



SusQI project report:

Reducing single-use surgical instruments during laparoscopic appendicectomy: Using sustainable quality improvement as a catalyst to encourage wider behavioural change in a surgical department



Team Members:

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Date of Report: Project completed as part of the Green Surgery competition, 26/04/2021 – 07/07/2021. Updated in June 2022.

Abstract:

Aims: Reduce the carbon footprint of laparoscopic appendicectomies whilst meeting the triple bottom line and instigate lasting behavioural change in the surgical department.

Method and measurement: We performed an audit of 25 consecutive appendicectomies to confirm which single-use instruments were routinely opened and proposed a revised appendicectomy set focused on replacing 5mm ports, 12mm ports, Johann, Maryland and scissors with reusables; and acquired a loan set to trial. Costs of the instruments were provided by the procurement team and annual cost was extrapolated by our audit data. Carbon footprint calculations were conducted using a bottom-up approach. Qualitative social benefit data was collated via staff surveys.

Results: We applied our audit results to represent the 500 laparoscopic appendicectomies performed annually. With an initial cost of £19,730.53 and 47.7 kg CO₂e, investing in reusable will be cost neutral within six months (accounting for sterilisation and lifespan). If purchasing reusable instruments reduced single-use instrument use by 75% (a conservative estimate), we expect to save £34,423 and 512kg CO₂e per year. Socially, over 90% of responders said they would now consider sustainability in their surgical practice and know who to contact if they have ideas to improve surgical sustainability.

Conclusion: We have successfully proposed an updated appendicectomy set that will significantly reduce the carbon footprint of laparoscopic appendicectomies whilst meeting the triple bottom line. We exceeded our second aim by bringing surgical sustainability onto the agenda with results disseminated beyond the surgical department.



The Centre for Sustainable Healthcare would like to acknowledge the Green Surgery Challenge gold sponsors NIHR **1** Surgical MedTech Co-operative and Elemental Healthcare; as well as our partners NIHR Surgical MedTech Co-operative, Royal College of Surgeons of England, Royal College of Surgeons of Edinburgh, Sustainable Healthcare Coalition, Association for Perioperative Practice and Brighton and Sussex Medical School.

Background:

Carbon footprint of surgery:

Surgery is carbon-intensive. Approximately 23% of emissions from surgery are due to the surgical procedure itself¹. Of this, 58% of emissions are attributable to energy consumption and one third to consumables¹. Anaesthetic agents account for 2% of all NHS emissions². Surgical equipment must be produced, transported to site, cleaned/sterilised and disposed of at the end of its life-cycle. Temperature control and ventilation systems make operating theatres 3-6 times more energy intensive than the hospital building average³.

Local context

Our trust declared a climate health emergency in 2020 and has since published its green plan⁴. For trust-wide change to be sustainable, behavioural change must take place at an individual level. As end users, surgeons are best placed to modify surgical consumable usage. We therefore focused on a susQI project aiming to reduce reliance on single-use surgical items.

Revising the appendicectomy set

We chose to revise the laparoscopic appendicectomy set for the following reasons:

- Appendicectomies are common: We perform ~500 appendicectomies per year at our trust. Even a modest reduction in their carbon footprint would result in a significant reduction in emissions.
- Frequent consumable use: Colleagues reported frequently opening disposable instruments during appendicectomies.
- Single procedure set: The set is only used for laparoscopic appendicectomies, making it easier to amend than a set used for multiple procedures.
- Surgeon dissatisfaction: Colleagues had expressed dissatisfaction with the existing set.
- Failing to meet the triple bottom line: Whilst clinical outcomes were good, we suspected that current practice would fare poorly if assessed from a sustainable healthcare perspective.

Specific Aims:

1. Reduce the carbon footprint of laparoscopic appendicectomies whilst meeting the triple bottom line.
2. Instigate lasting behavioural change in the surgical department to increase sustainable surgical practices.

Methods:

We performed a prospective audit to confirm which single-use instruments were being routinely opened. To determine how many appendicectomies to audit, we contacted the Sterilisation & Decontamination Unit (SDU) for baseline data on the seven appendicectomy sets. We settled on a sample size of 25 appendicectomies as this represented 5% of annual appendicectomies performed. To avoid recall bias, audit forms (Appendix 1) were filled in by theatre staff rather than surgeons. Consumables with no reusable alternative (e.g., laparoscopic gas tubing) were excluded.





