An evaluation of anaesthetic waste generation at a Johannesburg academic hospital

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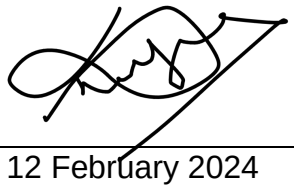
A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

Johannesburg, 12 February 2024

Declaration

I, Jeanne-Marie Meintjes declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



12 February 2024

Abstract

Background

The healthcare sector contributes directly to global warming and environmental decline. This is in part due to disproportionally large waste generation compared to other sectors, and the environmental consequences of incineration of medical waste [4,5,7,9]. Waste separation and recycling decreases total waste generation of the theatre complex, decreasing the cost of waste disposal, and if properly implemented can generate revenue [5,6,10,16]. Waste separation is not performed uniformly, and no recycling programs 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

107.6kg of anaesthetic waste was evaluated. Per anaesthetic, 74.6% (65.0-84.2%) was medical waste, and 25.4% (15.8-35.0%) 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 health care waste, was poor. The study demonstrated that most general anaesthetic waste is recyclable.

Acknowledgements

I would like to thank the following:

To my supervisor, Lizil Gilliland, for her expertise and clear sense of direction.

To my husband Simon Gowans for his support and encouragement.

To the Helen Joseph Hospital theatre staff, for their patience and good humour during data collection.

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Abbreviations

CO2	Carbon dioxide
USA	United States of America
UK	United Kingdom
HJH	Helen Joseph Hospital
WITS	University of the Witwatersrand
IQR	Inter quartile range

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the rest of the Research Report in order to comply with the author guidelines of the Southern African Journal of Anaesthesia and Analgesia (SAJAA), the journal to which it is intended to be submitted.

Section 1: Review of the literature

1.1 Introduction

Global warming and environmental decline pose an imminent and significant danger to public health. Global warming and the resultant climate change threaten the basic needs to sustain health, namely clean air and drinking water, adequate and sustainable food sources, and secure shelter (1, 2). Watts et al (1) highlights that those who will suffer most from the environmental and economic effects of climate change are the young, the elderly and those residing in low income countries.

The burning of fossil fuels results in carbon dioxide (CO_2) emission, which is the greatest contributor to greenhouse gas emissions and effective global warming (1, 3). All manufactured products use finite natural resources during manufacture and emit greenhouse gasses, such as CO_2, during their production. The 2019 Lancet commission on climate change has shown the health sector to be responsible for 4.6% of global carbon emissions (1).

The effect of the health sector on our environment is not just limited to its carbon emissions. Recent studies have found healthcare waste to be the second largest contributor to national waste in the United States of America (USA) and Australia respectively, surpassed only by the food industry (4, 5). This phenomenon is reflected in the United Kingdom (UK) (5).

An Australian review of healthcare greening initiatives have found a recent surge in healthcare waste, and its disproportional contribution to national waste to be multifactorial (5). Concerns about possible cross-infection of diseases such as hepatitis B and human immunodeficiency virus have demanded the use of disposable, single use plastic devices. A growing, aging population results in an increased burden on the healthcare system, resulting in more admissions every year. Furthermore, the evolution of the field of medicine has resulted in increasing numbers of operations performed worldwide every year (4-6).

Healthcare waste is generally separated into general waste and regulated medical waste. General waste, disposed of in clear bags, is comparable to domestic waste. It does not require specialized biohazardous handling and has the potential to be recycled (5, 7). The World Health Organization (WHO) estimates non-hazardous healthcare waste, i.e. 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.

In comparison, medical waste, disposed of in red bags, are 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). The disposal of medical waste carries significant environmental consequences. The incineration of 1kg of medical waste generates approximately 3kg of carbon dioxide (5). Incineration of waste not only increases our carbon footprint but also results in the emission of harmful pollutants such as dioxins, furans and mercury (4). These toxins have been linked to numerous harmful effects ranging from infertility to increasing acid content in our water and soil (10). Other forms of hazardous healthcare waste include chemical waste, pharmaceutical waste, radioactive waste and sharps (9).

The cost comparison for disposing general waste versus medical waste is also significant. An Australian study described waste management costs at a 780 bed tertiary hospital. They found that medical waste disposal costs seven times more than general waste disposal (6). After implementation of waste separation within their operating theatres, they found a 60% reduction in waste disposal costs. A frequently cited American review by Axelrod et al (11) estimated the costs of medical waste management to be five times more than that of general waste. Another study done in the USA found their medical waste to cost 10 times the amount of general waste to dispose of (12). Appropriate waste separation is a crucial step in reducing the financial and environmental cost of healthcare waste (10).

Studies done in high income countries, show that the operating theatre contributes 20% to 30% of total hospital waste. Anaesthetic waste forms approximately 25% of operating theatre waste (5, 10, 13, 14). Recent research from both the USA and Australia estimates that up to 90% of operating theatre waste is incorrectly labelled as medical waste and therefore sent for unnecessarily expensive waste disposal (5, 10). This improper sorting is partly due to ignorance of the importance of separating waste, or a fear of reprimand for incorrectly disposing a contaminated item into general waste (5).

An audit, done in 2008 at a 320 bed Australian hospital, reiterated that anaesthetic waste contributed a quarter of total operating theatre waste (15). They further stated that up to 60% of general anaesthetic waste is potentially recyclable. This was mirrored in practice after a recycling initiative was implemented at the previously mentioned 780 bed Australian hospital, resulting in a reduction of more than 50% in total operating theatre waste (6). The high potential for recycling is likely due to a large proportion of operating theatre waste consisting of disposable packaging and wrapping materials (6).

Recycling results in cost avoidance by reducing total general waste. A paper and cardboard recycling initiative in a UK operating theatre resulted in a total saving of £0.51 per case as well as a reduction of 25kg of CO_2 emissions per 20 cases (16). Research has also shown a potential to generate financial revenue by recycling items from the operating theatre. A recent study done in the USA estimated a $5000 annual profit and a $174 240 saving via cost avoidance by recycling the plastic polypropylene material that is used in operating theatres in the USA to wrap instrument trays for sterilization (10). Introducing recycling into the operating theatre has also shown to reduce the overall amount of medical waste generated. This may be due to greater staff awareness of waste management and separation (5, 10).

