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Medical Waste Management: Comparative Insight from Australia and Indonesia

Pengelolaan Limbah Medis: Wawasan Komparatif dari Australia dan Indonesia

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ABSTRAK

Pandemi COVID-19 telah menjadi masalah global, salah satunya adalah pengelolaan limbah medis secara efektif, terutama di negara-negara dengan sistem kesehatan yang berbeda seperti Indonesia dan Australia. Di Indonesia, pengelolaan limbah medis selama pandemi menghadapi tantangan serius, termasuk infrastruktur yang terbatas dan kurangnya kesadaran tentang risiko limbah infeksius. Sementara itu, Australia menunjukkan sistem yang lebih terstruktur, dengan regulasi ketat dan teknologi modern untuk pengelolaan limbah. Peningkatan signifikan dalam jumlah limbah medis akibat lonjakan kasus COVID-19 terjadi di kedua negara tersebut. Namun, pendekatan berbeda; Indonesia masih menghadapi berbagai masalah seperti keterbatasan sumber daya, infrastruktur, dan teknologi, serta masih rendahnya tingkat kepatuhan terhadap peraturan yang ada walaupun sudah terdapat peraturan yang mengatur tentang pengelolaan limbah medis berbasis wilayah, sedangkan Australia mengimplementasikan sistem pengelolaan yang terintegrasi dengan fokus pada keberlanjutan dan keselamatan. Perbandingan ini menunjukkan bahwa meskipun ada tantangan di kedua negara, pendekatan yang proaktif dan investasi dalam teknologi serta edukasi masyarakat menjadi kunci dalam pengelolaan limbah medis yang efektif. Dengan mempelajari praktik terbaik dari Australia, Indonesia dapat mengembangkan strategi yang lebih baik untuk pengelolaan limbah medis di masa depan, tidak hanya selama pandemi tetapi juga dalam menghadapi krisis kesehatan lainnya.

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ABSTRACT

The COVID-19 pandemic has become a global issue, including the effective management of medical waste, especially in countries with different health systems, such as Indonesia and Australia. In Indonesia, medical waste management during the pandemic faced serious challenges, including limited infrastructure and limited awareness of the risks posed by infectious waste. Meanwhile, Australia shows a more structured system, with strict regulations and modern technology for waste management. A significant increase in medical waste due to the surge in COVID-19 cases occurred in both countries. However, the approaches are different; Indonesia still faces various problems, such as limited resources, infrastructure, and technology, as well as the low level of compliance with existing regulations, even though there are regulations governing region-based medical waste management, while Australia implements an integrated management system with a focus on sustainability and safety. This comparison shows that despite challenges in both countries, a proactive approach and investment in technology and public education are key to effective medical waste management. By learning from Australia's best practices, Indonesia can develop more effective strategies for medical waste management in the future, not only during the pandemic but also in the face of other health crises.

1. INTRODUCTION

1.1 Background

Green hospitals are one of the activity programs to reduce the contribution of the health service industry and hospitals to global warming due to increased greenhouse gas (GHG) effects. The GHG effects of medical waste can be caused by organic body tissue or pharmaceutical materials that are degraded anaerobically to produce methane gas (CH_4), the incineration process in eliminating pathogens can also produce CO_2 and other GHGs, some medical waste consisting of chemicals or pharmaceuticals can also release GHGs through chemical reactions during disposal, for example the release of nitric oxide gas (N_20). The principle of this green hospital program is to reduce the use of natural resources, control its impact on the environment, and improve door air quality to promote better health. Hospitals must take responsibility for protecting sustainable environmental quality and reducing the use of natural resources (Corvalan et al., 2020).

