

Commentary

The Natural History of Medical Waste

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Introduction

The healthcare industry is the second largest contributor to landfills after the food industry (1). This is a product of the increase in single-use medical equipment and increasingly stringent recycling protocols (2, 3). Medical waste refers to all by-products generated in the care of a patient (4). More than 85% of medical waste is considered general waste and does not pose a direct hazard to human health. The remaining 15% is considered hazardous waste and comprises infectious, pathological, chemical, cytotoxic and radioactive waste. These need further processing prior to disposal (Figure 1).

Optimal medical waste management can help limit its impact on the environment and surrounding community. However, there are many factors that play a role in the efficiency of medical waste processing and recycling. There is limited data available on medical waste management in Canada and as such we will refer to international statistics when necessary to contextualize the issues raised. For many, education about medical waste management is the first step towards reducing its harmful impact and implementing environmentally friendly alternatives.

The Challenges and Costs of Medical Waste

The challenges posed by medical waste result from both the sheer volume of waste produced and the necessity of additional processing for hazardous waste. Among common operating room procedures, a two-hour hysterectomy produces 10kg of medical waste, leading to a hefty combination of plastics, packaging, and drapes - roughly five times what an individual generates each day (5, 6). At Hamilton Health Sciences, 11kg of medical waste are produced daily for each patient, leading to an annual production of over 500 tonnes of hazardous waste (7).

In the United States (US), the cost to dispose of general waste is \$0.12/kg compared to \$0.79/kg for hazardous waste – a difference of 560% (8). This is due to the fact that hazardous waste requires expensive technologies such as autoclaving and incineration, compared to the simpler landfill disposal of general waste. However, up to 85% of the products disposed of as hazardous waste are actually appropriate for general waste (4). Thus, segregation of waste to the appropriate disposal pathway is critical and something often overlooked in a busy hospital.

When waste is improperly segregated, it can have significant financial consequences at a systems level. A United Kingdom (UK) audit isolated one area with the greatest potential for improvements—anesthetic waste (2). The packaging of syringes and the glass vials for medications are potentially recyclable materials that can accumulate to 950kg per operating room per year. When the auditors examined the sharps bin, which should be one of the most streamlined forms of medical waste disposal, only 4% were truly sharps waste. The audit suggested that starting to recycle anesthetic waste alone would save 30% of the annual hospital budget allocated for disposing of clinical waste. Given the similarities of our system, these analyses suggest that improving medical waste segregation could have similar effects in Canada.

Cultural Attitudes and Legislation

Cultural attitudes and local regulations concerning waste management can have an important impact on the production and disposal of medical waste. For instance, despite the fact that both the UK and Germany have similar sterility standards, they produce drastically different amounts of waste (2). In the UK, up to 5.5kg of medical waste is produced daily for each patient compared to 1.9kg in Germany (2). This has been attributed in part to a strong cultural and historical emphasis on recycling in Germany, leading it to recycle 55% of all waste - more than any other country (9).

However, to be effective, cultural attitudes must permeate to institutional leadership and impact the decision-makers responsible for overseeing waste management. In Canada, lack of support from hospital leadership has been cited as the number one barrier to recycling in a survey of Canadian anesthesiologists (10). Furthermore, successful programs implemented in other jurisdictions have highlighted the importance of institutional support, with educational programs and engaged leadership being crucial to reducing their footprint (1, 11).

In terms of legislation, Canadian provinces have jurisdiction over medical waste disposal, but few have specific regulations. In Ontario, best practice guidelines were published in 2016 for institutions involved in hazardous waste generation and disposal, to ensure compliance with the Canadian Environmental Protection Act (12). Nationally the standards outlined by the Canadian Council of Ministers of the Environment place the bulk of responsibility for implementing and updating waste management policies on individual institutions (13). Policies are enforced through self-regulation, with institutions responsible for conducting their own audits, further highlighting the importance of institutional buy-in. The process of when and how hospitals are inspected for adherence to these standards is unknown (14). The lack of transparency and accountability surrounding these policies and their enforcement makes it difficult to identify areas of inefficiency or the extent of waste mismanagement in Canada.

Current Waste Processing Methods and Alternatives

The lack of regulations and enforcement in medical waste disposal accrues not only a financial cost, but a cost to community health as well. Incineration is traditionally the main method of medical waste processing (13). It is the only technology that can handle all components of medical waste, reducing waste volume by 90% and weight by 75%. In the US, 49-60% of medical waste is incinerated, 20-37% is autoclaved and 4-5% is treated by other technologies (8).

Medical waste contains a higher proportion of plastic and heavy metals, and as a result incineration creates toxic by-products such as polychlorinated dibenzo-p-dioxins, dibenzofurans, and mercury (8). In the US, the release of these toxins contributes to an annual burden of 470,000 disability adjusted life years (10). As such, it is extremely important that we reconsider these incinerators as the primary method of medical waste disposal.