We engaged colleagues via an informative presentation on sustainable surgery, our trust's climate targets and the Green Surgery Challenge. We wanted to ensure that everyone understood the problem we are trying to solve before proposing solutions. We sent an initial online survey (Appendix 2) to colleagues asking about their current practice and reasons for why they use single-use items. This revealed that over half of surgeons rarely/never use reusable ports, usually due to concerns over trocar sharpness, ports slipping during use, instruments getting caught and air leak. Johann graspers and scissors were the most used single-use instruments; 81% stated that this was because the instrument was not on the set.

We proposed a revised appendectomy set that includes additional reusable instruments and new reusable ports that addressed surgeons' reasons above for not using the existing ports. We acquired a loan set of new reusable ports to trial.

Measurements:

Environmental

To estimate the environmental cost, we carbon-costed the above five items as follows:

1. Deconstructing the instrument and its packaging into its composite materials.
2. Weighing each material.
3. Determining what materials were used. This information was found from multiple sources; on the packaging, emailing companies directly, and academic publications.
4. Emissions factors for each material were taken from the UK government greenhouse gas emissions factors 2021 report⁵ and the Inventory of Carbon & Energy database.⁶ The copper wire emission factor was calculated based on a life cycle analysis from the European Copper Association.
5. Determine the transport route from factory to hospital.
6. Determine the disposal method.⁷ The emission factor for incineration were based on Rizan et al.⁸

Some companies didn't provide information on specifics of their product materials. In this case, we used average plastic emissions factors rather than plastic-specific emissions factors. Some instruments were difficult to fully deconstruct. In this case, we estimated the proportion of metal and plastic in the tools and calculated the emissions based on this.

Financial:

Prices of disposable instruments were provided by the procurement team. Based on the audit results, we estimated an annual cost from five items: 5mm ports, 12mm ports, Johann, Maryland and scissors during appendectomies. Cost of reusable instruments was obtained via a quote from a representative of the manufacturer (B Braun). SDU confirmed that these additions would not increase the size of the set tray, thereby not increasing the environmental cost of sterilising the set.



Social:

An appendectomy set survey (Appendix 3) was sent for opinions from colleagues which showed only 50% of surgeons were satisfied with the current set. They reported regularly opening disposable Johann graspers, ports and suction. Twelve responders listed additional instruments they would like to see included. The survey found strong support for susQI projects.

Results:

Environmental and financial savings

The audit found that 110 single-use instruments were opened in 25 appendicectomies. Ports and Johann graspers opened in every case. Scissors were opened in 28% and Marylands in only 4% of cases, likely because one set was missing a Maryland and one set had scissors out for repair during the audit. Contrary to our survey of practice, disposable suction was rarely opened (4% of cases). By multiplying the results by 20 (to represent the 500 laparoscopic appendicectomies performed annually), we estimate that 2180 single-use instruments and ports are used per year, costing £49,656 and 692kg CO₂e.

The total investment cost for reusable items and ports is £19,730.53 and 47.7 kg CO₂e. SDU. The expected port lifespan is 500-700 uses according to the company. If we replace the ports in our seven appendicectomy sets, we expect them to be used for a minimum of 3500 appendicectomies over seven years. If we make no changes to current practice, in seven years we would expect to use 15,260 consumables costing £347,592 and 4.85 tonnes CO₂e.

Based on the cost of single-use items currently being used, this capital investment for ports and additional reusable instruments will pay for itself within six months. If purchasing reusable instruments reduced single-use instrument use by 75% (a conservative estimate), we expect to save £240,963 and 3.59 tonnes CO₂e over seven years (£34,423 and 512kg CO₂e per year) (Table 1). The above estimate does not include the small additional saving gained from preventing the incineration of 0.79 tonnes of consumables over the seven years.

Table 1: Estimated financial and environmental savings from proposed changes to appendicectomy set (presuming 75% reduction in consumable use).

