e-ISSN: 3033-4470

Segregating clean waste in operating theatres: proof of principle after abdominal surgery

Virginia Ledda, Dmitri Nepogodiev, Aneel Bhangu

Correspondence: Virginia Ledda, vxl275@student.bham.ac.uk, Institute of Applied Health research, University of Birmingham, Birmingham Clinical Trials Unit, College of Medical and Dental Sciences, Birmingham, B15 2TT

Cite as: V Ledda, D Nepogodiev, A Bhangu. Segregating clean waste in operating theatres: proof of principle after abdominal surgery . Impact Surgery. 2024;1(3):93-97. Doi: https://doi.org/10.62463/surgery.50

Introduction

The NHS produces 250,000 tonnes of waste every year, incurring in elevated financial costs and carbon emissions for its disposal and processing.[1] Reduce and reuse is a vital principle in preventing waste from entering the system in the first place but it will take time to implement and it is unlikely to ever be complete.[2] In the meantime, better strategies to deal with the waste produced are needed, with recycling being a popular option amongst frontline staff.[3]

Operating theatres are resource intensive environments and produce a high volume of waste.[4] There is limited knowledge around the composition of this waste, and how segregated waste at the end of a modern operation would appear.[5] Additionally, correct segregation of this waste could lead to benefits both in terms of cost and environmental impact, but it is also challenging, due to the risks of contaminated waste entering a clean recycling stream.[5-7] To fill these knowledge gaps, we aimed to audit the waste produced from a laparoscopic bowel cancer operation, to determine if appropriate segregation can decrease the environmental impact of waste in the operating theatres.

Methods

We conducted an audit of the waste produced during a laparoscopic right hemicolectomy performed in April 2023. Approval was given by theatre management, hospital clinical managers, and hospital level waste managers. For this process, a clinician oversaw the collection of the clean, potentially recyclable waste produced and segregated it within different predefined streams. Waste was then collected in bags and weighed with a calibrated digital scale. Infectious and clinical waste (contaminated with body fluids, chemicals or pharmaceuticals) was disposed of in the usual waste streams, in keeping with infection control and health and safety procedures. For the same reason, sharps and surgical devices were disposed of in the normal fashion (sharps boxes and orange bags appropriately).

Clean, potentially recyclable waste was collected and sorted within two initial streams: paper and carboard and plastic. Plastic waste was further divided into soft (low density polyethylene, LDPE, resin code 4) and hard plastic. Hard plastic was then divided in recyclable and non-recyclable, based on resin codes: recyclable plastic included Polyethylene Terephthalate (PET, Resin code 1), High-Density Polyethylene (HDPE, Resin code 2) and Polypropylene (PP, Resin code 5). Non-recyclable plastic included items with Resin codes which are not recyclable or that are not easily recycled locally (Polyvinyl Chloride, PVC, Resin code 3, Polystyrene, PS, Resin code 6, Other plastics, Resin code 7), and all other plastic items in which a Resin code could not be identified.[8]

For the purpose of this audit, we considered three main waste streams to assess the carbon footprint of the processing of waste produced in the operating theatre (Figure 1). Energy from waste (EfW) indicates the production of electrical energy from the low temperature incineration of waste. Typically, 500 to 600 kWh of electricity is generated per ton of waste incinerated.[9]

Data for the carbon footprint of each waste stream was extracted from existing literature.[10,11] Final estimates considered the transportation of the waste to the appropriate facilities as well as the avoided emissions from the production of energy in the EfW processes, and the avoided primary production in the recycling streams.[10,11] We estimated the carbon footprint for the clean waste produced during the laparoscopic right hemicolectomy in three different scenarios.

In the first scenario, or worst-case scenario, we estimated the emissions generated if all clean waste produced was disposed of as infectious waste in orange bags, undergoing processing through autoclaving, shredding and subsequently low temperature incineration with EfW. In the second scenario, it was assumed that all clean waste collected would be processed as domestic waste, via EfW. In the third or best-case scenario we estimated the carbon footprint generated if all recyclable material was disposed of through recycling, while non-recyclable material was processed as domestic waste. The carbon footprint was calculated by multiplying the weight of the waste collected by the carbon footprint of each waste stream, according to the scenarios described above.

Results

The total weight of the clean waste collected amounted to 2.9 Kg. Of this, 1.40 Kg was paper and cardboard, 0.68 Kg was soft plastic, 0.58 Kg recyclable hard plastic, and 0.24 Kg non-recyclable hard plastic (Figure 2).