Given the drawbacks of incineration, there has been increased focus on alternative strategies including autoclaving and microwaving. Although these methods cannot change the shape of sharps or kill spores and prions, they are overall more cost-effective solutions and should be applied more broadly where possible (Table 1) (13). There are also emerging technologies such as plasma pyrolysis, which can recycle plastics and metals, and do not generate the same toxic by-products (15). There is currently a lack of infrastructure for widespread adaptation of this technique, but it offers a higher standard of safe medical waste disposal (16). Furthermore, with improved waste segregation at the time of disposal, such as separating syringes from needles, excess release of toxins from incineration could be averted.

Of the methods mentioned, autoclaving is the most environmentally friendly and is already regularly used in university laboratories (8). With proper protocols and implementation, it is realistic for autoclaving to become more prevalent in hospitals. This would also encourage the adoption of reusable kits and supplies, thereby reducing single-use kits that generate more general waste. For example, Hamilton Health Sciences has successfully reduced their reliance on incineration, and now autoclaves more than half of their hazardous waste (7).

Individual Changes

As a medical student or physician your direct behaviour can help to reduce the environmental impact of medical waste. Consider using oral medications instead of intravenous when possible. For procedures, try taking only the equipment needed and not excess. Consider repurposing unpackaged equipment that's gone unused for teaching. Even separating the needle from the syringe instead of disposing of both in the sharps container helps appropriately segregate waste, reducing incineration. Ultimately, we can all do at least one small thing to reduce medical waste in our clinical encounters, even if it is as simple as recycling the plastic packaging for a procedure kit instead of throwing it all into the hazardous waste bin.

At the individual level, we must ensure that healthcare workers are informed about appropriate waste segregation and develop a culture of waste minimization. Education and advocacy cannot be emphasized enough. Education of staff and students is the first step to identifying points of action for improvement. Engage with hospital staff and inquire about whether the hospital has a centralized team dedicated to reducing waste. Does your hospital subcontract waste disposal or dispose of it on-site?

Conclusion

Improving medical waste management involves overcoming the significant challenge of ensuring patient safety while minimizing environmental impact. Our overview suggests three loci for intervention in the stream of waste management: reduced production, appropriate waste segregation and minimized incineration. In Canada where many hospitals face annual deficits,

proper streamlining is a fiscally sensible solution to reduce the cost of hazardous waste disposal (1).

However, Canada's medical waste management system relies on self-regulation, with little transparency. Lack of data at the provincial and federal levels about the amount of medical waste produced further limits our ability to raise awareness on the harms and identify areas for intervention. To facilitate change, there should be more enforcement and education about optimal waste management strategies at the institutional and individual level.

In our days of reusable straws and Starbucks® sipping cups, it's hard to justify mindlessly contributing to the mountains of medical waste without understanding the environmental, health, and societal costs.

References

1. Kagoma Y, Stall N, Rubinstein E, Naudie D. People, planet and profits: the case for greening operating rooms. *CMAJ*. 2012;184(17):1905-11.
2. Hutchins DC, White SM. Coming round to recycling. *BMJ*. 2009;338:b609.
3. Laustsen G. Reduce–recycle–reuse: guidelines for promoting perioperative waste management. *AORN journal*. 2007;85(4):717-28.
4. World Health Organization. Health-care waste: WHO; 2018 [Available from: <https://www.who.int/news-room/fact-sheets/detail/health-care-waste>].
5. Thiel CL, Eckelman M, Guido R, Huddleston M, Landis AE, Sherman J, et al. Environmental impacts of surgical procedures: life cycle assessment of hysterectomy in the United States. *Environmental science & technology*. 2015;49(3):1779-86.
6. Environmental Protection Agency. Municipal Solid Waste | Wastes | US EPA 2016 [Available from: <https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/>].
7. Hamilton Health Sciences. 2018 Sustainability Report: Hamilton Health Sciences; 2018 [Available from: https://issuu.com/hamiltonhealthsciences/docs/hhs_sustainabilityreport_2018].
8. Windfeld ES, Brooks MS-L. Medical waste management–A review. *Journal of environmental management*. 2015;163:98-108.
9. World Economic Forum. Germany recycles more than any other country 2017 [Available from: <https://www.weforum.org/agenda/2017/12/germany-recycles-more-than-any-other-country>].
10. Petre M-A, Bahrey L, Levine M, van Rensburg A, Crawford M, Matava C. A national survey on attitudes and barriers on recycling and environmental sustainability efforts among Canadian anesthesiologists: an opportunity for knowledge translation. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*. 2019;66(3):272-86.
11. Wyssusek KH, Foong WM, Steel C, Gillespie BM. The gold in garbage: implementing a waste segregation and recycling initiative. *AORN J*. 2016;103(3):316. e1-. e8.
12. Government of Ontario. C-4: The Management Of Biomedical Waste In Ontario 2016 [Available from: <https://www.ontario.ca/page/c-4-management-biomedical-waste-ontario>].
13. Canadian Council of Ministers of the Environment. Guidelines for Management of Biomedical Waste in Canada 1992 [Available from: https://www.ccme.ca/files/Resources/waste/hazardous/pn_1060_e.pdf].