Reusable items	Quantity	Uses	Financial cost (£)	kg CO ₂ e cost
Reusable 12mm port + accessories	7	2625	£5023.27	6.61
Reusable 5mm port + accessories	14	2625	£5,135.75	10.05
Reusable Johanns	7	2625	£5,895.89	18.01
Reusable scissors	1	2625	£998.23	2.53
Reusable Maryland	1	2625	£1,563.69	2.50
Mayo needle holder	7	2625	£400.68	2.35
Large Langenbecks	14	2625	£713.02	5.63





Single use items	Quantity	Uses	Financial cost (£)	kg CO ₂ e cost
12mm port	910	1	£20,748.00	295.5
5mm port	1715	1	£20,580.00	299.1
Johanns	910	1	£38,220.00	459.1
Scissors	245	1	£5,880.00	116.4
Maryland	35	1	£1,470.00	41.2
Total cost over seven years			£106,628.53	1259.0
Total savings over seven years			£240,963.47	3586.2
Total savings per year			£34,423.35	512.3 kgCO₂e

To put this saving into context, we estimated annual CO₂e emissions attributable to our theatres to be 4479 tonnes CO₂e, based on floor area and previous research². To meet our trust target (20% reduction in carbon footprint by 2025), theatres must reduce annual emissions by 895,800kg. This appendectomy set change will account for 0.06% of changes required within the next four years.

Clinical and Health outcomes:

Whilst the project is unlikely to directly improve health outcomes for patients, it contributes to health outcomes indirectly by reducing Scope 1 emissions related to the volume of waste being incinerated on site. This reduces air pollution in our local area with health benefits for patients, staff and the public.

Social sustainability:

A staff survey (Appendix 4) found almost all surgeons felt they had a much greater understanding of the impact of surgery on carbon emissions, how carbon costing is calculated, and how our trust's targets apply to theatres. Over 90% of responders said they would now consider sustainability in their practice and know who to contact if they have ideas to improve surgical sustainability.

Barriers encountered:

Initial engagement from theatres was challenging due to incorrect belief that sets had been recently updated. There had also been a recent failed trial of part-reusable ports. The project was able to demonstrate that the existing reusable ports were being avoided due to poor function, that an alternative was available, and that other essential equipment was missing from the sets.

Due to time constraints, we were not able to complete feedback from the surgeons on the new ports during the project phase. Since this time, we have collated feedback demonstrating 100% of 13 responders were either satisfied or very satisfied with the new ports. We submitted a business case which was accepted, reusable instruments have been purchased, and are currently being put into the appendectomy sets (April 2022). We plan to close the audit loop to demonstrate the reduction in single use instrument consumption once the sets are in circulation.





Conclusions:

We have successfully proposed an updated appendicectomy set that will significantly reduce the carbon footprint of laparoscopic appendicectomies whilst meeting the triple bottom line. The set will be updated once feedback on the new ports is completed. The Green Surgery Challenge allowed us to take a conceptual problem (carbon emissions from surgery) and demonstrate how our individual practice directly impacts this problem.

We exceeded our second aim of instigating behavioural change in the surgical department. The project has pushed surgical sustainability onto the agenda with results disseminated beyond the surgical department. Team members now have sustainability management roles to ensure lasting change, embedding sustainability into the organisation. The project has led to changes in theatre energy management and surgeon representation on the sustainability committee.

The project had huge interest from other departments in the trust resulting in the following repercussions:

- Presenting our findings to the trust board.
- Colleagues are updating other surgical sets; for example, the upper GI surgeons are revisiting the laparoscopic cholecystectomy set - another high frequency procedure with frequent use of disposable ports.
- Shutting down the air conditioning systems in elective theatres overnight is being discussed, potentially reducing energy usage by up to 1/3. This change alone could allow us to meet our 2025 target given the contribution of energy to emissions.
- Our hospital is scheduled to be rebuilt. As a result of the Green Surgery Challenge results being presented to the trust board, one team member has been asked to join the new Sustainability Committee, reporting to the Future Hospital Committee and ensuring that the new hospital will meet our climate obligations.





References

1. Whiting A, Tennison I, Roschnik S, Collins M. Surgery and the NHS carbon footprint. Bull R Coll Surg Engl. 2020 Jul;102(5):182–5.
2. NHS England and NHS Improvement. Delivering a ‘net zero’ National Health Service. 2020.
3. MacNeill A, Lillywhite R, Brown C. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. Lancet Planet Health. 2017;1(9):E381–8.
4. University Hospitals Plymouth NHS Trust. For a greener future: Our sustainable development green plan 2020 - 2025 [Internet]. Plymouth; 2020 [cited 2021 Jun 27]. Available from: <https://www.plymouthhospitals.nhs.uk/environment-group>
5. Department for Business, Energy & Industrial Strategy. Greenhouse gas reporting: Conversion factors 2021 [Internet]. 2021 [cited 2021 Jun 28]. Available from: <https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting>
6. Circular Ecology. Inventory of Carbon & Energy (ICE) database V3.0 [internet]. 2019 [cited 2021 Jun 28]. Available from: <https://circularecology.com/embodied-carbon-footprint-database.html>
7. European Copper Institute. Copper life cycle assessment data for copper wire [internet]. 2021 [cited 2021 Jun 28]. Available from: http://copperalliance.eu/uploads/2018/01/lca_copper_wire_2707.pdf
8. Rizan C, Bhutta M, Reed M, Lillywhite R. The carbon footprint of waste streams in a UK hospital. J Clean Prod 2021; 286: 125446.