In addition to the potential profit generation and the established cost avoidance, recycling has environmental benefits. It reduces the amount of general waste ending up on our already limited landfills and it decreases the amount of medical waste needing energy-intensive and pollutant producing treatment and disposal (17). Furthermore, producing products from recycled materials has a lower carbon footprint compared to production from raw materials (5, 17).

No publications describing recyclable anaesthetic waste within a South African setting, nor its potential financial effects were found. There is currently no recycling of non-contaminated anaesthetic waste within the major academic hospitals in Johannesburg, South Africa. In addition to this, waste separation is not performed uniformly amongst these hospitals, despite the obvious financial and environmental benefit.

1.2 Summary

With increasing evidence linking climate change and environmental decline as a direct threat to public health, healthcare providers have a responsibility to explore all options to mitigate these effects (1, 2). As several studies and interventions in high income countries have shown, proper waste separation, and operating theatre recycling significantly decreases the overall waste generation of the theatre complex (5, 6). Waste separation and recycling can decrease the cost of waste management and if properly implemented can generate revenue for the hospital (5, 6, 10, 16). From studies done in high income countries we know that up to 60% of anaesthetic general waste is recyclable (15).

Waste separation is not performed uniformly, and there are no recycling programs set up in the operating theatre complexes of the academic hospitals in Johannesburg. Anaesthetic waste items that are potentially recyclable are not identified in our setting. Lastly, the financial impact of recycling these items is not known.

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Section 2: Author's guidelines

Southern African Journal of Anaesthesia and Analgesia (SAJAA)

AUTHORSHIP

Named authors must consent to publication **by signing a covering letter** which should be submitted as a supplementary file. Authorship should be based on substantial contribution to:

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(ii) drafting or critical revision for important intellectual content; and

(iii) approval of the version to be published. These conditions must all be met (uniform requirements for manuscripts submitted to biomedical journals; refer to **www.icmje.org**); and

(iv) exact contribution of each author must be stated.

DECLARATION OF CONFLICT OF INTEREST

Authors must declare all sources of support for the research and any association with a product or subject that may constitute a conflict of interest. If there is no conflict of interest to declare please include the following statement: The authors declare no conflict of interest.

FUNDING SOURCE

All sources of funding should be declared. Also define the involvement of study sponsors in the study design, collection, analysis and interpretation of data; the writing of the manuscript; the decision to submit the manuscript for publication. If the study sponsors had no such involvement, this should be stated as follows: No funding source to be declared.

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Original articles on research relevant to anaesthesia and analgesia should not exceed 3 200 words, no more than 30 references, with up to 6 tables or figures. A structured abstract under the following headings, Background, Methods, Results, and Conclusions is a requirement and should not exceed 300 words.

Clinical Review articles

Review articles relevant to anaesthesia and analgesia should not exceed 2 400 words, with a maximum of 20 references and no more than 6 tables or figures. A summary of 300 words or less is required.

Case reports

Case reports should not exceed 1 800 words with no more than 10 references. Figures are limited to 2 figures and may include images or photographs. The case report should have three headings: Summary (not exceeding 100 words), Case report (with no introduction) and Discussion. Case reports will be published online only. The summary and the URL will appear in the printed version.

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Refer to articles in recent issues for the presentation of headings and subheadings. If in doubt, refer to 'uniform requirements' - **www.icmje.org**. Manuscripts must be provided in **UK English**.

Qualification, affiliation and contact details

This information must be provided for ALL authors and must be submitted as a supplementary file.

Email addresses of all author must be provided.

ORCID number of **ALL** authors must be provided - if authors do not have ORCID, please register at https://orcid.org/

Abbreviations

All abbreviations should be spelt out when first used and thereafter used consistently, e.g. 'intravenous (IV)' or 'Department of Health (DoH)'.

Scientific measurements

Scientific measurements must be expressed in SI units except blood pressure (mmHg) and haemoglobin (g/dl). Litres is denoted with a lowercase 'l' e.g. 'ml' for millilitres). Units should be preceded by a space (except for %), e.g. '40 kg' and '20 cm' but '50%'. Greater/smaller than signs (> and 40 years of age) should also be preceded by a space e.g. > 20 years. No spaces should precede ± and °, i.e. '35±6' and '19°C'.

Numbers should be written as grouped per thousand-units, i.e. 4 000, 22 160...

Quotes should be placed in single quotation marks: i.e. The respondent stated: '...' Round **brackets** (parentheses) should be used, as opposed to square brackets, which are reserved for denoting concentrations or insertions in direct quotes.

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Disclaimers should follow the Conclusion and it should be in the following order: Acknowledgements, Declaration conflict of interest, Funding source, Ethics declaration and ORCID.

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If tables or illustrations submitted have been published elsewhere, the author(s) should provide consent to republication obtained from the copyright holder.

Tables may be embedded in the manuscript file **and** provided as **'supplementary files'**. They must be numbered in Arabic numerals (1,2,3...) and referred to consecutively in the text (e.g. 'Table 1'). Tables should be constructed carefully and simply for intelligible data representation. Unnecessarily complicated tables are strongly discouraged. Tables must be cell-based (i.e. not constructed with text boxes, tabs or enters) and accompanied by a concise title and column headings. Footnotes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || then ** †† ‡‡ etc.

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All references should be listed at the end of the article in numerical order of appearance in the **Vancouver style** (not alphabetical order). Approved abbreviations of journal titles must be used; see the List of Journals in Index Medicus. Names and initials of all authors should be given; if there are more than six authors, the first four names should be given followed by et al. First and last page, volume and issue numbers should be given. **Wherever possible, references must be accompanied by a digital object identifier (DOI) link and PubMed ID (PMID)/PubMed Central ID (PMCID).** Authors are encouraged to use the DOI lookup service offered by **CrossRef**. Crossref DOIs should always be displayed as a full URL link in the form https://doi.org/10.xxxx/xxxxx

Journal references:

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Scientific Letters

(2400 words) (3-4 pages)

Case Studies

(1 800 words) (3 pages)

Clinical reviews

(2 400 words) (3-4 pages)

Section 3: Draft article

An evaluation of anaesthetic waste generation at a Johannesburg academic hospital

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Key words: Anaesthetic waste, theatre, recycling, medical waste, waste separation

Abstract

Background

The healthcare sector contributes directly to global warming and environmental decline. This is in part due to disproportionally large waste generation compared to other sectors, and the environmental consequences of incineration of medical waste [4,5,7,9]. Waste separation and recycling decreases total waste generation of the theatre complex, decreasing the cost of waste disposal, and if properly implemented can generate revenue [5,6,10,16]. Waste separation is not performed uniformly, and no recycling programs 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

107,6kg of anaesthetic waste was evaluated. Per anaesthetic, 74.6% (65.0-84.2%) was medical waste, and 25.4% (15.8-35.0%) 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 health care waste, was poor. The study demonstrated that most general anaesthetic waste is recyclable.