The carbon footprint was calculated for each of the scenarios described above. The overall carbon footprint from clean waste produced during one laparoscopic right hemicolectomy would lead to the production of 1.66 KgCO2e if all waste was disposed of as clinical, 0.50 KgCO2e if disposed of as domestic waste and it would save 1.66 KgCO2e if all recyclable clean material was effectively recycled. (Table 1)

Scaling this finding to the number of colectomies undertaken in 2022/2023[12], 19878 procedures, Scenario 1 would produce 32.8 tCO2e, Scenario 2 9.9 tCO2e while recycling of the materials in Scenario 3 would lead to overall saving of 33.0 tCO2e.

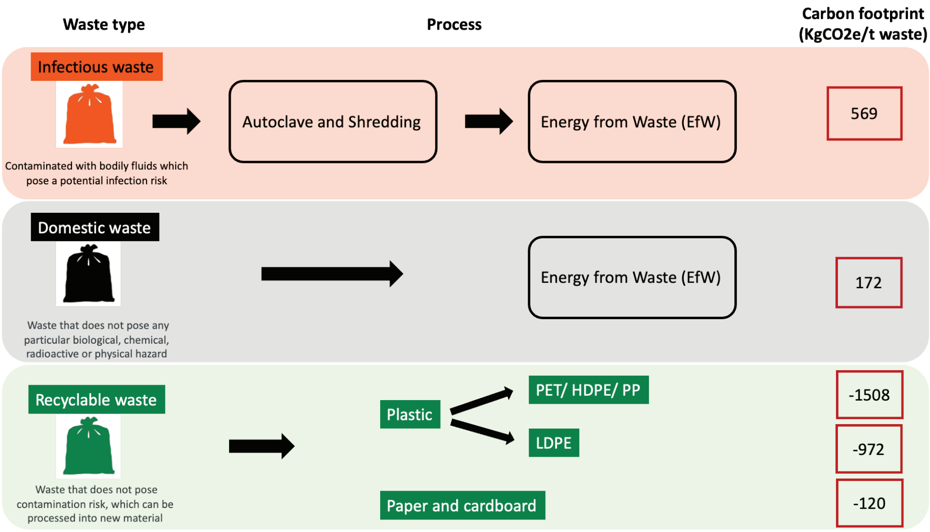
Discussion

This study is a proof of concept that waste segregation can be implemented and can lead to considerable changes to the environmental impact of waste disposal in the operating theatres. The scenarios created do not reflect the complexity of the waste management process in hospitals, but they highlight the importance of appropriate segregation.

Challenges to reaching the best-case situation in Scenario 3 are found within the operating theatre itself, the wider hospital and the outer setting.

Within the operating theatre, appropriate segregation can be difficult to ensure, given the high-pressure

Figure 1. Hospital waste streams considered within the waste audit and relative carbon footprint [10,11]



EfW: energy from waste, PET: Polyethylene Terephthalate, HDPE: High-Density Polyethylene, PP: Polypropylene, LDPE: low density polyethylene.

Figure 2. Waste collected during the operation.

environment: this waste audit required a clinician solely overseeing collection and sorting of the waste, which cannot be realistically guaranteed during all operations.[13] Literature shows that education and training of theatre staff and changes in logistics such as improving in signage and having smaller bins for clinical waste can make a difference in implementing appropriate waste segregation.[14-16]

More widely, waste disposal and processing in hospitals is dependent on existing contracts as the NHS trusts largely depend on private companies for their waste management. This means that waste management can vary significantly among trusts. Transparency of processes and results can be beneficial to ensure carbon efficient waste streams are utilised and that contracts are evaluated not only based on cost but also environmental impact. Additionally, compliance to the contracts needs to be ensured, to guarantee waste reaches the appropriate waste stream both internally and at the point of external collection, and that it is ultimately correctly processed.

To facilitate implementation of appropriate segregation of waste, clear labelling of plastics and materials is fundamental. Resin codes were useful to classify the material produced during this case, but they were not easily identifiable in all items. Additionally, the ability to recycle different types of plastics changes depending on facilities, therefore cannot be guaranteed NHS-wide at present.

Crucially, it is important to ensure that interventions adopted in the operating theatres to reduce the environmental impact of waste processing are sustained over time. Behavioural change models should be employed to assess the barriers and facilitators to the proposed intervention and findings should be used to design components to the intervention, to maximise its potential effectiveness and sustainability over time.[17,18]

This proof-of-concept study showed that appropriate segregation of clean waste can lead to a significant reduction in the environmental impact of operating theatres. While the processing of the waste collected in theatre depends on several factors, also external to the operating theatre and the hospital itself, correct segregation represents the first step that frontline teams can address in theatres. Behavioural change models should be utilised in the design of interventions in this field, to ensure these are sustainable over time.

Conflict of interest: None

Funding: This study/project is funded by the NIHR (NIHR 204403: Developing environmentally sustainable operating theatres).