Appendix 1: Appendicectomy audit data collection form

Date		Patient hospital number	
Additional kit opened		Yes/No	Quantity
12mm disposable ports		Y / N	
5mm disposable ports		Y / N	
Disposable Johanns		Y / N	
Disposable Maryland		Y / N	
Disposable scissors		Y / N	
Disposable suction		Y / N	
Other (please specify):			
Other (please specify):			

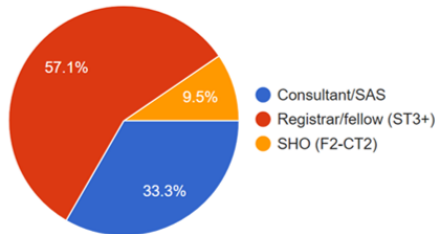




Appendix 2: Surgeon habits for using laparoscopic ports, and self-reported reasons why surgeons use single-use ports and instruments and support for sustainable surgery SusQI projects

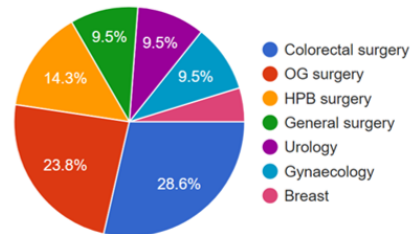
Please select your grade/position

21 responses



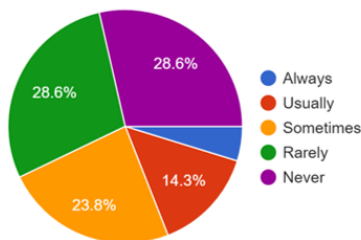
Please select your primary specialty

21 responses



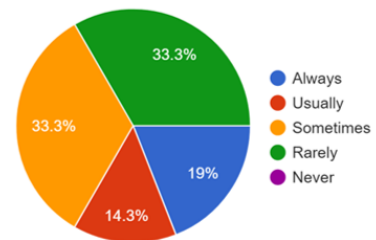
Do you ever use the reusable (metal) ports?

21 responses



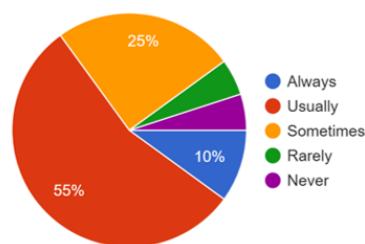
Do you ever use the single use balloon ports?

21 responses



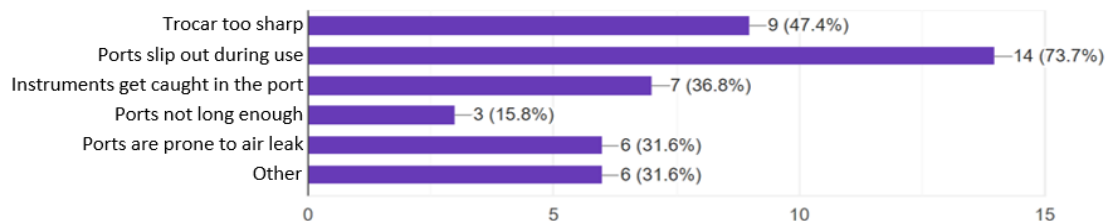
Do you ever use the single use standard (non-balloon) ports?

