The Journal of Laryngology & Otology

cambridge.org/jlo

Rationalising surgical instruments in tonsillectomy: a pilot study to reduce greenhouse gas emissions and costs

Justin Jui Yuan Yeo, Keshav Kumar Gupta, Zahir Mughal and Chaitanya Bhatt

The Dudley Group NHS Foundation Trust, Russells Hall Hospital, Pensnett Road, Dudley, DY1 2HQ, UK

Main Article

Justin Jui Yuan Yeo takes responsibility for the integrity of the content of the paper

Cite this article: Yeo JJY, Gupta KK, Mughal Z, Bhatt C. Rationalising surgical instruments in tonsillectomy: a pilot study to reduce greenhouse gas emissions and costs. *J Laryngol Otol* 2025;1–4. https://doi.org/10.1017/S0022215124001129

Received: 18 August 2023
Revised: 24 March 2024
Accepted: 29 March 2024

Keywords:
carbon footprint; sustainability; surgery

Corresponding author:
Justin Jui Yuan Yeo;
Email: justinjuiyuanyeo@hotmail.com

Abstract

Objective. The healthcare industry is estimated to contribute 4.4 per cent of global greenhouse gas emissions. This pilot study aimed to investigate the impact of rationalising surgical instruments in tonsillectomy trays on greenhouse gas emissions and costs.

Method. We conducted a prospective observational study over a six-month period. All patients who underwent tonsillectomy were included. The instruments used during the procedure and their frequency of use were counted, with the operating surgeon being unaware of the study.

Results. During the 6-month timeframe, 46 tonsillectomies were performed. From the standard tonsillectomy tray containing 38 pieces, 9 pieces were never used. The removal of unused reusable instruments resulted in an estimated total reduction of 594 g of carbon dioxide equivalents and a saving of €9.63 per operation.

Conclusion. Rationalising the contents of the surgical instrument tray can have a positive environmental impact by reducing greenhouse gas emissions. There are also pecuniary benefits for the National Health Service because of the potential for cost savings.

Introduction

Carbon dioxide (CO_2) is one of the main contributors to global warming and climate change, and is estimated to account for between 9 and 26 per cent of the greenhouse effect.[1] Between 1970 and 2003, global CO_2 increased by 1.6 per cent a year, rising to 3.2 per cent a year from 2003 to 2011.[2] During a similar period (1981–2021) there was a recorded 0.18°C annual increase in global temperatures, with the 10 warmest years on record all occurring since 2010.[3] It is estimated that the healthcare industry is responsible for 4.4 per cent of global greenhouse gas emissions.[4] In the National Health Service, medical equipment alone accounts for 10 per cent of its carbon footprint in England.[5] Surgery plays a substantial role in the healthcare industry's carbon footprint, with an estimated 150–170 kg of carbon dioxide equivalents (CO_2e) per procedure, comparable to driving 450 miles in a petrol car.[6]

Tonsillectomy, ranked as the fifth most commonly performed surgical procedure in England, was performed on nearly 50 000 people between 2016 and 2017.[7] A recent study from the UK demonstrated that the mean carbon footprint of products used for tonsillectomy was 7.5 kg CO_2e per procedure for reusable surgical equipment alone.[8] Other factors that contribute to the carbon footprint during surgical procedures are maintaining operating-room conditions, anaesthetic equipment and the inhalation therapies used.

Given the substantial contribution of surgery to greenhouse gas emissions, and tonsillectomy being one of the most commonly performed procedures, we aimed to assess whether the surgical instruments used during a tonsillectomy could be rationalised to mitigate greenhouse gas emissions and costs.

Methods

All tonsillectomy procedures performed at a single district general hospital in the UK within a 6-month period (March–August 2023) were included. Prospective data were collected to include patient demographics, indication for surgery, method of tonsillectomy and grade of surgeon. The primary outcome was the instruments used and their frequency of use during the procedure. This was recorded discreetly against the instrument checklist that came with each tonsillectomy tray. The surgeons were blinded to the data collection and were not informed of it to minimise the impact on their operating and therefore reduce the chance of performance bias. The findings were cross-checked with the scrub nurse immediately at the end of each procedure to validate the findings. Where duplicate numbers of the same piece were included on the tray, these were only counted if all of the pieces were used.