Data sharing: No data to share.

Table 1. Estimated carbon footprint for different waste segregation scenarios

Types of waste	Weight (kg)	Carbon footprint (kgCO2e/kg)		
		Scenario 1- Worst case	**Scenario 2 – Middle case**	**Scenario 3 -Best case**
		All clean waste processed as infectious	All clean waste processed as domestic	Recyclable material effectively recycled, non recyclable processed as domestic
Soft plastic (LDPE)	0.68	0.39	0.12	-0.66
Paper and cardboard	1.4	0.80	0.24	-0.17
Recyclable hard plastic (PET/ HDPE/PP)	0.58	0.33	0.10	-0.87
Non-recyclable hard plastic	0.24	0.14	0.04	0.04
Total	**2.9**	**1.66**	**0.50**	**-1.66**

LDPE: low density polyethylene, PET: Polyethylene Terephthalate, HDPE: High-Density Polyethylene, PP: Polypropylene.

References

1. Mahase E. New legislation places duty on NHS to tackle climate change. BMJ. 2022;378:o1681. doi:10.1136/bmj.o1681

2. United States Environmental Protection Agency. Reduce, reuse, recycle. United States Environmental Protection Agency. Accessed 15/11, 2023. https://www.epa.gov/recycle/reducing-and-reusing-basics

3. National Institute for Health Care Research Global Health Research Unit on Global Surgery. Reducing the environmental impact of surgery on a global scale: systematic review and co-prioritization with healthcare workers in 132 countries. Br J Surg. Jun 12 2023;110(7):804-817. doi:10.1093/bjs/znad092

4. MacNeill AJ, Lillywhite R, Brown CJ. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. Lancet Planet Health. Dec 2017;1(9):e381-e388. doi:10.1016/S2542-5196(17)30162-6

5. Hossain MS, Santhanam A, Nik Norulaini NA, Omar AKM. Clinical solid waste management practices and its impact on human health and environment – A review. Waste Management. 2011/04/01/ 2011;31(4):754-766. doi:https://doi.org/10.1016/j.wasman.2010.11.008

6. World Health Organisation. Health-care waste. Accessed 29/09, 2023. https://www.who.int/news-room/fact-sheets/detail/health-care-waste

7. NHS England. NHS clinical waste strategy. Accessed 16/11, 2023. https://www.england.nhs.uk/wp-content/uploads/2023/03/B2159i-nhs-clinical-waste-strategy.pdf

8. Cambrian Packaging. What are resin identification codes? Accessed 16/11/2023, https://cambrianpackaging.co.uk/what-are-resin-identification-codes/

9. Korai MS, Mahar RB, Uqaili MA. Assessment of Power Generation Potential from Municipal Solid Wastes: A Case Study of Hyderabad City, Sindh, Pakistan. Pak J Anal Env Chem. 2014;15(1):18-27.

10. Rizan C, Bhutta MF, Reed M, Lillywhite R. The carbon footprint of waste streams in a UK hospital. Journal of Cleaner Production. 2021/03/01/ 2021;286:125446. doi:https://doi.org/10.1016/j.jclepro.2020.125446

11. Turner DA, Williams ID, Kemp S. Greenhouse gas emission factors for recycling of source-segregated waste materials. Resour Conserv Recy. Dec 2015;105:186-197. doi:10.1016/j.resconrec.2015.10.026

12. NHS Digital. Hospital Episode Statistics (HES). Accessed 16/11, 2023. https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-

episode-statistics

13. Lim BLS, Narayanan V, Nah SA. Knowledge, attitude, and practices of operating theatre staff towards environmentally sustainable practices in the operating theatres. Pediatr Surg Int. Mar 17 2023;39(1):152. doi:10.1007/s00383-023-05400-6

14. Martin DM, Yanez ND, Treggiari MM. An Initiative to Optimize Waste Streams in the Operating Room: RECycling in the Operating Room (RECOR) Project. AANA J. Apr 2017;85(2):108-12.

15. Wormer BA, Augenstein VA, Carpenter CL, et al. The green operating room: simple changes to reduce cost and our carbon footprint. Am Surg. Jul 2013;79(7):666-71.

16. Denny NA, Guyer JM, Schroeder DR, Marienau MS. Operating Room Waste Reduction. AANA J. Dec 2019;87(6):477-482.

17. Davies JF, Ikin B, Francis JJ, McGain F. Implementation approaches to improve environmental sustainability in operating theatres: a systematic review. Br J Anaesth. Jun 20 2023;doi:10.1016/j.bja.2023.05.017

18. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. Apr 23 2011;6:42. doi:10.1186/1748-5908-6-42