Introduction

There is increasing evidence linking climate change and environmental decline as a direct threat to public health[1,2]. It threatens the basic needs to sustain health, namely 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 the economic and environmental effects of climate change.[1]

All manufactured products use finite natural resources during manufacture, and emit 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 specialized biohazardous handling and has the potential to be recycled.[5,6,7] 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 are 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 forms of hazardous healthcare waste include chemical waste, pharmaceutical waste, radioactive waste, and sharps.[9]

The cost comparison for disposing general waste versus medical waste is significant, with medical waste disposal costing five to 10 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]

The operating theatre contributes 20% to 30% of total hospital waste, with anaesthetic waste forming approximately a quarter of operating theatre waste.[5,10,13-15]

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 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 on 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 has a lower carbon footprint compared to production from raw materials.[5,17]

Despite the financial and environmental benefit, there is currently no recycling of non-contaminated anaesthetic waste within the major academic hospitals in Johannesburg, South Africa. In addition to this, 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 focussing on anaesthesia's contribution to climate change has grown exponentially, culminating in a consensus statement from the World Federation of Societies of Anaesthesiologists.[18] This 2022 consensus statement acknowledges that to protect public health, anaesthesia needs to incorporate sustainable practices to limit their contribution to global warming.[18] 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 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.

Prior to 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 was collected over a three-week period, on weekdays from 07:30 until 16:30. A consecutive convenience sampling method was used. The sample size consisted of 132 anaesthetic cases, providing a 95% confidence interval with a 5% margin of error, to be representative of an average amount of cases done per month. The sample size was determined in consultation with a biostatistician, using Raosoft™ sample size calculator.

On the completion of every anaesthetic during the data collection period, the waste bags attached to the anaesthetic workstation were collected (Figure 1). This consisted of a clear general waste bag, and a red medical waste bag. Sharps waste was excluded. Other theatre waste bags were 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 gram. The scale was calibrated at its production factory and did not require repeat calibration. All samples were weighed with the same scale.

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

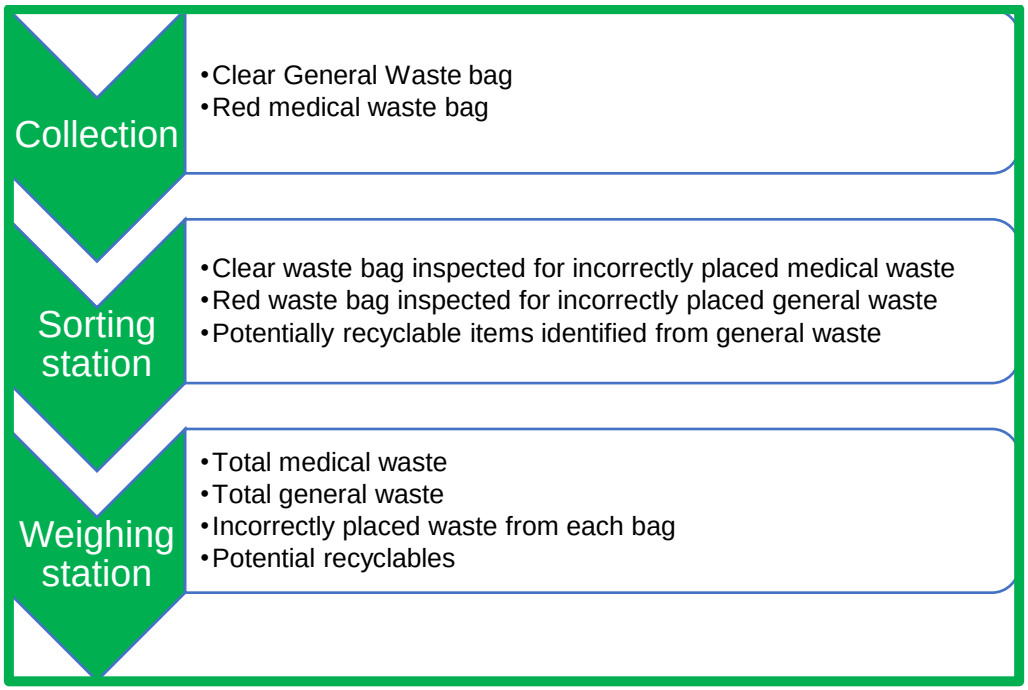

Figure 1: Data collection process

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 results from the test indicated that the data was not normally distributed, therefore median and interquartile range (IQR) was used to describe the data. For the correctly sorted waste bags, frequencies and percentage were used to describe the data. To compare the amount of waste produced per case, by speciality, the non-parametric Kruskal Wallis test was used.

Results

Waste generated

A total of 132 anaesthetic cases, with total waste accumulating to 107.6kg, was analysed. As shown in Table 1, 84.5kg (78.5%) was medical waste, and 23.1kg (21.5%) general waste. Of the general waste produced, 16.5kg (71.4%) was potentially recyclable.

Table 1: Total waste produced

Waste Category	Total Weight in kgs
	Total =107.6 kg
Medical waste	84.5
General waste	23.1
Recyclable waste	16.5

Per anaesthetic, the median percentage of medical waste produced was 74.6% (65%-84.2%), and the median percentage of general waste 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 2.