In 2015, the United Nations (UN) member countries adopted an agenda for sustainable development that integrates economic, environmental, and social development (XinYing et al., 2023). Medical waste management plays an important role in achieving the Sustainable Development Goals (SDG). In Goal 3, related to good health and well-being, effective medical waste management contributes directly to public health and well-being. In Goal 6 related to clean water and sanitation, good medical waste management can play a role in maintaining water quality and sanitation. In Goal 12, related to responsible consumption and production, responsible medical waste management, including the controlled reduction, recycling, and reuse of medical materials, can contribute to more sustainable consumption and production patterns. In Goal 13, related to climate change action, cleaner, and more efficient medical waste treatment technologies, such as autoclaving or environmentally friendly waste treatment systems, can reduce the climate change impacts of medical waste. In goal 15, related to life and land, proper medical waste treatment that does not pollute the soil can protect terrestrial ecosystems and existing biodiversity. These commitments show the importance of sustainable development with an environmental perspective for the survival of humans and organizations. Future economic growth relies heavily on sustainability business models (Despeisse et al., 2012; Akanbi et al., 2018), does the hospital business, which generates medical waste. Therefore, the most effective methods must be implemented to reduce and prevent safe infection by improving the effectiveness of medical waste disposal (Teymourian, 2021).

The type of waste, the location where it was generated, and the type of infectious disease all affect how medical waste is handled and treated (WHO, 2020). Improper medical waste management activities can increase contamination risk. Medical waste generated in developing countries during the COVID-19 pandemic is mainly disposed of in the environment, and the waste management process is inappropriate, increasing the risk of contamination. Estimates indicate 8.4 million more plastic bags and masks were produced due to COVID-19-related operations in 193 countries. This represents a 10% increase since the World Health Organization (WHO) declared the disease a global pandemic in March 2020.

The additional plastic waste produced during the pandemic included virus testing kits, plastic packaging materials (from increased online shopping), and personal protective equipment (masks, gloves, and face shields). These items accounted for 7.6%, 4.7%, and 0.3% of the waste from healthcare institutions (Peng et al., 2020). Geographically, Asia accounts for 46.3% of global garbage production, with Europe (23.8%), South America (16.4%), Africa (7.9%), and North America (5.6%) following. About 3,800 to 25,900 tons of plastic waste are thought to have been dumped into the ocean, according to modelling plastic waste dynamics associated with COVID-19. By the end of 2021, there are expected to be 280 million confirmed COVID-19 cases, resulting in an estimated 11 million tons of medical waste and 34,000 tons of ocean pollution (Peng et al., 2020). With the increasing amount of medical waste produced, especially during the COVID-19 outbreak, the question in this study is how a country can manage and process its medical waste sustainably and without polluting the environment. Australia is one of the countries that has succeeded in managing its medical waste by implementing the right technology and demonstrating commitment and compliance in medical waste management. Some key related research questions are: 1) What are the hospital strategies?; 2) What are the policy directions in dealing with healthcare waste; 3) What are the trends in strategies suggested by the literature review to address its management? Finally, the study focused on possible research gaps and sought answers in the recent scientific literature.

1.2 Research Objectives

This study aims to systematically review the experiences of Australian hospitals that have successfully managed their medical waste during the COVID-19 pandemic and Indonesia regarding sustainable approaches to hospital medical waste management, with a particular focus on the impacts of COVID-19 and future challenges related to climate change. This study also aims to compare management strategies and policies for handling medical waste in both countries.

2. METHOD

This research used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework to conduct a systematic literature review of previous studies on medical and infectious waste related to COVID-19. Data was chosen from a number of sources:

1. PubMed database with keywords: COVID-19, environmental impacts, and waste management in Indonesia and Australia.
2. Sage Pub database with keywords: solid waste, waste management, waste management solutions, socioeconomic impacts on society, and waste management regulations in Indonesia and Australia.
3. Scopus database with keywords: waste, managing medical waste during the COVID-19 epidemic in Indonesia and Australia

Several steps are listed in the review description:

1. Search for articles from each database using selected keywords.
2. Select several articles from each database: PubMed 53 articles, Sage Pub 119 articles, and Scopus 17 articles.
3. Filter several articles using the following inclusion criteria: publication within the last three years (2022-2025), research topics in environmental science, and research locations in Indonesia and Australia. Twenty-eight articles were obtained for analysis.
4. Conduct thematic and content analysis of each article according to the selected inclusion criteria.

Compile the articles and draw conclusions from the analysis.

