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ORIGINAL RESEARCH

An evaluation of anaesthetic waste generation at a Johannesburg academic hospital

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Background: The healthcare sector contributes directly to global warming and environmental decline. This is partly due to disproportionately large waste generation compared to other sectors and the environmental consequences of medical waste incineration. Waste separation and recycling decrease the total waste generation of the theatre complex, decreasing the cost of waste disposal, and if properly implemented, can generate revenue. Waste separation is not performed uniformly, and no recycling programmes exist in the theatre complexes of the academic hospitals in Johannesburg. Potentially recyclable anaesthetic waste is not identified in our setting.

Methods: Recyclable anaesthetic waste items were identified. Anaesthetic waste was collected after every anaesthetic case. General and medical waste were weighed respectively and inspected for correct separation. Recyclable items were separated from general waste and weighed.

Results: A total of 107.6 kg of anaesthetic waste was evaluated. Per anaesthetic case, 74.6% (65.0–84.2%) was medical waste, and 25.4% (15.8–35.0%) was general waste. Of the general waste, 68.8% (57.7–78.8%) was recyclable. Only 6.8% of medical and 61.4% of general waste bags inspected were correctly separated. Within each medical waste bag, 6.9% (2.3–15.5%) of waste was incorrectly placed general waste. Similarly, each general waste bag contained 6% (0–21.6%) incorrectly placed medical waste. Waste generated per surgical discipline was significantly different.

Conclusion: Correct waste separation, a key step in decreasing the burden of healthcare waste, was poor. The study demonstrated that most general anaesthetic waste is recyclable.

Keywords: anaesthetic waste, theatre, recycling, medical waste, waste separation

Introduction

Increasing evidence links climate change and environmental decline to a direct threat to public health.[1,2] It threatens the basic needs to sustain health: clean air and water, adequate and sustainable food sources, and secure shelter. Those residing in low-income countries are likely to suffer the most from climate change's economic and environmental effects.[1]

All manufactured products use finite natural resources during manufacture, emitting greenhouse gases such as carbon dioxide (CO_2), the greatest contributor to global warming, during their production.[1,3] The 2017 Lancet Commission on climate change has estimated the health sector to be responsible for 4.6% of global carbon emissions.[1,3] The effect of the health sector on our environment is not just limited to its carbon emissions. Recent studies in high-income countries have found healthcare waste to be the second largest contributor to national waste, surpassed only by the food industry.[4,5]

Healthcare waste is separated into general waste and medical waste. General waste is comparable to domestic waste. It does not require specialised biohazardous handling and has the potential to be recycled.[5-7] The World Health Organization (WHO) estimates general waste to range from 75% to 90% of total healthcare waste generated.[8] General waste, if not recycled, is disposed of at landfill sites.

Medical waste is items that have been contaminated with blood, bodily fluids, or human tissue. Medical waste requires specialised handling and disposal, such as incineration.[5,7,9] Incineration of waste not only increases our carbon footprint but also results in the emission of harmful toxins.[4,10] Other hazardous healthcare waste include chemical, pharmaceutical, radioactive, and sharps.[9] The operating theatre contributes 20–30% of total hospital waste, with anaesthetic waste forming approximately a quarter of operating theatre waste.[5,10,13-15]

The cost comparison for disposing of general waste versus medical waste is significant, with medical waste disposal costing five to ten times that of general waste disposal.[6,11,12] One centre found a 60% reduction in waste disposal costs after implementing waste separation.[6] Appropriate waste separation is a crucial step in reducing the financial and environmental cost of healthcare waste.[10]

Recycling has been shown to reduce total general waste, resulting in cost avoidance, and has the potential to generate financial revenue for the hospital.[10,16] Introducing recycling into the operating theatre has also been shown to reduce the overall amount of medical waste generated, likely due to greater staff

awareness of waste management and separation.[5,10] Recycling reduces the amount of general waste ending up in already limited landfills, and it decreases the amount of medical waste needing energy-intensive and pollutant-producing treatment and disposal.[17] Furthermore, manufacturing products from recycled materials have a lower carbon footprint compared to production from raw materials.[5,17]

Local and international studies have suggested that living near a landfill site could be linked to hazardous medical outcomes, ranging from general malaise, birth defects, certain cancers, and increased respiratory and skin disorders. This is a further public health incentive to recycle and limit landfill waste.[18-20] Despite the financial and environmental benefits, non-contaminated anaesthetic waste is not recycled within the major academic hospitals in Johannesburg, South Africa. In addition, waste separation is not performed uniformly amongst these hospitals. Anaesthetic waste items that are potentially recyclable are not identified in our setting.