Table 2: Waste generated per anaesthetic

Waste Category		Median weight in grams (IQR)	Median percentage (IQR)
Medical Waste bag	Incorrectly discarded general waste items	23.5 (10.5 – 62)	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 – 29)	6.0 (0.0 – 21.6)
	Correctly discarded general waste items	93 (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 (89.5 – 220.5)	25.4 (15.8 – 35.0)
Recyclable general waste		94 (53.5 – 168.5)	68.8 (57.7 – 78.8)

Waste separation

Only nine medical waste bags (6.8% of all medical waste bags) 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 1). Table 2 summarises waste separation per anaesthetic. Of each medical waste bag weighed, 23.5g (10.5 – 62g) was the median weight of incorrectly placed general waste. Cumulatively, a total of 5.5kg of general waste was found within the inspected medical waste bags. Similarly, each general waste bag consisted of a 6g (0-29g) median weight incorrectly placed medical waste, totalling 3.4kg of incorrectly placed medical waste within all general waste bags inspected.

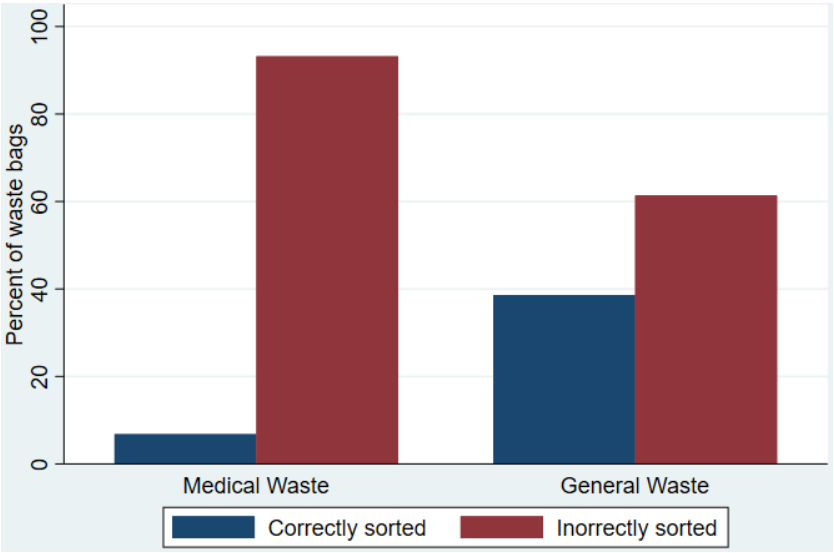

Figure 2: Sorting of waste bags

Waste generated per case, by speciality

Anaesthetic waste generated for the different surgical specialities, per case, is presented in Table 3. There was a significant difference between the anaesthetic waste produced for surgical specialities (p-value = 0.018). Neurosurgery (1042.5g (929g – 1339g)) and ear, nose, and throat surgery (1012g (486g – 1966g)) produced the most waste per case, while ophthalmology (269.5g (199.5g – 475g)) produced the least waste per case.

Table 3: Anaesthetic waste generated per case by speciality

Speciality	Medical waste in grams Median (IQR)	General waste in grams Median (IQR)	Total waste in grams Median (IQR)
Neurosurgery	760.5 (515 – 963)	312 (185 – 597)	1042.5 (929 – 1339)
Ear, nose & throat	874 (376 – 1876)	130 (125 – 336)	1012 (486 – 1966)
Plastic	427.5 (250 – 643)	187 (62 – 405)	740 (610 – 961)
General surgery	484 (272 – 1343)	128 (90 – 231)	611 (388 – 1464)
Orthopedic	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)

Discussion

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

During the sample period consisting of 15 workdays, anaesthesia produced 107.6kg of waste. This is proportionally less than McGain et al during their landmark study done in Melbourne, where anaesthesia produced 90kg of waste over just five days of data collection.[15] 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-middle income setting, as well as 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 more expensive to dispose of. This high proportion of medical waste far exceeds that found by McGain et al, who found in their Melbourne institution that only 26.6% of anaesthesia waste consisted of medical waste.[15] It also exceeds that of three studies that analysed entire operating room waste who found it to consist of 33%, 32%, and 58.8% medical waste respectively.[6,14,20] Only one case report done in 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 prior to discarding them.

The remainder, 25.4% of 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 audit done in 2012, that found 58% of general anaesthetic waste recyclable.[15] It exceeds an earlier study done by McGain et al in 2008, looking at total theatre waste, that found only 43% potentially recyclable.[14] Similar to our results, a separate initiative in Australia implemented theatre recycling and found that they were able to 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.[19]

Of the 132 general waste bags inspected, 51 was 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 in keeping with McGain et al, who found within their general waste stream 7% was in fact infectious items.[15]

Medical waste was poorly separated with only nine bags out of 132 not containing general waste items. Each medical waste bag consisted on average of 6.9% general non-infectious waste. This is in keeping with the 8% found by McGain et al.[15] Our study did not explore the reasons for such poor waste separation, but 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 as to which items are classified as medical waste, and fear of reprimand for disposing a perceived contaminated item into general waste.[5] Again, this could be improved easily with education and posters explaining correct separation.

The study lastly identified that there is a significant difference in anaesthetic waste generated for different surgical specialties. Anaesthesia for neurosurgery, ear nose and throat surgery and plastic surgery generate the most waste. These areas should be targeted first for any waste interventions. The reason for the increased waste production during neuro- and ear nose and throat surgery could be that total intravenous anaesthesia is used more commonly within these specialties. Analysis of the type of anaestetic done was not an objective in this study, however this finding again demonstrates that the environmental benefit of total intravenous anaesthesia vs volatile anaesthesia is still an ongoing debate. No other studies were found comparing the waste production within different surgical disciplines.

Limitations

The results discussed are for one hospital only and cannot be extrapolated to other health care facilities. Glass ampoules and bottles, which are often included in recycling programs in high income countries, were not included in this study as local practice is to place them into the sharps bin with hazardous sharps.

The researcher attempted to estimate the total cost avoidance if recycling were theoretically implemented for the sample time of 3 weeks, but after numerous enquiries into current costs for general waste management, was unsuccessful. These enquiries identified the need for a waste audit cycle to be implemented.

The study was conducted during the Covid-19 pandemic. This greatly impacted on 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 health care waste, was inconsistently performed. This would result in increased waste disposal costs and unnecessary incineration of general waste.

The majority of general anaesthetic waste was identified as recyclable. Correct waste separation and a recycling programme could therefore 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 particular pertinent to a financially strained health system.

A review should be made of the classification of medical and pharmaceutical waste, as many of these products are made from recyclable material. In observation during practice of anaesthesia, these items commonly do not become contaminated with bodily fluid and handling of empty pharmaceutical containers and vials are unlikely to pose any danger. A further recommendation is a cost analysis study, to estimate the financial impact of recycling anaesthetic waste.