3. RESULTS AND DISCUSSION

3.1 Medical Waste Management

COVID-19's medical waste is categorized as infectious waste. The infectious medical waste produced needs to be handled to prevent transmission, protect the environment, and safeguard public health. According to Boreujani (2021), between 10 and 25 percent of the infectious garbage produced by hospitals and healthcare facilities cannot be dumped with regular residential rubbish. Medical trash consists of 27% infectious or hazardous waste from pharmaceutical and pathological waste, 67% general garbage (such as food and other waste), and less than 4% sharps and instruments like needles and scalpels (Klemes et al., 2020). Managing COVID-19 infectious waste is an essential public service to prevent future negative consequences on public (WHO, 2020).

The increase in medical waste generation during the COVID-19 pandemic by around 30% has caused a substantial increase in the amount of medical waste in Indonesian hospitals (Sutrisno & Meilasari, 2020), the results of a study found an increase from 25.6 kg/month to 192.3 kg/month in a hospital in Jakarta City, Indonesia (Atthar et al., 2022). This surge in waste generation poses challenges in solid waste management, including increased food and plastic waste, lack of infectious waste management, and uneven distribution of waste management facilities in various cities (Budiharjo, et al., 2022). The pandemic has also caused major changes in the pattern and composition of waste production, exacerbating the problem of medical waste management in Indonesia (Safitri et al., 2024). The increase in medical waste, especially hazardous biomedical waste, poses a risk to human health and has a negative impact on the environment (Limijadi & Devi, 2023).

Environmental contamination, workplace accidents, and the spread of diseases might result from poor management of medical waste and hospital setting. In addition to causing nosocomial illnesses, it can contribute to air, water, and soil contamination within and outside hospitals. In areas with severe contamination, the risk of COVID-19 infection from COVID-19 medical waste is greater than that from conventional medical waste (Klemes et al., 2020).

Waste management workers in developing countries are often not equipped with personal protective equipment, increasing the risk of infection (Scheinberg et al., 2020). In addition, the waste produced by COVID-19 patients during quarantine at home is often mixed with other waste, and there is a risk of transmitting COVID-19 infection from the waste if it is disposed of carelessly, such as face masks, gloves, so that the waste will transmit to others (Graff et al., 2021). The WHO report states that the most common problems associated with healthcare waste are unawareness of the health hazards posed by medical waste, inadequate training in proper medical waste management, limited medical waste management and disposal systems, and limited human and economic resources (Iris, 2019). This WHO-reported problem still needs to be addressed in underdeveloped and developing countries and even in developed countries, which are also struggling to overcome the challenges posed by the increasing pile of infectious waste.

The Australian government is very concerned about the problems and difficulties associated with handling medical waste generated during the COVID-19 pandemic (Boroujeni et al., 2021; O'Sullivan et al., 2020; Codreanu et al., 2021). The amount of medical waste generated by the COVID-19 pandemic that has accumulated in labs, healthcare institutions, residential homes, quarantine, and elderly care facilities, and facilities for people with disabilities has expanded exponentially with the rise in the number of confirmed cases in Australia (Boroujeni et al., 2021). There are serious issues with COVID-19 waste management procedures in a number of nations, including Australia and Indonesia. These include a lack of a sustainable medical waste management strategy, inadequate knowledge and awareness, lax laws and regulations, insufficient funding, and inadequate implementation (UNEP, 2020; CDCP, 2020; Harapan et al., 2020).

Medical waste is estimated to be tens of thousands of tons due to the pandemic, which puts pressure on the medical waste management system because its impact can threaten human health and the environment (WHO, 2022). Indonesia also feels the same way, with medical waste from the pandemic increasing by 30%, while processing capacity in some areas remains limited. A survey conducted by the Indonesian Hospital Association (PERSI) in 2018 of 95 hospitals explained that most hospitals (70%) did not have solid waste management. Thirty 30% of hospitals have incinerators, and around 55% have licensed incinerators. This explains that most hospitals also do not comply with waste management standards (Buruno, 2021).