Since 2020, publications focusing on anaesthesia's contribution to climate change have grown exponentially, culminating in a consensus statement from the World Federation of Societies of Anaesthesiologists (WFSA).[21] This 2022 consensus statement acknowledges that to protect public health, anaesthesia needs to incorporate sustainable practices to limit their contribution to global warming.[21] Despite the increased interest, no local publications nor comparable low- to middle-income country publications evaluating anaesthetic waste were found.

Methods

This prospective, descriptive study was conducted in 2021 at the Helen Joseph Hospital (HJH) theatre complex. HJH is an academic, public, secondary level hospital in Auckland Park, Johannesburg. An ethics waiver was obtained from the Human Research Ethics Committee (medical) and the Graduate Studies Committee of the University of the Witwatersrand.

Before data collection, anaesthetic items from the anaesthetic stock room, anaesthetic trolleys, and medication room were catalogued. With the assistance of a Buhle Waste representative, the company currently tendered for medical and hazardous waste management at all the academic hospitals in Johannesburg, these items were reviewed, and recyclable items were identified (Appendix 1).

Data were collected over three weeks, on weekdays from 07:30 to 16:30. A consecutive convenience sampling method was used. The sample consisted of 132 anaesthetic cases, providing a 95% confidence interval with a 5% margin of error to represent an average number of cases done per month. The sample size was determined in consultation with a biostatistician using the Raosoft™ sample size calculator.

On completion of every anaesthetic case during the data collection period, the waste bags attached to the anaesthetic workstation were collected (Figure 1). These consisted of a clear general waste bag and a red medical waste bag. Sharps waste

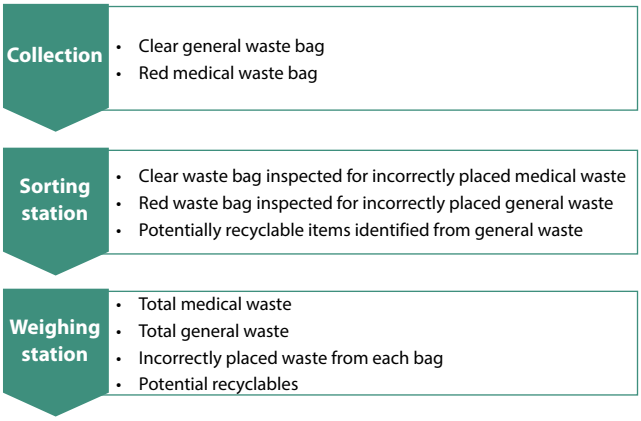


Figure 1: Data collection process

was excluded for researcher safety, and other theatre waste bags were also excluded.

Waste bags were taken to a dedicated sorting and weighing station. Weighing was done on a standard domestic digital scale, with a minimum reading of 1 g. The scale was calibrated at its production factory and did not require repeat calibration. All samples were weighed using the same scale.

Waste analysis and weighing were done immediately after every anaesthetic case. Theatre number and surgical discipline were noted. The red medical waste bag was weighed and visually inspected for any general waste. Any general waste found in the medical waste bag was separated and weighed. The clear general waste bag was then weighed and visually inspected for any medical waste. Medical waste found in the general waste bag was separated and weighed. After that, the general waste was separated into recyclable and non-recyclable waste. The recyclable waste was then weighed. Both medical and general waste were returned to appropriate waste bags and discarded as per standard theatre protocol.

Data was captured electronically per anaesthetic case and transcribed on an Excel® spreadsheet. Data analysis was done by a statistician. The Shapiro-Wilk test was used for normality, and the results indicated that the data was not normally distributed. Therefore, median and interquartile range (IQR) were used to describe the data. Frequencies and percentages were used to describe the data for the correctly sorted waste bags. To compare the amount of waste produced per case and by speciality, the non-parametric Kruskal-Wallis test was used. Thereafter, a post hoc analysis was done using Dunn's test, with Bonferroni correction for error.

Table I: Total waste produced

Waste category	Weight in kg
Medical waste	84.5
General waste	23.1
Recyclable waste	16.5
Total	107.6

Results

Waste generated

A total of 132 anaesthetic cases were analysed, with total waste accumulating to 107.6 kg. As Table I shows, 84.5 kg (78.5%) was medical waste, and 23.1 kg (21.5%) was general waste. Of the general waste produced, 16.5 kg (71.4%) was potentially recyclable.

Per anaesthetic case, the median percentage of medical waste produced was 74.6% (65–84.2%), and the median percentage of general waste was 25.4% (15.8–35%). Of the general waste per anaesthetic case, a median of 68.8% (57.7–78.8%) consisted of recyclable material. These results are summarised in Table II.