Let this be encouragement for anaesthetists to be socially and environmentally responsible and become leaders in the formidable task of reducing our sector's carbon footprint.

Acknowledgement

This research was done in partial fulfilment of a Master of Medicine degree.

A sincere thank you to the anaesthetic and theatre staff of HJH for their enthusiasm and encouragement.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

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Section 4: Proposal

An evaluation of anaesthetic waste generation at a Johannesburg academic hospital

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1. Introduction

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Global warming and environmental decline pose an imminent and significant danger to public health. Global warming and the resultant climate change threaten the basic needs to sustain health namely clean air and drinking water, adequate and sustainable food sources and secure shelter (1, 2). Watts et al (1) highlights that those who will suffer most from the environmental and economic effects of climate change are the young, the elderly and those residing in low income countries.

The burning of fossil fuels results in carbon dioxide (CO_2) emission, which is the greatest contributor to greenhouse gas emissions and effective global warming (1, 3). All manufactured products use finite natural resources during manufacture and emit greenhouse gasses, such as CO_2, during their production. The latest Lancet commission on climate change has shown the health sector to be responsible for 4,6% of global carbon emissions (1).

The effect of the health sector on our environment is not just limited to its carbon emissions. Recent studies have found healthcare waste to be the second largest contributor to national waste in the United States of America (USA) and Australia respectively, surpassed only by the food industry (4, 5). This phenomenon is reflected in the United Kingdom (UK) (5).

An Australian review of healthcare greening initiatives have found a recent surge in healthcare waste, and its disproportional contribution to national waste to be multifactorial (5). Concerns about possible cross-infection of diseases such as hepatitis B and human immunodeficiency virus have demanded the use of disposable, single use plastic devices. A growing, aging population results in an increased burden on the healthcare system, resulting in more admissions every year. Furthermore, the evolution of the field of medicine has resulted in increasing numbers of operations performed worldwide every year (4-6).

Healthcare waste is generally separated into general waste and regulated medical waste. General waste, disposed of in clear bags, is comparable to domestic

waste. It does not require specialized biohazardous handling and has the potential to be recycled (5, 7). The World Health Organization (WHO) estimates non-hazardous healthcare waste, i.e. 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.

In comparison, medical waste, disposed of in red bags, are 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). The disposal of medical waste carries significant environmental consequences. The incineration of 1kg of medical waste generates approximately 3kg of carbon dioxide (5). Incineration of waste not only increases our carbon footprint but also results in the emission of harmful pollutants such as dioxins, furans and mercury (4). These toxins have been linked to numerous harmful effects ranging from infertility to increasing acid content in our water and soil (10). Other forms of hazardous healthcare waste include chemical waste, pharmaceutical waste, radioactive waste and sharps (9).

The cost comparison for disposing general waste versus medical waste is also significant. An Australian study described waste management costs at a 780 bed tertiary hospital. They found that medical waste disposal costs seven times more than general waste disposal (6). After implementation of waste segregation within their operating theatres, they found a 60% reduction in waste disposal costs. A frequently cited American review by Axelrod et al (11) estimated the costs of medical waste management to be five times more than that of general waste. Another study done in the USA found their medical waste to cost 10 times the amount of general waste to dispose of (12). Appropriate waste segregation is a crucial step in reducing the financial and environmental cost of healthcare waste (10).

Studies done in high income countries, show that the operating theatre contributes 20% to 30% of total hospital waste. Anaesthetic waste forms approximately 25% of operating theatre waste (5, 10, 13, 14). Recent research from both the USA and Australia estimate that up to 90% of operating theatre waste is incorrectly

labelled as medical waste and therefore sent for unnecessarily expensive waste disposal (5, 10). This improper sorting is partly due to ignorance of the importance of segregating waste, or a fear of reprimand for incorrectly disposing a contaminated item into general waste (5).

An audit, done in 2008 at a 320 bed Australian hospital, reiterated that anaesthetic waste contributed a quarter of total operating theatre waste (15). They further stated that up to 60% of general anaesthetic waste is potentially recyclable. This was mirrored in practice after a recycling initiative was implemented at the previously mentioned 780 bed Australian hospital, resulting in a reduction of more than 50% in total operating theatre waste (6). The high potential for recycling is likely due to a large proportion of operating theatre waste consisting of disposable packaging and wrapping materials (6).

Recycling results in cost avoidance by reducing total general waste. A paper and cardboard recycling initiative in a UK operating theatre resulted in a total saving of £0.51 per case as well as a reduction of 25kg of CO_2 emissions per 20 cases (16). Research has also shown a potential to generate financial revenue by recycling items from the operating theatre. A recent study done in the USA estimated a $5000 annual profit and a $174 240 saving via cost avoidance by recycling the plastic polypropylene material that is used in operating theatres in the USA to wrap instrument trays for sterilization (10). Introducing recycling into the operating theatre has also shown to reduce the overall amount of medical waste generated. This may be due to greater staff awareness of waste management and segregation (5, 10).

In addition to the potential profit generation and the established cost avoidance, recycling has environmental benefits. It reduces the amount of general waste ending up on our already limited landfills and it decreases the amount of medical waste needing energy-intensive and pollutant producing treatment and disposal (17). Furthermore, producing products from recycled materials has a lower carbon footprint compared to production from raw materials (5, 17).

No publications describing recyclable anaesthetic waste within a South African setting, nor its potential financial effects were found. There is currently no recycling of non-contaminated anaesthetic waste within the major academic hospitals in Johannesburg, South Africa. In addition to this, waste segregation is not performed uniformly amongst these hospitals, despite the obvious financial and environmental benefit.

2. Problem statement

With increasing evidence linking climate change and environmental decline as a direct threat to public health, healthcare providers have a responsibility to explore all options to mitigate these effects (1, 2). As several studies and interventions in high income countries have shown, proper waste segregation, and operating theatre recycling significantly decreases the overall waste generation of the theatre complex (5, 6). Waste segregation and recycling can decrease the cost of waste management and if properly implemented can generate revenue for the hospital (5, 6, 10, 16). From studies done in high income countries we know that up to 60% of anaesthetic general waste is recyclable (15).