Prior to the study period, the only two methods of tonsillectomy performed at our centre were cold-steel and bipolar diathermy dissection. There were no changes made to operating protocol during the study period. No patients were excluded during the study period. Instruments used for a procedure other than a tonsillectomy (such as adenoidectomy) were excluded.

The cost and greenhouse gas emissions were estimated for the instruments that remained unused during the operation. This calculation was based on the findings of a sterilisation unit within the same region.[9] Sterilisation per piece as part of an instrument tray accounted for 66 g of CO_2e. Emission factors for each process-based carbon footprint were sourced from the UK Government Greenhouse Gas Conversion Factors for Company Reporting database,[10] the Small World Consulting Carbon Factors Dataset,[11] the Inventory of Carbon and Energy database,[12] and a study done by the sterilisation unit on healthcare waste.[13] The processes included were the materials and energy required by the washer and/or disinfector and steriliser, the sterile barrier system and the disposal of materials. Processes excluded were capital goods, hospital infrastructure and the production and disposal of surgical instruments. It should be noted that the method of sterilisation by this unit was via steam, a standard method in the UK.

The cost of instrument decontamination was calculated based on the charge by the sterilisation services department of the referenced study to the surgical departments per set of instruments, and took into account the cost of procurement and decontamination of the sterile barrier systems.[9] For this study, we took the value of €1.07, which equated to the cost of decontamination for each instrument housed in a tray wrap, the method in which tonsil trays are prepared in our unit.

Given that our investigation centred on surgical instruments and not patient-related information, this study was deemed a service improvement evaluation by our local audit department, therefore no ethical approval was required.

Results

A total of 46 tonsillectomies were performed during the study period. Sex distribution among the operated individuals was balanced, with 23 males and 23 females. The mean age was 14.1 years (standard deviation, 10.9 years) Recurrent tonsillitis was the most common indication for tonsillectomy (60.9 per cent, $n = 28$), followed by obstructive sleep apnoea (30.4 per cent, $n = 14$) and tonsillectomy for histology (9 per cent, $n = 4$). Bipolar diathermy was the predominant method for dissection (89.1 per cent, $n = 41$) followed by a combination of cold-steel and bipolar techniques (10.9 per cent, $n = 5$). The majority of procedures were carried out by surgical trainees (71.7 per cent, $n = 33$), with the remaining performed by consultant ENT surgeons (28.3 per cent, $n = 13$).

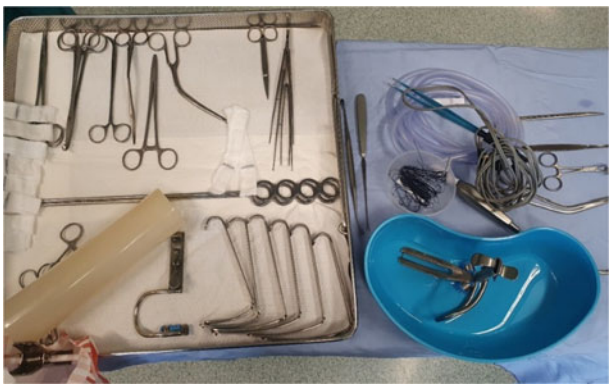

Figure 1. The standard tonsillectomy surgical tray.

The standard tonsillectomy surgical tray at our centre comprises 36 different pieces (38 pieces in total), housed within a metal tray and a disposable single-use tray wrap. These are listed in Table 1 and illustrated in Figure 1. A total of 17 pieces were used across all 46 surgical procedures, with 12 pieces being used more than once. Nine pieces remained untouched throughout the study period. These findings are summarised in Figure 2. If the unused pieces were removed from the tonsil tray, using the estimation calculation outlined in our methods, we estimate that a reduction of greenhouse gas emissions by 594 g CO_2e and a cost saving of €9.63 per tonsillectomy could be achieved.

Discussion

There has been increasing awareness of the importance of reducing the carbon footprint in healthcare, particularly surgery, over the last few years. In the UK and Ireland, the surgical colleges have released a 'green theatre' checklist to help address this issue.[14] Dividing areas of improvement into four sections (anaesthesia, preparation for surgery, intra-operative practice and post-operative measures), the overarching theme relates to the reduction of single-use equipment, reducing and recycling waste, and mindfulness with instruments and anaesthetic gases.

