SUSQI PROJECT REPORT

Norwich Hand Unit Greener Surgery Project

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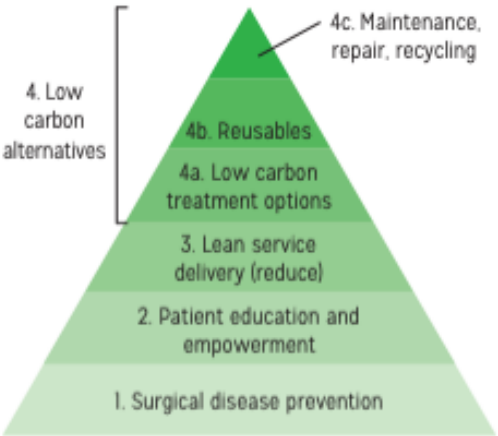
Background:

In October 2020, the NHS became the first national health service to pledge to become carbon neutral. The NHS is directly responsible for 22.8 million tonnes of CO2 per year, a staggering 4-5% of the UK's total net CO2e emissions. This is equivalent to the total annual emissions of Croatia, a mammoth task to offset by 2040[1]. One of the largest contributors to the NHS' carbon footprint are operating theatres. Surgical activity generates between 20-30% of total hospital waste and is 3 to 6 times more energy-intensive than any other hospital department[2].

The principles of surgical sustainability, adapted by Rizan et al.[3], provides a hierarchical description of the interventions required for a surgically sustainable NHS (Figure 1).

Figure 1: Principles of surgical sustainability



Single-use surgical instruments are one of the most carbon-intense products used within healthcare and 'overage', a term given to the number of unused yet open or prepared items in an operation[4], is a significant problem. Studies have shown that standardising surgical sets and improving surgeons awareness of routinely opened sets/items can lead to substantial reduction in both materials and cost[5]. For example, in the case of paediatric surgery[6], the rationalisation approach led to the removal of 1826 instruments (a 39.5% reduction), saving the processing of 45,856 instruments annually and eliminating nine trays from regular rotation. The 'just in case 'mindset produces numerous unused sterile instruments, gloves and swabs.

Reusable surgical instruments, lines and preoperative equipment have a lower carbon footprint than their single-use equivalents, even with the consideration of sterilisation and laundering in the UK[4]. A six-month pilot study by Agarwal et al.[7] found that switching to reusable surgical headwear reduced carbon emissions by 11 kg CO_2e per user. Moreover, a recent systematic review[8] demonstrated that reusable headwear performs equivalently to disposable alternatives in terms of surgical site infection (SSI) rates.

Post-operative care is an often under-recognised contributor to healthcare's environmental impact. Applying principles of resource stewardship, particularly in prescribing and supply practices, offers significant opportunities to reduce unnecessary waste. Routine discharge prescribing opioids in ambulatory orthopaedic and plastic surgery procedures exemplifies this issue. In a study of over 4,000 patients, 65% of orthopaedic and 62% of plastic surgery patients had not used any opioids by postoperative day one, highlighting substantial overprescribing and associated pharmaceutical waste[9].

This project was initiated to reduce environmental impact, improve cost efficiency, and maintain high standards of patient care within our surgical service. This project was undertaken within the Norwich Hand Unit, involving the entire multidisciplinary team. Approximately 240 cases are undertaken each month with around 7 staff per day, per Ambulatory Procedure Unit (APU) theatre. This team was well-placed to deliver change due to its cohesive structure, prior engagement with sustainability efforts, and alignment with organisational priorities.

Several practices were identified as resource-intensive with limited clinical benefit, including:

- Use of large, non-streamlined sterile packs.
- Use of visor masks, which are more expensive and often unnecessary.
- Inefficient scrubbing practices (water-based rather than sanitising gel).
- Daily use of single-use surgical hats.
- Oversized surgical sets.
- Routine prescribing of paracetamol and ibuprofen post-operatively.
- Routine distribution of bottled water post-operatively.

These practices contribute to significant financial costs, unnecessary waste generation, and carbon emissions. Literature supports sustainable healthcare initiatives as key to reducing healthcare's environmental footprint while maintaining safety and quality.