Limited waste management facilities result in significant medical waste that needs to be processed properly. This is due to the capacity and volume of medical waste generated by the private sector and health service facilities with licensed incinerators, which still need to be proportional to the volume generated by existing health service facilities and hospitals. Regulation of the Minister of Health No. 2 of 2023 (hereafter referred to as *Permenkes* No. 2/2023) has regulated the technical requirements of medical waste management and supervision of waste management originating from health facilities. Article 24 of this regulation states that all health facilities must treat the medical and non-medical waste generated. This also explains that Indonesia already has medical and non-medical waste management regulations.

In Australia, COVID-19-related medical waste filled a 240-litre container on average once a week during the pandemic (Boroujeni et al., 2021). Up to twelve 240-litre bins

were filled each day by states and territories with higher rates of active coronavirus infections, for an estimated weekly total of 84 bins (Boroujeni et al., 2021). Therefore, compelling collection, sorting, storage, transportation, treatment, and disposal strategies are needed for COVID-19 medical waste and other healthcare waste (UNEP, 2020; CDCP, 2020; WHO, 2022; Das et al., 2021).

Indonesia already has waste management programs in collaboration with the government and the private sector. For example, DKI Jakarta, a Jakarta Kini (JAKI) or Jakarta Now platform, provides information on waste management and household medical waste pick-up services (Raihan, 2021). Banyuwangi Regency has a waste pick-up program called *Giat Mobile Garbage Bank* (BAGIAK), designed to minimise community mobility during the pandemic. In Makassar, there is a *Garbage Mall and Octopus* managed by the private sector to handle medical waste. While in Semarang and Surabaya, there is a *waste safety box* for separating and sorting medical waste in collaboration with the government and Surabaya Institute Technologies (ITS) academics (Rachmawati et al., 2021).

Indonesia already has a special regulation on medical waste management namely MoEF Circular Letter Number 3 of 2021 concerning Hazardous Waste Management and Waste from COVID-19 Handling. This circular letter regulates the stages of medical waste management originating from healthcare facilities, households, apartments, industrial estates, and public facilities. The problem faced by Indonesia is the handling of infectious waste that has yet to be maximized. In terms of regulations, solutions are needed regarding the handling of infectious waste. The addition of infectious waste treatment facilities and education or community participation in handling residential infectious waste needs to be improved (Listiningrum et al., 2021).

In October and December 2019, the Ministry of Health conducted a study on medical waste management compliance based on e-monev to 299 hospitals. The results showed that hospitals must thoroughly follow compliance in their medical waste management. As many as 13.5% of hospitals lack a licensed TPS, 15.7% lack internal or external solid medical waste treatment, and 11.4% lack a designated work unit (Buruno, 2021). Australia does not have laws or regulations explicitly governing medical waste. The Australian government sets waste management policies and strategies by collaborating with relevant jurisdictions to define and classify waste nationally, including medical waste, in line with international conventions. At the state level, its waste management policies and regulations, including medical waste, are implemented to align with international conventions (DEE, 2021; WHO, 2015).

Both non-hazardous and hazardous medical waste streams accounted for in Western Australia's 2016 medical waste management strategy. In southern Australia, environmental protection policies apply to all types of trash. However, the Radiation Control Act of 1982 explicitly regulates radioactive waste. Healthcare has created medical waste management codes of practice in collaboration with the waste management industry to promote and standardize safe and economical medical waste management procedures throughout the process's handling, treatment, and disposal stages (DEE, 2021).

3.2 Comparison of Medical Waste Management

Australia has put in place a tiered system to manage waste, including medical waste from the COVID-19 pandemic. State governments use policies, legislation, and programs to manage medical waste (DEE, 2021). Transported COVID-19 waste is recognized, handled, and disposed of sustainably in states and territories. The National Environmental Protection Measure (NEPM) was created by the Australian government to regulate the movement of regulated waste (DEE, 2021). There are parallels with Indonesian waste management, where area-based approaches are being developed.

