application of hospital waste management is the responsibility of hospital administration and every part of health care provider personnel and individuals in the hospital. When carrying out waste management activities produced by hospitals, it is necessary to consider who contributes to waste products to help streamline the waste. [15] The share of hospital services carried out by doctors and nurses was the most significant contributor to the number of wastes in hospitals. [20] Some of the positive benefits that support good waste management in the hospital area (Table 8).

Benefit(s)	Purpose	Researchers
Helping to Reduce Hospital Environment Pollution	Waste that is adequately treated to cause pollution reduction can effectively have an impact on reducing adverse effects on the hospital environment.	Svebrant *et al.*, 2021. [55] Mihai, 2020. [56] Dermatas, 2017. [57] Bean *et al.*, 2016. [58] Cebe, Dursun and Mankolli, 2013. [59]
Reducing Safety Hazards and Reducing Disease Spread in Hospitals	The better the waste management, the more the ability to sort the types of waste, especially hazardous waste. Finally, this contributes to lowering the risk of spreading the disease to the surrounding community and the hospital.	Akpieyi, Tudor and Dutra, 2015. [60] Bonner and Davidson, 2020. [61] Al-Khatib, Eleyan and Garfield, 2016. [62] Rizan, Reed and Bhutta, 2021. [63] Kumar, Somrongthong and Shaikh, 2015. [64]
Reducing Hospital Budget	Waste segregation, according to its type, can increase the effectiveness of allocating costs that must be spent in hospital waste management.	Chu *et al.*, 2021. [65] Żebrowski *et al.*, 2020. [66] Anderson *et al.*, 2021. [67] Aini *et al.*, 2019. [68] 5) Ullah and Khan, 2011. [69]

Table 8. Benefits of Hospital Waste Management

The two keywords with the strongest correlation with hospital waste management can be summarized as indicators that can influence environmental factors. It is because those are vulnerable to causing secondary environmental pollution, especially when facing a sudden pandemic emergency. The analysis of the results of this study provides a referral to the hospital for appropriate treatment. The effect can be realized through an organized medical waste management flow plan. Policymakers must participate in increasing efficiency and strengthening basic hospital research on environmental impacts by increasing population-based waste disposal facilities and promoting treatment equipment. Furthermore, it is related to parameter indicators that can be used as benchmarks in implementing hospital waste management. The genetic content of SARS-CoV-2 in wastewater samples as recommendations can be given to overcome them by checking the content of the sample hospital wastewater regularly.

Covid is proven to be able to provide new dynamics in the implementation of hospital waste management in hospitals. From this study, it appears that before the onset of COVID-19, many hospitals tended to ignore the importance of rules in the operation of hospital waste management, especially infectious waste. [71] One of the supported articles by Loveday *et al.*, (2014), which is the most cited article, revealed that in the epic3 guideline, which contains new things about comprehensive recommendations to reduce HCAI in hospitals, one of them is by disposing of waste according to standard protocols. [30] Epic3 is the result of the 3rd update of the national evidence-based Guidelines for preventing healthcare-

associated infections (HCAI) in National Health Service (NHS) hospitals in the UK.

Research conducted by the province of Tekirdağ, a part of Western Turkey, reported that Before COVID-19, this area generated 79,027 kg of medical waste per month; after COVID-19, this number increased to 116,714 kilograms. [71] When COVID-19 began to become a pandemic, all hospitals experienced increased use of single-use personal protective equipment (ppe) in handling Covid cases, contributing to a long list of waste management problems in hospitals. [30] Widespread use, inadequate infrastructure, and poor waste management all contribute to the generation of new waste. [72] Like it or not, hospitals must pay more attention to waste management.

The researcher recommends that it is essential for the government and hospital managers to know the state of waste management in hospitals to set priorities and allocate resources to operate hospital waste management better. Differences in environmental conditions, resource availability, leadership, and the extent local managers use innovative approaches to address deficiencies in hospital waste management. Input and support from the central and local governments are significant in improving the quality of waste management in hospitals as a fundamental basis for reducing the amount of waste produced and possible environmental impacts.

5. CONCLUSION

Based on the interpretation of the facts presented above, the research may be concluded. First, the study's findings show that the Pearson correlation between hospital waste management is mostly related to hazardous waste, waste disposal, solid waste management practices, infectious waste management, medical waste management practices, human resource management, chemical waste, health care facility. Hazardous waste, waste disposal, and infectious waste management are some of the terms used to describe the characteristics of hospital waste. Second, according to the findings of this study, it was possible to find 4 main clusters and the most discussed trending topics regarding hospital waste management. The 4 clusters are Factors that affect hospital waste management, Parameters for hospital waste management, Hospital waste, and Hospital healthcare worker practice. The researcher explores more about the two themes discussed are matters that affect hospital waste management and hospital waste management parameters. Most of the research on these themes aims to identify factors and conditions that are considered capable of impacting hospital waste management. In addition, recent research shows that, in the face of this research, the current COVID-19 pandemic situation affects waste management in hospitals. Furthermore, the research theme focuses on managing the types of infectious waste more likely to be generated during a pandemic. In addition, in managing hospital waste in many countries, there are still problems related to the waste treatment process due to the limited number of incinerators. Their implementation still needs periodic monitoring to ensure compliance with its implementation to break the chain of spreading COVID-19 infections. Based on the results, the researcher recommends further research to deeply explore the problems found in this research. Further research may also use a different perspective related to the rapidly growing field of hospital waste management.

Declaration by Authors

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