20 responses



If you do not regularly use the reusable (metal) ports, why? (tick all that apply)

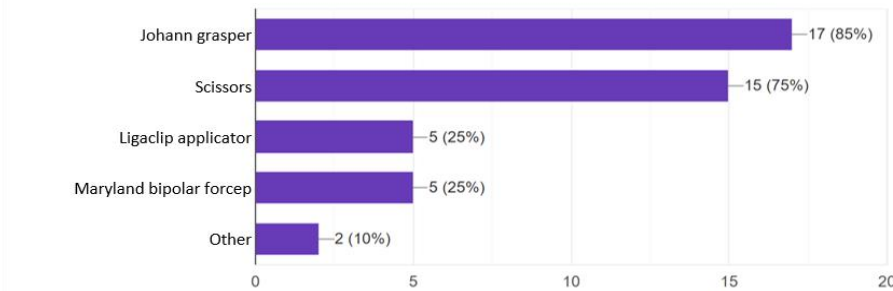
19 responses





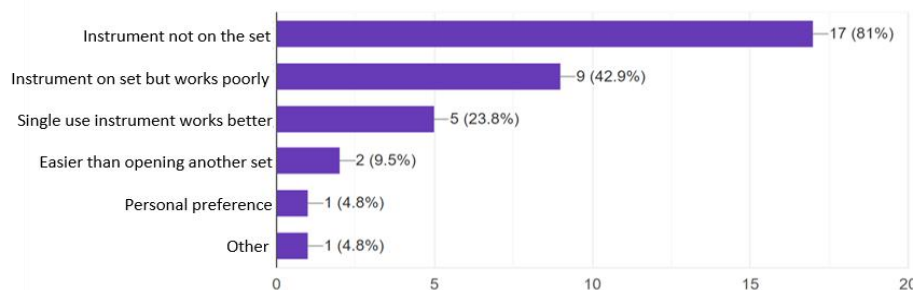
Which laparoscopic instruments do you have to regularly open during cases? (tick all that apply)

20 responses



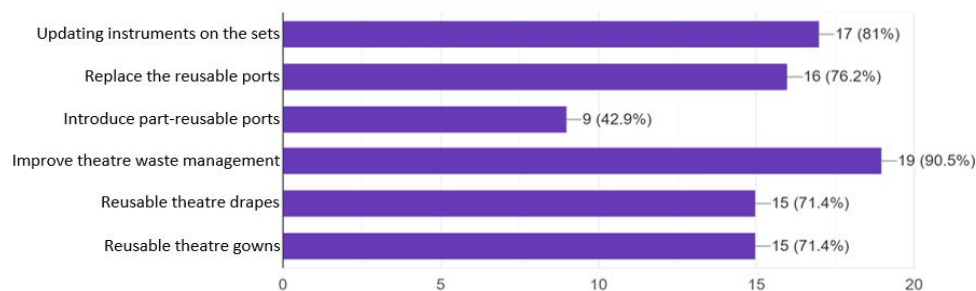
If you regularly open single use laparoscopic instruments, what are your reasons for doing so?

21 responses



Please select which of the following projects/suggestions you would be happy for the department to explore further (ensuring that all surgeons were involved in any proposed changes).

21 responses



Do you have any further suggestions regarding improving theatre sustainability?

3 responses

I fell like an environmental terrorist every time I do a list. The amount of plastic waste is horrifying. Plastic jugs, plastic speculums, disposable ligatureclips, disposable scissors, warming blankets and tubing etc etc

We are always attempting to make Caesarean packs more environmentally friendly - no excess equipment opened "just in case"

Foot control for water while scrubbing. The gallons of water wasted during scrubbing for an operation is criminal.

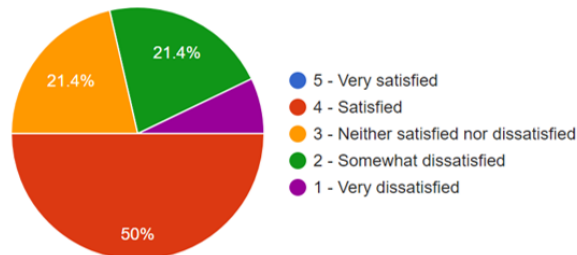




Appendix 3: Appendectomy set survey

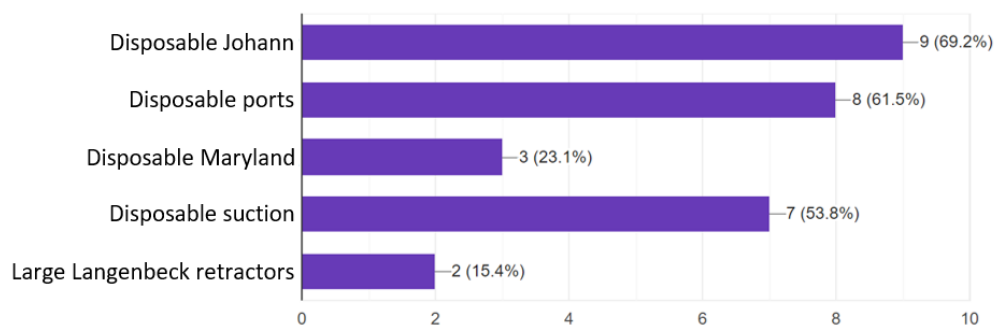
How satisfied are you with the existing appendicectomy set?