Indonesia's area-based medical waste treatment method is self-managed in the region of the relevant healthcare facility. The process will thus reduce the distance and travel time of waste shipment. This method can be implemented by enhancing cooperation between regional government agencies and private waste managers. Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Management of Hazardous and Toxic Waste, and Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 6 of 2021, as well as Regulation of the Minister of Health of the Republic of Indonesia Number 56 of 2015 concerning management of medical waste are regulations that govern the management of hazardous waste in Indonesia (Sutrisno & Meilasari, 2020). Indonesia's medical waste management system still faces several challenges: regulations, processing capacity, the role of local governments, inter-institutional coordination, human resources, facilities and infrastructure, licensing, the role of the private sector, and financing. The following is a comparison of medical waste management in Australia and Indonesia (see Table 1)

According to Table 1, Australia adheres to international regulations on waste management. The federal government then provides policies and guidelines to each state, territory, or lower-tier system for managing medical waste, including COVID-19-related waste. The state or territorial government, which supervises and manages the trash in line with its policies and programs, is primarily in charge. Through practical, ecologically safe collection, sorting, transportation, processing, and disposal, COVID-19 medical waste is properly recognized before disposal. Australia also has a National Environmental Protection Measure (NEPM) agency that oversees the movement of controlled waste.

Indonesia has national laws about waste management. Regulation of the Minister of Health No. 18 of 2020 concerning Management of Medical Waste from Service Facilities, which specifically regulates the management of medical waste in health facilities, including during the COVID-19 pandemic. This regulation covers procedures for handling, transporting, and processing infectious medical waste generated from the treatment of COVID-19 patients. Regulation of the Minister of Environment and Forestry No. P.56/MENLHK-SETJEN/2015 concerning Procedures and Technical Requirements for the Management of B3 Waste from Health Service Facilities. This regulation provides further guidelines on the management of B3 waste in health service facilities, covering all aspects from storage, transport, to waste processing (KLHK, 2020).

Table 1. Medical Waste Management in Australia and Indonesia

No	Australia	Indonesia
1.	Adopt international regulations and a tiered system in waste management, including medical waste from the COVID-19 pandemic. Policies and guidelines are left to the respective territories/ states (Andeobu et al., 2022).	The central government developed an area-based medical waste management method based on the existing waste law (Listiningrum et al., 2021).
2.	The state and territorial governments manage COVID-19 medical waste, and they do so in line with their policies and plans (Andeobu et al., 2022).	Medical waste management still faces numerous challenges in regulation, processing capacity, interagency coordination and the role of local governments, human resource capabilities, infrastructure and facilities, ease of licensing and financing, and the role of the private sector (Listiningrum et al., 2021).
3.	COVID-19 waste transported in states and territories is identified, monitored, handled and disposed of in an environmentally responsible manner. This is done to facilitate the traceability process in the event of waste contamination (Andeobu et al., 2022).	The Ministry of Environment and Forestry is pushing for the implementation of tracking technology as part of stricter toxic hazardous waste management efforts. However, this implementation is not yet evenly distributed throughout Indonesia and is more widely adopted in areas with better technological infrastructure (KLHK, 2020).
4.	The government actively monitors the controlled waste movement with the support of technology, and also creates the National Environmental Protection Act (NEPM). Having trained and experienced human resources in medical waste management. Training and certification programs are often conducted to ensure that professionals have the necessary competencies (Andeobu et al., 2022).	Regulations on infectious waste management are not yet optimal regarding infectious waste management, minimal infectious waste processing facilities, and minimal education or community participation in handling household infectious waste. The Ministry of Environment and Forestry has created a Hazardous and Toxic Waste Management Information System (SIPLah B3) and provides a platform for tracking and monitoring waste transportation, although it focuses more on documentation and reporting (Website PSLB3-KLHK, 2024).

There are still numerous challenges under *Permenkes* RI, 2020, which governs handling medical waste in community-based healthcare facilities. Aspects of the regulations that are still being applied haphazardly, processing capacity limitations, the role of local governments, intergovernmental coordination, human resource capabilities, facilities and infrastructure, licensing, the role of the private sector, and financing, a lack of knowledge or community involvement in the removal of infectious waste from residential homes are some of these challenges. This results in medical waste management not being maximized, the capacity and number of medical waste managers of healthcare facilities and hospitals still need to be expanded and balanced with the number of healthcare facilities that generate waste. For this reason, the active role of local governments is needed to facilitate medical waste management in their regions (KLHK, 2020).