Waste segregation is not performed uniformly, and there are no recycling programs set up in the operating theatre complexes of the academic hospitals in Johannesburg. Anaesthetic waste items that are potentially recyclable are not identified in our setting. Lastly, the financial impact of recycling these items is not known.

3. Aim

The aim of this study is:

- to evaluate the anaesthetic waste generated at Helen Joseph Hospital (HJH), over a two week period.

4. Objectives

The primary objectives of this study are to:

- describe which general waste items generated during an anaesthetic are recyclable.
- quantify the weight of recyclable general anaesthetic waste generated, and the proportion it constitutes of the general anaesthetic waste.
- quantify the weight of medical anaesthetic waste generated.
- quantify the weight and proportion of general anaesthetic waste incorrectly placed into medical waste bags.

The secondary objective of this study is to:

- compare the weight difference of anaesthetic waste generated between the different surgical disciplines.

5. Research assumptions

The following definitions will be used in the study:

General waste: Any items placed in the clear plastic waste bag. This waste is assumed to not contain any items that are hazardous, or any items that have been contaminated with any bodily fluids or tissue.

Medical waste: Any items placed in the red plastic waste bag. These items are assumed to have come in contact with bodily fluids and/or might be infectious or hazardous in nature.

Anaesthetic waste: Any waste discarded into the waste bags allocated to the anaesthetic trolley or station. This includes general waste and medical waste bags.

Sharps: Any waste discarded into the yellow hazardous bin. These usually include hypodermic needles, blades, guidewires and glass ampoules.

Recyclable waste: general waste that can be converted into reusable material.

6. Demarcation of study field

This study will be conducted in the theatre complex of HJH, affiliated to the Department of Anaesthesiology at the University of the Witwatersrand (WITS). HJH is a 500-bed central hospital. The hospital has 9 functioning theatres performing neuro, general, plastic, breast, urological, ophthalmic, and orthopaedic surgery. Since July 2020, an average of 200 anaesthetic cases are done per month.

7. Ethical considerations

Approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical) and the Graduate Studies Committee of the University of the Witwatersrand. As this study involves no humans, I will apply for an ethics waiver. Likewise, anonymity and confidentiality are not applicable.

Approval will be obtained from the Head of Department of Anaesthesia of HJH (Appendix 1). Approval will be obtained from the CEO of HJH and the operational manager of HJH theatre complex (Appendix 2).

If any contaminated items are found within the general non-contaminated waste, these items will be removed and discarded with other contaminated waste. If a significant amount of general waste is found within the medical red bags, a staff education session will be given on waste segregation. A copy of my results and analysis will be forwarded to the HJH operating theater management.

Data will be stored securely for six years after completion of study, electronically on a password protected database. The study will be conducted according to the principles of the Declaration of Helsinki (18) and the South African Guidelines for Good Clinical Practice (19).

8. Research methodology

8.1 Research design

A prospective, descriptive research design will be followed in this study.

8.2 Study population

The study population consists of all anaesthetic waste generated during sampling periods, excluding sharps and waste gas, in the HJH operating theatre complex.

8.3 Study sample

Sample method

A consecutive, convenience sampling method will be used. Consecutive, convenience sampling in this study, refers to the attempt by the researcher to include all accessible anaesthetic waste during the sample period, in a non random manner (20).

Sample size

Due to the Covid-19 pandemic, elective cases have been limited, with an average of only 200 anaesthetic cases being performed per month since July 2020. A waste analysis of 132 anaesthetics will be representative of the study population, providing a 95% confidence interval with a 5% margin of error. The sample size was determined in consultation with a biostatistician, using Raosoft™ sample size calculator.

Inclusion and exclusion criteria

The inclusion criteria for this study is:

- Anaesthetic waste generated within the HJH operating theatre complex during working hours 07:30 – 16:30.

The exclusion criteria for this study are:

- Any sharps waste.
- Waste generated during local lists. These cases are done under local anaesthetic administered by the surgeon, with no anaesthetist present.
- Any scrub room and surgical waste generated
- Any waste generated during anaesthesia for Covid-19 positive patients.

8.4 Collection of data

Prior to data collection, identification of potentially recyclable items will be done with assistance from a waste management company representative. The company currently on tender to manage the hospital waste at HJH, Buhle Waste, has agreed to assist me. Items commonly generated as waste during anaesthesia will be catalogued as recyclable or not (example Appendix 3). These items have been identified from the anaesthetic trolleys and anaesthetic stock room at HJH.

Potential cost of recycling versus normal waste management cost will also be obtained from the waste management representative during this meeting.

Data will be collected over a two week period, during working hours from 07:30 until 16:30. Anaesthetic waste will be collected from both elective and emergency theatres.

Anaesthetic waste comprising of a clear bag of general waste and a red bag of medical waste will be collected at the end of each operation. These will then be taken to a dedicated sorting and weighing station. Theatre number and surgical discipline will be noted.

Medical, red bag waste, will be weighed and thereafter the general, clear bag waste, will be weighed. Medical waste will be visually inspected and any general waste found within the medical waste bag will be weighed separately. This incorrectly placed waste is deemed contaminated and will be combined again with the medical waste into its original red bag.

General waste will then be separated into recyclable and non-recyclable waste. The recyclable waste will be weighed. Recyclable and non-recyclable general waste will be combined again into its original clear bag.

Both the general and medical waste bags will be handed back to the operating theatre complex cleaning staff, for disposal via the normal hospital waste management route.

Weighing will be done on a standard domestic digital scale, with a minimum reading of 1 gram. The scale is calibrated at its production factory and does not require repeat calibration. All samples will be weighed with the same scale. All data will be collected onto electronic data sheets (Appendix 4) and thereafter transcribed onto a Microsoft Excel™ spreadsheet.

Contaminated medical waste will be handled, which could pose an infectious risk to the researcher. To negate this risk, I as principal researcher and data collector will wear personal protective equipment including gloves, mask, scrubs and plastic apron.

9. Data analysis

The appropriate data analysis was determined in consultation with a biostatistician. All captured data will be recorded on a Microsoft Excel™ spreadsheet. The bulk of the analysis will be purely descriptive. Variables that are normally distributed will be summarised using means and standard deviations and those that are not normally distributed will use medians and interquartile ranges. Categorical variables will be described using proportions and frequency tables. Comparison of proportions will be done using the test of proportions. A test of proportion assesses whether or not the proportion from my sample population represents the true proportion from the entire population (21). Comparison of anaesthetic waste generated between different surgical disciplines will be done using the Anova test. A p value of <0,05 will be considered statistically significant.