14. Walkinshaw E. Medical waste-management practices vary across Canada. *Can Med Assoc*; 2011.
15. Nema S, Ganeshprasad K. Plasma pyrolysis of medical waste. *Current science*. 2002;271-8.
16. Mathur P, Patan S, Shobhawat AS. Need of biomedical waste management system in hospitals-An emerging issue-a review. *Current World Environment*. 2012;7(1):117.

About the Authors

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Figures and Tables

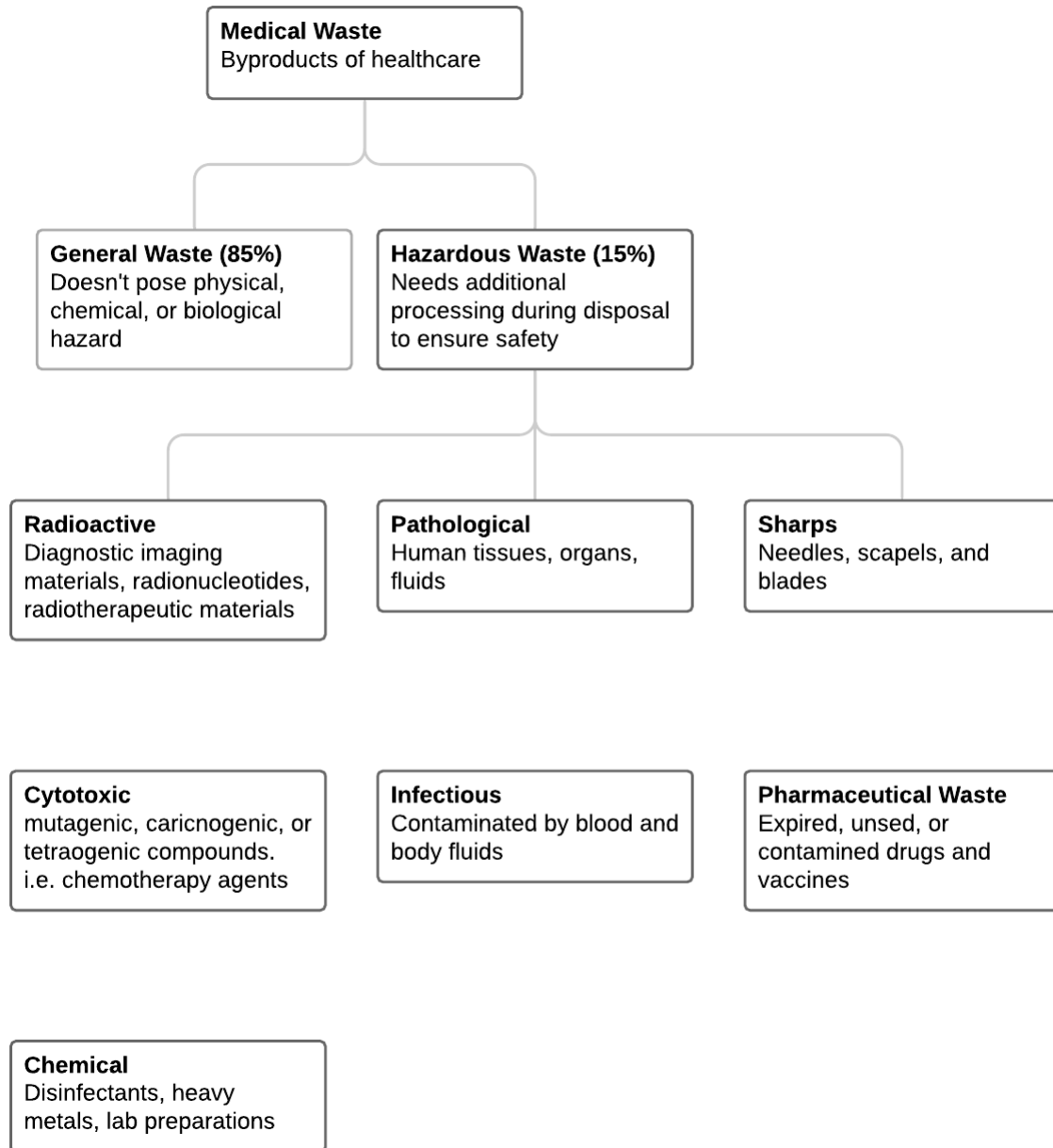


Figure 1. Breakdown of the different components of medical waste according to World Health Organization (WHO) definitions (4).

Table 1. Streamlining of biomedical waste according to Canadian Council of Ministers of the Environment (CCME) 1992 guidelines (13).

Waste Type		Steam Autoclaving	Chemical Decontamination	New Technology
Human Anatomical Waste		No	No	Plasma Pyrolysis (regulatory approval required) (15)
Animal Waste	Anatomical	No	No	
	Non-Anatomical	Yes*	No	
Microbiology Laboratory Waste		Yes	Regulatory Approval Required	
Human Blood and Body Fluid Waste		Yes	Yes	
Waste Sharps		Yes	Yes**	

*Only if followed by incineration under strict control

**Chemical treatment alone does not render sharps safe for additional handling. This treatment option applies to filled sharps containers that may undergo further treatment after chemical decontamination, as part of a process, e.g. chemical decontamination coupled with mechanical shredding.