3.3 Hospital Medical Waste Treatment Technology

Permenkes R.I. No. 18 of 2020 on Medical Waste Management for Area-Based Health Service Facilities states that every health service facility, including hospitals, must carry out internal and external medical waste management. The management activities include reduction and sorting, internal and external transportation, temporary storage, collection, internal and external processing, and landfilling. The wastes managed are solid medical waste, liquid waste, infectious gaseous materials, toxic chemicals, and some radioactive materials, which are processed separately. COVID-19 medical waste can be managed by type and processed using techniques tailored to its characteristics. Medical waste that cannot be managed and treated independently within the hospital environment can be sent to a third party. Standard medical waste management and treatment techniques in the world have been used in many large hospitals in Indonesia. Medical waste management can be categorized into several types, as shown in Table 2.

Each medical waste treatment technique can handle only some medical waste classes, according to UNEP 2020 and WHO 2020. Treatment options for medical waste must be evaluated for safety, effectiveness, cost, environmental impact, and compliance with regulatory requirements. The hospital should implement all current management and treatment procedures to ensure that medical waste is appropriately separated before treatment using the technology. To manage and treat medical waste, Australia follows the directives of UNEP and WHO (Andeobu et al., 2022). The following compares medical waste management and treatment techniques in Australia and Indonesia, as shown in Table 3.

Table 2. Types, Management Techniques, and Treatment Technologies of Medical Waste

Waste Type	Example	Management Techniques / Processing Technology
Domestic solid waste	Kitchen/canteen activities and office waste	Composting, recycling, or transported to landfill
Infectious medical solid waste	Syringes, masks, medicine bottles, waste categorized as B3, body tissues, cytotoxic and pharmaceutical waste (leftover drugs)	Collected according to type and sent to a third party or burned using medical incinerators, autoclave techniques, microwave techniques
Infectious radioactive liquid waste	Liquid waste from bathrooms, kitchen/canteen activities, sinks	WWTP with aerobic-anaerobic biofilter technique
Infectious radioactive liquid waste	Infected body fluids, laboratory wastewater, radioisotopes from medical procedures	WWTP with chemical-physical process techniques, radiation sterilization, or collection sent to a third party

Source: (Setiyono, 1999; Said, 2013; Andeobu et al., 2022)

Table 3. Medical Waste Management Techniques and Technologies in Australia and Indonesia

Waste Type	Australia	Indonesia
Domestic solid waste	Landfill	Composting, recycling, or transporting to landfill
Infectious medical, solid waste	landfill, medical incinerator, autoclave and shredding, chemical disinfection, microwave	Medical incinerator, autoclave, microwave
Domestic liquid waste	waste water treatment plant	waste water treatment plant
Infectious radioactive liquid waste	Incinerator	waste water treatment plant chemical- physical process, radiation sterilization

Source: (Setiyono, 1999; Said, 2013; Andeobu et al., 2022)

4. CONCLUSION

Australia has a strong legal framework, including the National Environment Protection Measures (NEPM) and various state laws. These regulations set strict standards for the management of medical waste, including hazardous waste. Indonesia is governed by Government Regulation No. 101 of 2014 and other related regulations, but implementation is often inconsistent in the field. Compliance levels are relatively high, with a strict monitoring system, regular audits, and strict sanctions for violators. Counseling and training for waste managers also increased awareness and compliance. In Indonesia, compliance levels vary; some facilities follow the regulations well, while others struggle to implement them. Oversight remains a challenge, especially in remote areas. Australia has an integrated and efficient tracking system, including the use of information technology to monitor waste movements in real time. Indonesia has a Hazardous and Toxic Waste Management Information System (SIPLah B3), but it focuses more on documentation and reporting. The tracking system is still under development and needs improvement. Australia has an integrated, efficient tracking system, that uses information technology to monitor waste movements in real time. Training and certification programs are often conducted to ensure professionals have the necessary competencies. In Indonesia, human resources in medical waste management are often poorly trained. Despite training efforts, much still needs to be done to improve competency and awareness.

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