Our results demonstrate that many instruments on our standard tonsillectomy tray went unused over a six-month

Table 1. Standard tonsillectomy tray with 38 instruments

Tongue blade 4½''	Draffin bipod rods	Denis Brown tonsil forceps	Needle holder 7''
Tongue blade 4''	Yankauer suction tube	Luc tonsil forceps	Diathermy quiver
Doughty tongue blade 4½''	Ball and socket towel clips ×3	Birkett artery straight forceps	Bipolar forceps
Doughty tongue blade 4''	Turn Over End dissecting forcep 5''	Negus artery broad curved forceps	Bipolar lead
Doughty tongue blade 3½''	Waugh dissecting forcep 8'' toothed	Negus artery tight curved forceps	Bulldog clip
Doughty tongue blade 3''	Waugh dissecting forcep 8'' non-toothed	Wilson artery forceps	Used instrument bag
Doughty tongue blade 2½''	McIndoe scissors 7½''	Scott artery forceps	Polypropylene receiver 12''
Boyle Davis gag	Stitch scissors 5''	Negus ligature pusher	Polypropylene gallipot 6''
Asherson gag	Gwynn Evans tonsil dissector	Molluson pillar retractor	Tonsil gauze swabs (15 × 2.5 cm) ×5

https://doi.org/10.1017/S0022215124001129

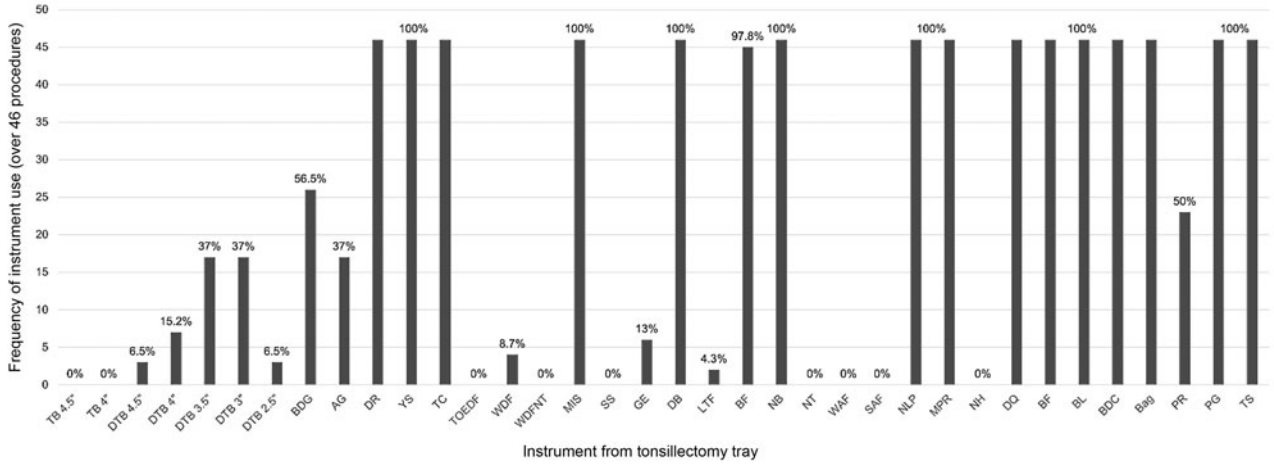

Figure 2. Frequency of use of each piece in the standard tonsillectomy tray across the study period. TB = tongue blade, DTB = Doughty tongue blade, BDG = Boyle Davis gag, AG = Ashersons gag, DR = Draffin bipod rods, YS = Yankauer suction, TC = Ball & socket towel clip, TOEDF = Turn Over End dissecting forcep, WDF = Waugh dissecting forcep, WDFNT = Waugh dissecting forcep non-toothed, MIS = McIndoes scissors, SS = Stitch scissors, GE = Gwynn Evans tonsil dissector, DB = Denis Brown tonsil forceps, LTF = Lucs tonsil forceps, BF = Birkett artery straight forceps, NB = Negus artery broad curved forceps, NT = Negus artery tight curved forceps, WAF = Wilsons artery forceps, SAF = Scotts artery forceps, NLP = Negus ligature pusher, MPR = Mollison pillar retractor, NH = Needle holder 7", DQ = diathermy quiver, BF = Bipolar forceps, BL = bipolar lead, BDC = Bulldog clip, Bag = Used instrument bag, PR = Polypropylene receiver 12", PG = Polypropylene gallipot 6", TS = Tonsil gauze swabs (15 × 2.5 cm).