Specific Aims:

Scrubbing Up:

- **Hats:** Replace single use disposable hats with reusable hats
- **Visor Masks:** Replace use of masks with attached visors for standard masks, as visors are not clinically indicated (and often ripped off / thrown away before use of mask)
- **Sterile Packs:** Sterile packs contain the elements to create sterile field and carry out procedure. We aimed to streamline the sterile packs to reduce size and wasted sterilisation cycles for unused instruments.
- **Reusable Gowns:** Replace single use gowns with reusable gowns
- **Scrubbing:** Transition scrubbing practice to use sanitising gel.
- **Surgical Sets:** Our surgical sets contain reusable instruments. We reviewed and aimed to downsize surgical sets to reflect actual use to reduce unnecessary sterilisation of unused instruments

Post Operatively:

- **Bottled Water:** Eliminate routine bottled water provision post-operatively
- **Medications:** Cease routine prescription of paracetamol/ibuprofen post-operatively.

Methods:

Interventions and implementation:

Scrubbing Up:

- **Hats:** Planning phase underway, with charitable funds identified for procurement. Staff engagement is ongoing to ensure compliance and understanding of washing procedures. For some staff, they will take their hats home to wash along with their uniforms. For others who wear hospital scrubs, their hats will be laundered by the hospital.
- **Visor Masks:** Unnecessary visor masks were removed, with staff education delivered through presentations and meetings highlighting their costs and environmental impact. We cost compared to other masks, and new masks that were an option on the ordering procurement system have been ordered.
- **Sterile Packs:** Collaboration with procurement to redesign and reduce pack size. Progress was slow due to multiple layers of approval required. However, a pilot was instigated with no issues reported from staff.
- **Scrubbing:** Adoption of sanitising gel has been implemented for all but the first scrub, significantly reducing water usage and improving efficiency.
- **Surgical Sets:** Review initiated to match set size to actual usage, aiming to reduce unnecessary sterilisation for equipment that has been opened but not used. We are initiating conversations with sterile services to look at feasibility to move forward with this project. Reducing size of the sets will allow more sets to be sterilised within one cycle.

Post Operatively:

- **Bottled Water:** Post-operatively patients are offered drinks to recover from surgery. An audit revealed 144 bottles used monthly at £1.25 each (£180/month). The sink by theatres was reviewed and deemed safe as drinking water and existing reusable jugs were reallocated to

the department. Bottled water was therefore stopped entirely, replaced with refillable water jugs and single use drinking cups. We will explore options to replace these with reusable cups in the future.

- **Medications:** Routine post-operative prescribing of paracetamol/ibuprofen was stopped, as most patients already had supplies at home or could easily obtain them. When booking patients electively they were counselled pre-operatively to obtain further analgesia (OTC) over-the-counter medications prior to surgery. No negative feedback or increase in complications was reported.

Engagement: The entire Norwich Hand Unit was involved throughout the process. Staff engagement was achieved through awareness campaigns, team meetings, and presentations. Feedback mechanisms were used to ensure all voices were heard and supported.

Resources: Minimal upfront costs except for reusable hats (coming from charitable funds), Education delivered internally, Procurement and estates supported implementation.

Learning: No interventions have failed to date. All changes implemented or planned have been accepted without complication. Two projects are ongoing – reusable hats and surgical sets.

Measurement:

Patient outcomes:

There are no changes to patient care or outcomes anticipated. Standards of care remain fully compliant with national guidelines. We have continued to monitor complications and adverse incidents, as well as patient feedback and readmission data.

Population outcomes:

While not measured, there are potential population benefits through reduced environmental burden and improved resource allocation. Potential cost savings may allow reinvestment into patient care.

Environmental sustainability:

Scrubbing Up

- **Hats:** Has not been calculated as part of this project as not all data was available, and project is ongoing.
- **Visor Masks:** The GHG emissions associated with a visor and mask has been taken from Rizan et al. 2021.
- **Sterile Packs:** GHG emissions for both the current and streamlined sterile packs were estimated using a bottom-up, process-based approach. This assessment included emissions from primary material production, packaging material production, transportation, and end-of-life disposal. Material weight and composition were converted to GHG emissions using emission factors from the 2025 DESNZ database. Transport emission factors were sourced from the same database, while disposal emission factors were taken from Risan et al. (2020). The current sterile packs are estimated to generate 4.70 kgCO2e per pack, while the streamlined pack 1.81 kgCO2e per pack, a saving of 2.89 kgCO2e per pack.
- **Reusable Gowns:** GHG emissions for a reusable gown were sourced from a previous CSH project, where they had been calculated using a bottom-up approach. In the absence of site-

specific laundering data, laundering emissions were based on figures reported by Rizan et al. 2023, with transport emissions adjusted to reflect NNUH's laundry location. For the disposable surgical gown, the emission factor was taken from Rizan et al. 2021.