Waste separation

Only nine medical waste bags (6.8% of all) did not contain any general waste items. Of the general waste bags, 51 (38.6%) were correctly sorted, and 81 (61.4%) contained medical waste items (Figure 2). Table II summarises waste separation per anaesthetic case. Of each medical waste bag weighed, 23.5 g (10.5–62.0 g) was the median weight of incorrectly placed general waste. Cumulatively, a total of 5.5 kg of general waste was found within the inspected medical waste bags. Similarly, each general waste bag consisted of a 6.0 g (0.0–29.0 g) median weight of incorrectly placed medical waste, totalling 3.4 kg of incorrectly placed medical waste within all general waste bags inspected.

Waste generated per case, by speciality

Anaesthetic waste generated for the different surgical specialities, per case, is presented in Table III. Neurosurgery (1 042.5 g [929–1 339 g]) and ear, nose, and throat surgery (1 012 g [486–1 966 g]) produced the most waste per case, while ophthalmology (269.5 g [199.5–475 g]) produced the least waste per case. There was a significant difference between the anaesthetic waste produced for surgical specialities ($p = 0.018$). However, after post hoc analysis, this significance only applies to waste produced during neurosurgery.

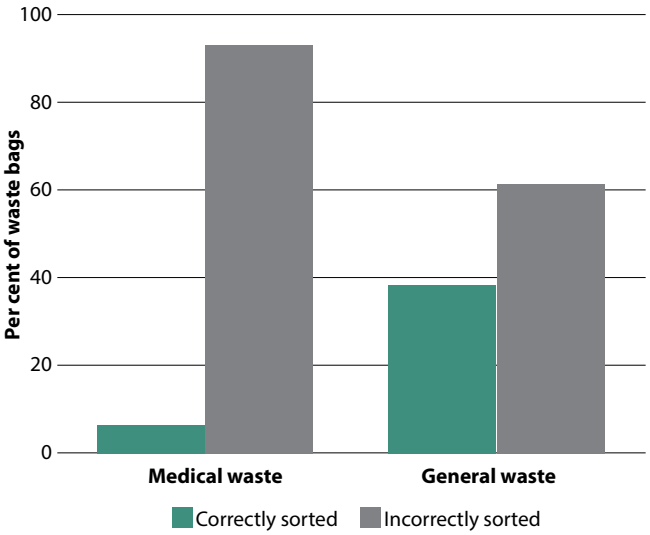


Figure 2: Sorting of waste bags

Discussion

As there is no local contextual research, this study's results could only be compared to those of high-income countries. Furthermore, most published waste audits include all the operating room waste. Only one study by McGain et al.[15] in 2009 in Melbourne, Australia, focused specifically on anaesthetic waste.

During the sample period of 15 workdays, anaesthesia produced 107.6 kg of waste. This is proportionally less than McGain et al.[15]

Table II: Waste generated per anaesthetic case

Waste category		Median weight in g (IQR)	Median percentage (IQR)
Medical waste bag	Incorrectly discarded general waste items	23.5 (10.5–62.0)	6.9 (2.3–15.6)
	Correctly discarded medical waste items	321.5 (215.5–673)	93.1 (84.4–97.7)
General waste bag	Incorrectly discarded medical waste items	6.0 (0.0–29.0)	6.0 (0.0–21.6)
	Correctly discarded general waste items	93.0 (45.5–176.5)	94.0 (78.4–100)
True medical waste produced		367.5 (225–693)	74.6 (65.0–84.2)
True general waste produced		137.0 (89.5–220.5)	25.4 (15.8–35.0)
Recyclable general waste		94.0 (53.5–168.5)	68.8 (57.7–78.8)

Table III: Anaesthetic waste generated per case by speciality

Speciality	Medical waste in g Median (IQR)	General waste in g Median (IQR)	Total waste in g Median (IQR)
Neurosurgery	760.5 (515–963)	312 (185–597)	1 042.5 (929–1 339)
Ear, nose, and throat	874 (376–1 876)	130 (125–336)	1 012 (486–1 966)
Plastic	427.5 (250–643)	187 (62–405)	740 (610–961)
General surgery	484 (272–1 343)	128 (90–231)	611 (388–1 464)
Orthopaedic	385 (218.5–650)	104 (40.5–195)	550 (347–773.5)
Vascular	299 (188–427)	72 (45–236)	435 (361–527)
Urology	267 (117–395)	69 (53–103)	391 (246–556)
Ophthalmology	157.5 (112.5–377.5)	77 (44.5–186)	269.5 (199.5–475)

during their landmark study in Melbourne, where anaesthesia produced 90 kg of waste over five days of data collection. They did not specify how many anaesthetic cases were performed during their five-day sample period. This discrepancy would be interesting to explore, with potential contributors being the COVID-19 pandemic limiting the number of cases being done, theatre inefficiency within a low- to middle-income setting, and more single-use medical items in a high-income setting.