period. By removing these instruments from the set, and avoiding their unnecessary repeated sterilisation, there is not only a cost saving of €9.63 but also a reduction in greenhouse gas emissions of 594 g of CO_2e. In addition, we found that 15 pieces were used in all tonsillectomies over a 6-month period with a further piece being used in 97.8 per cent of procedures during this time. These 16 pieces therefore serve as the principal instruments of a tonsillectomy procedure at our unit and can be used to help rationalise the tonsillectomy tray. These results are comparable to similar studies in the existing literature. For example, a study in 2021 demonstrated that only 12.5–22.9 per cent of surgical instruments in vascular surgery trays were used over a 3-month period, leading to the removal of 1255 unused instruments. This represented an annual re-sterilisation saving of $97 444.[15] Other studies in the USA have consistently reported that only 13–22 per cent of instruments opened for a surgical procedure were used, with the total cost of re-sterilisation (sterile processing and labour) ranging from $0.51 to $3.01 per instrument.[16,17]

However, it is imperative to consider other factors prior to the removal of instruments from surgical trays. The alteration of instrument trays without consultation with operating surgeons could potentially compromise the safety of the procedure, for example in the case of a complication requiring a rarely used instrument. Moreover, it has been established that counterintuitively, if an instrument is likely to be used even occasionally for a procedure, its retention on the tray might be warranted, as substituting it with a single-use item could lead to increased cost and greenhouse gas emissions.[18,19] The scrub nurses are essential stakeholders as they are often well-acquainted with individual surgeon preferences and can provide suggestions that might not be immediately apparent to task-focused surgeons when faced with difficulties.

One of the limitations of this study was that greenhouse gas emissions and costs were not calculated directly. Instead, we relied on findings from a hospital within the same region. Factors including the method of sterilisation, the size and efficiency of the sterilisation machine, and the carbon footprint of outsourcing may not have been fully considered in the calculation.

This study did not investigate the time savings with smaller surgical trays. Previous studies have shown a reduction of personnel time by removing unused instruments from surgical trays.[15,20] This is intuitive as fewer surgical instruments per tray reduces theatre set-up time, turnover time between cases, time spent sterilising instruments and sterilisation errors. This has the potential to translate to scheduling more surgical procedures per day.[21,22]

Another limitation is that no episodes of post-tonsillectomy bleeding were identified during the period of data collection. Although the identical instrument tray would be used for this procedure, it is likely that more advanced methods of haemostasis may need to be deployed, making use of the 'never-used' instruments. In addition, no data were collected in terms of intra-operative blood loss or surgical procedural time. It may have been the case that all the tonsillectomies performed during this period were straightforward and therefore did not require the use of additional instruments on the tray that may be required during intra-operative complications or difficult procedures. A longer data-collection period may be necessary to overcome this. Despite this, our data do represent all tonsillectomies performed over a reasonable study period (six months), thereby offering a representative snapshot of standard tonsillectomy practice. In addition, because post-tonsillectomy bleeds returning to theatre is a rare occurrence, one could argue that instruments normally used for these cases (such as the needle holder) should be packaged as single-use instruments. More data on the instruments used in such cases are required. Finally, no data were collected for the additional single-packaged instruments used. This could be useful to assess whether instruments that are commonly used could be added to the standard tonsillectomy tray.

Conclusion

Rationalising surgical instrument trays is a simple change that can reduce cost and ameliorate our carbon footprint. By mitigating our carbon footprint, we can reduce the health impacts of climate change on the global population. However, this pursuit should not compromise the quality of patient care. While

https://doi.org/10.1017/S0022215124001129

we have demonstrated potential reductions in cost and greenhouse gas emissions by removing instruments that were never used from the standard tonsillectomy tray, there are other important factors that need to be considered before this is utilised at our unit. Further research is required over a longer time period to fully evaluate a broader sample of tonsillectomies that is more likely to include varying levels of complexity that may require the use of different instruments. It is the hope that this study can therefore act as a pilot to help drive forward research in this area where each unit can implement a similar study to assess local surgeon practice to be able to rationalise their surgical trays on a unit-by-unit basis.