14 responses



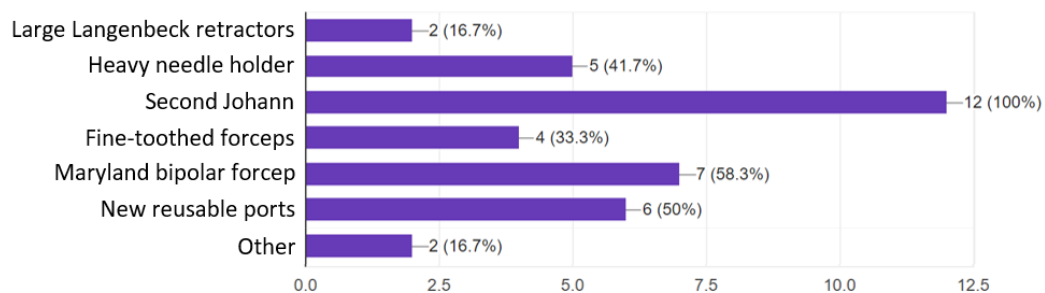
What items of equipment do you regularly need to open because they are either not provided on the set, or are provided but do not work well?

13 responses



Which additional/replacement items would you like to see on the set?

12 responses

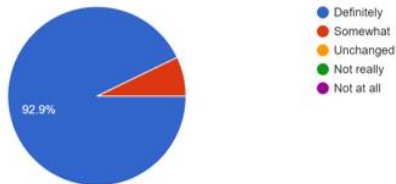




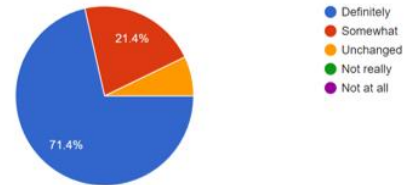
Appendix 4: Feedback following presentation to the surgical department on results of the project

As a result of the Green Surgery Challenge project:

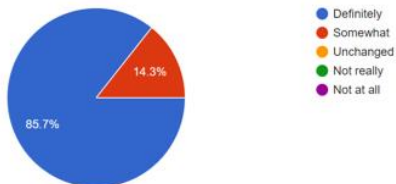
Are you more aware of the impact of surgery and theatres on carbon emissions?
14 responses



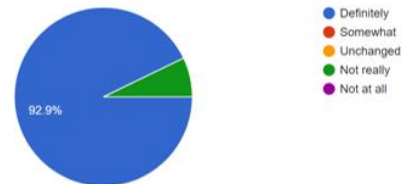
Do you have a better understanding of how carbon costing is calculated?
14 responses



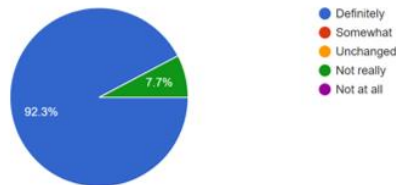
Do you have a better understanding of the Trust's emissions targets and how these apply to our department?
14 responses



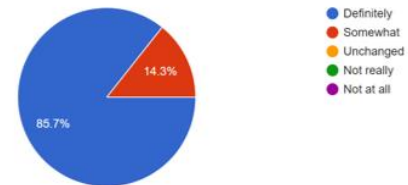
Are you more likely to consider the sustainability of your current surgical practice?
14 responses



Are you more likely to consider sustainability as one of the relevant factors when considering changes to your future practice (as well as clinical/financial)?
13 responses



If you had an idea to improve surgical sustainability in the department, do you know who you could approach to take your idea forward?
14 responses



Any comments?

4 responses

Very informative presentation championing a very vital issue in surgery

Excellent and enlightening.

Inspiring project/challenge - very impressed and keen to help as able!

Superb presentation and valiant effort. Green surgery is definitely the way forward for the future, as part of the country's (and global) effort to combat climate change.