10. Significance of the study

South Africa is a middle income country, putting us at greater risk for the detrimental economic and public health effects of climate change. In addition to the environmental benefits of recycling, in a resource limited setting such as ours, any potential financial benefit of proper segregation and recycling of anaesthetic

waste should be explored. The results of this study may change practice in that appropriate waste segregation may be prioritized, and it may motivate for recycling to become standard practice in our theatres.

A copy of my results and analysis will be forwarded to the HJH operating theater management.

10. Validity and reliability of the study

A biostatistician has been consulted to advise on the sample size and data analysis. Appropriate ethical approval will be applied prior to conducting this study, including approval from local management.

I as single researcher will be the sole data collector. A single, factory calibrated scale will be used for each sample. This scale will only be used for the study and the same technique will be used during weighing. Items will be compared to a predetermined catalogue of potentially recyclable items in our context and setting.

11. Potential limitations of the study

This study is contextual to our setting and results will therefore not be applicable to any other hospital. Theatre waste segregation into general waste and medical waste is not performed uniformly throughout the academic hospitals of the WITS circuit, limiting extrapolation of my results.

As convenience sampling will be used, there is a risk that the data might not be representative of the average waste generated in the HJH theatre complex.

All obstetric and gynaecological operations are performed at HJH's sister hospital, Rahima Moosa Mother and Child Hospital. These operations might have a significantly different waste profile which will not be represented in my findings.

Glass ampoules and bottles, which are often included in recycling programs in developed countries, will not be included in my analysis as current practice in our setting is to place them into the sharps bin with hazardous sharps. This will limit the number of recyclables and potential financial benefit of recycling in our setting.

The aims and objectives of my study will not be shared with the anaesthetists at HJH. However, they may become aware that my study focusses on waste management and thereby change their practice, for instance separating waste more appropriately.

12. Project outline

	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	April 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Nov 2021
Literature review																			
Preparing Protocol																			
Protocol assessment																			
Ethics Application																			
Collecting data																			
Data analysis																			
Writing up																			

13. Financial plan

The Department of Anaesthesiology will bear the cost of printing and paper for the proposal and research report.

Approximate printing costs:

Item	Price per page	Number of pages	Copies	Total
Proposal	1	15	10	R 150
Post graduate form	1	2	6	R 12
Complete report	1	100	4	R 400
Grand total				**R 812**

I as principal researcher will pay for a calibrated digital scale to weigh the waste products. An appropriate scale will be sought on the advisement of the waste management representative, however a brief online internet search has identified scales ranging from R200 - R550. Personal protective equipment, namely gloves, surgical masks and plastic aprons will be obtained from HJH operating theatre stock.

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Appendices

1. Anaesthetic general waste item catalogue
2. Letter to Head of department of anaesthesia HJH
3. Letter to CEO and Operational Manager
4. Data collection sheet

Appendix 1: Anaesthetic general waste catalogue

ANAESTHETIC GENERAL WASTE CATALOGUE					
ITEM	RECYCLABLE		ITEM	RECYCLABLE	
	YES	NO		YES	NO
Drugs			**Circuit**		
Cardboard packaging	X		Circuit caps	X	
Plastic ampoule holder		X	Filter wrapper		X
Polystyrene ampoule holder	X		Elbow/extension		X
Plastic top over rubber stopper	X		Circuit tubing		X
Plastic ampoules		X	Wrapping for elbow/extension		X
Paper information inlay	X		Circuit tubing plastic wrapping	X	
Sharps			**Oxygenation**		
Needle packaging		X	Oxygen tubing		X
Plastic needle cap	X		Nasal canula		X
Syringes			Face mask		X
Used syringe		X	Nasal canula wrapping		X
Syringe wrapper		X	Face mask wrapping		X
Insulin syringe		X	**Neuraxial**		
Airway devices			Spinal needle cap	X	
OPA wrapper		X	Spinal needle wrapping		X
ETT wrapping		X	Epidural set packaging	X	
Yankauer suction wrapper		X	**Miscellaneous**		
Yankauer suction		X	Empty U/S or defib gel bottles	X	
Supra-glottic device wrapper	X		Opsite wrapper		X
Supra-glottic device plastic holder	X		NGT wrapper		X
Soft suction wrapper		X	Sterile gel sachet	X	
IV			Used webcol		X
IV canula plastic cap	X		Webcol wrapper	X	
IV canula wrapping		X	Gauze paper wrapping		X
Extension set		X	Uncontaminated gauze		X
Extension set wrapping		X	Gloves		X
Giving set wrapping		X	Sterile glove wrapping		X
Giving/extension set cap	X		Non-sterile glove box	X	
3way tap wrapping		X	Empty sleek centre	X	
CVC set packaging	X		Nerve-stim packaging	X	
A-line set packaging	X		Electrodes		X
Fluids			Electrodes package	X	
Empty IV fluid bags	X		Eye patches		X
Fluids bag plastic wrapping	X		Eye patch wrapping	X	
Plastic top over rubber stopper	X		Cardboard box	X	
Sterile water bottle	X		Bair hugger blanket		X
Sterile water cap	X		Bair hugger packaging		X
Povidern bottle	X		Anaesthetic agent bottle cap	X	
Cidex/Endozyme bottle	X		Anaesthetic agent cardboard	X	
Hibitane bottle	X		Sterile gown packaging	X	

Appendix 1: Letter to HOD

26 March 2020

Dear Dr Gardner

I am a registrar in Anaesthesia at the University of Witwatersrand and I would like to complete a research project in the theatre complex of Helen Joseph Hospital (HJH). The study's title is: An evaluation of anaesthetic waste generated at a Johannesburg academic hospital.

I want to describe what proportion of anaesthetic waste is appropriately segregated and what proportion of general anaesthetic waste generated is recyclable.