Competing interests. None declared

References

1 Alley R, Berntsen T, Bindoff NL, Chen Z, Chidthaisong A, Friedlingstein P *et al.* Climate change 2007: the physical science basis. Summary for policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: https://cimss.ssec.wisc.edu/climatechange/nav/IPCCreport07.pdf [10 October 2022]

2 Olivier JGJ, Peters JAHW. *Trends in Global CO_2 and Total Greenhouse Gas Emissions*. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency, 2020

3 National Centers for Environmental Information. Annual 2022 Global Climate Report. In: https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202113 [14 August 2023]

4 Karliner J, Slotterback S, Boyd R, Ashby B, Steele K. Health care's climate footprint. Climate-smart health care series green paper number one. Health care without harm, 2019. In: https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf [9 August 2023]

5 Tennison I, Roschnik S, Ashby B, Boyd R, Hamilton I, Oreszczyn T *et al.* Health care's response to climate change: a carbon footprint assessment of the NHS in England. *Lancet Planet Health* 2021;**5**:e84–92

6 Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The carbon footprint of surgical operations: a systematic review. *Ann Surg* 2020;**272**:986–95

7 NHS Digital Hospital admitted patient care activity, 2016–17. In: https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2016-17 [1 August 2023]

8 Rizan C, Lillywhite R, Reed M, Bhutta MF. The carbon footprint of products used in five common surgical operations: identifying contributing products and processes. *J R Soc Med* 2023;**116**:199–213

9 Rizan C, Lillywhite R, Reed M, Bhutta MF. Minimising carbon and financial costs of steam sterilisation and packaging of reusable surgical instruments. *Br J Surg* 2022;**109**:200–10

10 UK Government Department for Environment, Food and Rural Affairs/Department for Business, Energy & Industrial Strategy. GHG Conversion Factors for Company Reporting. In: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019 [8 June 2020]

11 Small World Consulting. *Carbon Factors Dataset Version 1.5*. Lancaster: Small World Consulting, Lancaster University, 2018

12 Jones C, Hammond G. Inventory of carbon and energy v3.0. In: https://circularecology.com/embodied-carbon-footprint-database.html [8 June 2020]

13 Rizan C, Bhutta MF, Reed M, Lillywhite R. The carbon footprint of waste streams in a UK hospital. *J Clean Prod* 2021;**286**:125446

14 Royal College of Surgeons of Edinburgh. Intercollegiate green theatre checklist compendium of evidence, 2022. In: https://www.rcsed.ac.uk/professional-support-development-resources/environmental-sustainability-and-surgery/green-theatre-checklist [1 August 2023]

15 Knowles M, Gay SS, Konchan SK, Deshpande V, Farber MA, Wood BC *et al.* Data analysis of vascular surgery instrument trays yielded large cost and efficiency savings. *J Vasc Surg* 2020;**73**:2144–53

16 Stockert EW, Langerman A. Assessing the magnitude and costs of intraoperative inefficiencies attributable to surgical instrument trays. *J Am Coll Surg* 2014;**219**:646–55

17 Van Meter MM, Adam RA. Costs associated with instrument sterilization in gynecologic surgery. *Am J Obstet Gynecol* 2016;**215**:652.e1–5

18 Thiel CL, Woods NC, Bilec MM. Strategies to reduce greenhouse gas emissions from laparoscopic surgery. *Am J Public Health* 2018;**108**:158–64

19 Sherman JD, Raibley LA, Eckelman MJ. Life cycle assessment and costing methods for device procurement: comparing reusable and single-use disposable laryngoscopes. *Anesth Analg* 2018;**127**:434–43

20 Virginia Mason Institute. Case study: surgical setup reduction improves patient outcomes, 2020. In: https://www.virginiamasoninstitute.org/resource/surgical-setup-reduction-improves-patient-outcomes/ [1 August 2023]

21 Farrokhi FR, Gunther M, Williams B, Blackmore CC. Application of lean methodology for improved quality and efficiency in operating room instrument availability. *J Healthc Qual* 2015;**37**:277–86

22 Heslin MJ, Doster BE, Daily SL, Waldrum MR, Boudreaux AM, Smith AB *et al.* Durable improvements in efficiency, safety, and satisfaction in the operating room. *J Am Coll Surg* 2008;**206**:1083–9