The majority (78.5%) of waste produced was medical, contaminated waste. This is problematic, as all contaminated waste is automatically precluded from recycling and is more expensive to dispose of. This high proportion of medical waste far exceeds the findings of McGain et al.,[15] who found that only 26.6% of anaesthesia waste consisted of medical waste in their Melbourne institution. It also exceeds the findings of three studies that analysed entire operating room waste and found it to consist of 33%, 32%, and 58.8% medical waste, respectively.[6,14,22] Only one case report from Korea describing the total waste produced for five different surgeries found similarly that medical waste contributes 74.4% to total waste.[7]

Numerous intravenous fluid bags, commonly known as vaculitres, still containing fluid, were observed within the medical waste bags. This fluid added greatly to the overall weight of the medical waste bag and could explain the high proportion of medical waste compared to general waste. Fortunately, this can easily be rectified with education to empty the bags before discarding them. The high volume of medical waste can also be explained by what we currently classify as medical waste, as in some centres, for example, empty intravenous fluid bags are not considered contaminated waste.

The remainder, 25.4% of the waste produced, was general waste. Analysis of the general anaesthetic waste generated has shown that the majority (68.8%) is recyclable. This figure is in keeping with and exceeds that of the McGain et al.[15] audit in 2015, which found 58% of general anaesthetic waste recyclable. It exceeds an earlier study done by McGain et al.[14] in 2009, looking at total theatre waste, which found only 43% potentially recyclable. Similar to our results, a separate initiative in Australia implemented theatre recycling and found that they could recycle up to 70% of their general theatre waste.[6] The high potential for recycling is due to a large proportion of anaesthetic waste consisting of disposable packaging and wrapping materials, and the ongoing trend towards single-use items in medicine.[6] Encouragingly, a recent survey of South African anaesthesia providers found that 92% of respondents considered the environmental impact of anaesthesia important, and 90.7% would like to recycle at work.[23]

Of the 132 general waste bags inspected, 51 were correctly sorted, with the remaining 81 containing contaminated waste items. On average, 6% of each general waste bag consisted of incorrectly placed, contaminated, or medical waste items. This is consistent with McGain et al.,[15] who found 7% infectious items within their general waste stream.

Medical waste was poorly separated, with only nine bags out of 132 not containing general waste items. Each medical waste bag consisted of an average of 6.9% general, non-infectious waste. This is in line with the 8% found by McGain et al.[15] Our study did not explore the reasons for such poor waste separation; it is likely to be similar to those identified in other waste management studies. These include ignorance of the importance of waste separation, lack of knowledge about which items are classified as medical waste, and fear of reprimand for disposing of a perceived contaminated item into general waste.[5] Again, this could be improved easily with education and posters explaining correct separation.

Anaesthesia for neurosurgery, ear, nose, and throat surgery, and plastic surgery generates the most waste. These areas should be targeted first for any waste interventions. An analysis of the type of anaesthetic performed was not an objective in this study; however, this could be a future area of investigation to determine whether this finding is due to total intravenous anaesthesia being used more commonly within these specialties. No other studies were found comparing waste production within different surgical disciplines.

Limitations

The results discussed are for one hospital only and cannot be extrapolated to other healthcare facilities. For researcher safety, glass ampoules and bottles were not included in this study, as the local practice is to place them into the sharps bin with hazardous sharps. Interestingly, much of the glass used to make ampoules is not recyclable, and the ampoules still require incineration due to the residual pharmaceutical waste.

The researcher attempted to estimate the total cost avoidance if recycling were theoretically implemented for the sample time of three weeks but was unsuccessful after numerous enquiries into current costs for general waste management. These enquiries identified the need to implement a waste audit cycle.

The study was conducted during the COVID-19 pandemic. This greatly impacted the number of cases being done and possibly made practitioners overly cautious, thereby exacerbating the number of general items placed into medical waste bags for fear of possible contamination.

Conclusion

Correct anaesthetic waste separation, a key step in decreasing the burden of healthcare waste, was inconsistently performed. This would result in increased waste disposal costs and unnecessary general waste incineration. Most of the general anaesthetic waste was identified as recyclable. Therefore, correct waste separation and a recycling programme could reduce the amount of general waste being sent to landfills. It may also provide an income and offset the cost of waste disposal. This is pertinent to a financially strained health system.

A review should be made of medical and pharmaceutical waste classification, as many of these products are made from

recyclable materials. In observation during anaesthesia practice, these items commonly do not become contaminated with bodily fluid, and the handling of empty pharmaceutical containers and vials is unlikely to pose any danger. A further recommendation is a cost analysis study to estimate the financial impact of recycling anaesthetic waste.

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Conflict of interest

The authors declare that no financial or personal relationships have inappropriately influenced the writing of this paper.

Ethical approval

An ethics waiver was obtained from the Human Research Ethics Committee (medical) and the Graduate Studies Committee of the University of the Witwatersrand.

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