Anaesthetic waste, comprising of a clear bag of general waste, and a red bag of medical waste next to the anaesthetic trolley, will be collected at the end of each operation. These will be taken to a dedicated sorting and weighing station. Each bag will be weighed, and thereafter the clear bag waste will be separated into recyclables and non-recyclables. The portion of recyclables will be weighed and then combined again with the non-recyclable general waste into the clear bag. The medical waste bag will be visually inspected and any general waste found within the bag will be weighed and placed back into the medical waste bag. Both the general and medical waste bags will be handed back to the operating theatre complex cleaning staff, for disposal via the normal hospital waste management route.

The study will be conducted over a two week period.

The only financial cost to HJH will be the use of gloves, plastic aprons and surgical masks from HJH theatre stock.

The study will be conducted pending consent from you, the Post Graduate Committee of the University of the Witwatersrand and the Human Ethics Committee of the University of the Witwatersrand.

For any queries please feel free to contact me at drjm.email@gmail.com. Thank you.

Yours sincerely

Dr Jeanne-Marie Meintjes

Appendix 2: Letter to CEO and Operational manager

26 March 2020

Dear Sir/Madam

I am a registrar in Anaesthesia at the University of Witwatersrand and I would like to complete a research project in the theatre complex of Helen Joseph Hospital (HJH). The study's title is: An evaluation of anaesthetic waste generated at a Johannesburg academic hospital.

I want to describe what proportion of anaesthetic waste is appropriately segregated and what proportion of general anaesthetic waste generated is recyclable.

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The only financial cost to HJH will be the use of gloves, plastic aprons and surgical masks from HJH theatre stock.

The study will be conducted pending consent from you, the Post Graduate Committee of the University of the Witwatersrand and the Human Ethics Committee of the University of the Witwatersrand.

For any queries please feel free to contact me at drjm.email@gmail.com. Thank you.

Yours sincerely

Appendix 4: Data collection sheet

Date	
Sample no	
Theatre	
Surgical speciality	

Waste	**Weight (grams)**
Medical	
Incorrectly labelled medical	
General	
Recyclable	

Any contaminated items in general waste:

Yes	No	Weight

Section 5: Annexures

5.1 Ethics approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

20/05/2021

Ref: W-CBP-210520-01

TO WHOM IT MAY CONCERN

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

Investigator: Dr J-M Meintjes
Student No. (if appropriate): 06 0371 9A
Staff No. (if appropriate): A0068400

Supervisor: Dr L Gilliland

School: Clinical Medicine
Department: Anaesthesia
Medical School
University

Project title: *An evaluation of anaesthetic waste generated at a Johannesburg academic hospital*

Reason: Study of unidentifiable waste material
No human participants will be involved in the study

Dr CB Penny
Chairperson: Human Research Ethics Committee (Medical)

Research Office Secretariat:
Third Floor, Phillip Tobias Building, corner of St Andrews and York Roads, Parktown, Johannesburg 2193
Postal address: Private Bag 3, Wits 2050
Tel Nos: +27 (0)11 717 1234/1252/2656/2700
Office E-mail: HREC-Medical.ResearchOffice@wits.ac.za
Website:
https://www.wits.ac.za/research/researcher-support/research-ethics/ethics-committees/

5.2 Graduate studies approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

24 March 2021
Person No: 0603719A
PAG

Dr J Meintjes
10 6th Avenue
Parktown North
2193
South Africa

Dear Dr Jeanne-Marie Meintjes

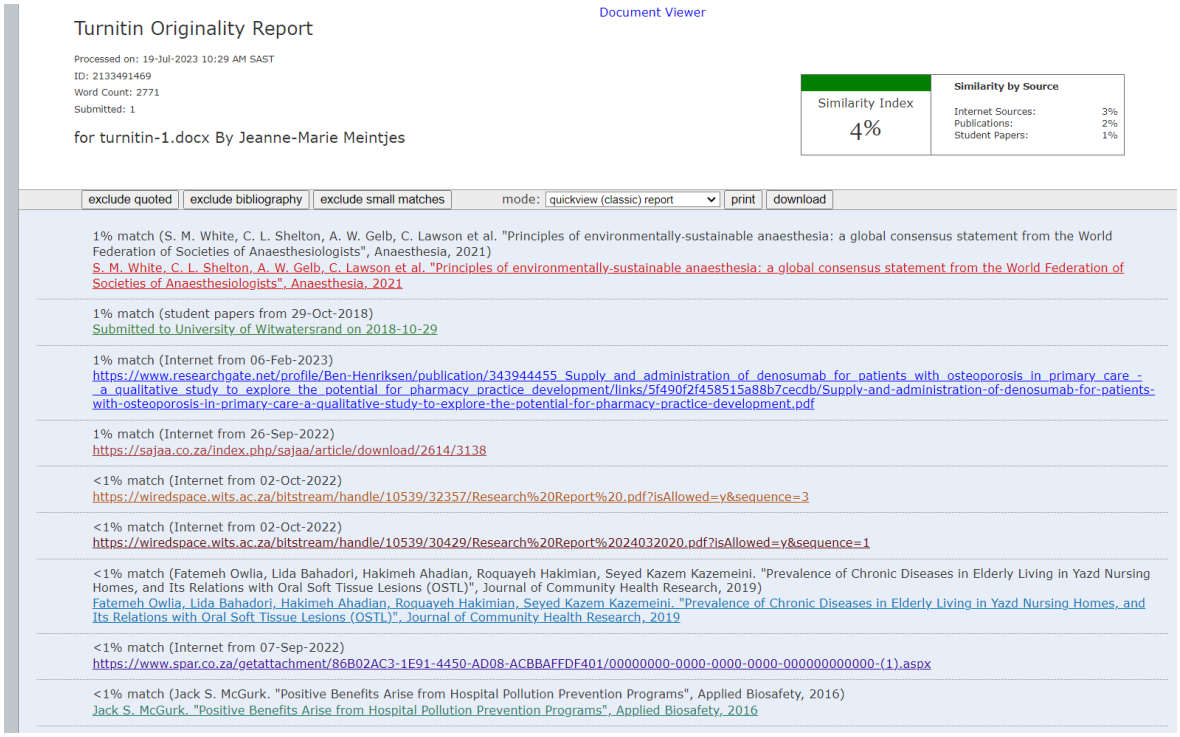
Master of Medicine in Anaesthesia: Approval of Title

We have pleasure in advising that your proposal entitled *An evaluation of anaesthetic waste generation at a Johannesburg academic hospital.* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

5.3 Turnitin report



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