- **Scrubbing:** Water use per scrub was estimated at 30 litres, as provided by the teams. Using data from the RCS Green Theatre Checklist, heating water to 41°C via a gas-heated system was estimated to produce approximately 8.4 kg CO_2e per m^3. This factor was applied to convert water and gas consumption into GHG emissions per case, assuming three scrubs per case. Emissions from hand gel use were excluded, as they were assumed to be equivalent to those from the hand wash used during scrubbing.
- **Surgical Sets:** Has not been calculated as part of this project as not all data was available, and project is ongoing.

Post Operatively:

- **Bottled Water:** An audit revealed 144 bottles used monthly. GHG emissions of a 500ml water bottle has been sourced from What Is The Carbon Footprint Of A Plastic Bottle? and is estimated to be 82.3 grams CO2e per bottle.
- **Medications:** GHG emissions associated with pharmaceuticals were estimated using an Environmentally Extended Input-Output Analysis (EEIOA). The financial cost of paracetamol and ibuprofen were adjusted to 2022 prices using the UK Bank of England inflation rate, and then converted into GHG emissions using the 2022 UK Government Standard Industrial Classification (SIC) emission factor for pharmaceuticals.

Economic sustainability:

Scrubbing Up

- **Hats**: We have reviewed cost of ordering hats through one supplier and are raising charitable funds
- **Visor masks:** Costs were obtained via the theatre consumables team.
- **Sterile Packs and gowns:** Costs were obtained via the theatre consumables team.
- **Scrubbing**: Costs were obtained via the theatre consumables team and sustainability team – cost of gas per kWh is £0.04 and water per m3 is £0.90.
- **Surgical Sets:** Data is not available.

Post operatively

- **Water Bottles:** Individual price from the supplier Serco was provided.
- **Medications**: The pharmacy provided a breakdown of cost of TTOs.

Social sustainability:

Impacts on patients and staff were considered throughout the project. Staff were engaged in all changes and encouraged to give feedback. While not formally measured, staff feedback and anticipated impacts are outlined in the results section.

Results:

Patient outcomes

There have been no impacts on patient safety, with no complications or adverse events reported. There were no returns to hospital related to these changes. Feedback and readmission data indicate no negative impact on patient care.

Environmental sustainability.
Annual GHG emissions for visors and masks, sterile packs and gowns are based on an average of 7 procedures per day in 2 theatres for 20 sessions a month. This is use of approximately 3,360 sets, and 10,080 masks and gowns (average of 3 staff per procedure) per year.

We have assumed prevention of an average of 6 scrubs for 3 people a day in each theatre (the first scrub of the day will still be required). This is a saving of 720 scrubs per month (8,640 per year) saving approximately 540L of heated water per day in theatres.

Medication and bottled water reductions were estimated using procurement data. We provided 380 packs of paracetamol and 251 packs of ibuprofen in the last financial year and provided approximately 1,728 water bottles.

Project	Implemented (Y/N)	Annual GHG emission savings (kgCO2e)
Scrubbing up		
Reusable hat	N	Savings not calculated as part of project
Reduction of visors and masks (3 scrubs per case)	Y	2,530
Streamlining sterile packs	Y	9,716
Reusable gowns (3 scrubs per case)	Y	6,104
Scrubbing: adoption of alcohol base gel to replace traditional scrubbing after the initial first scrub of the day (3 scrubs per case)	Y	2,177
Surgical sets	N	Savings not calculated as part of project
Post operative		
Medications	Y	193
Bottled water	Y	111
Total savings of implemented projects		20,831

Over the coming year, an estimated reduction of **20,831 kgCO_2e** is projected as a result of recent sustainability improvements. This is equivalent to driving 61,286 miles in an average car. Significant environmental benefits are expected from reductions in plastic, textile, and packaging waste—driven by changes to bottled water, visor masks, hats, and product packs. Furthermore, the introduction of

sanitising gel is anticipated to lower water consumption and reduce the associated environmental impact.

Economic sustainability:
Scrubbing Up:

- **Hats**: Financial impact not yet available
- **Visor Masks**: Cost Saving predicted for both theatres £630.96 per year.
- **Sterile Pack and gowns**: Cost saving is £8.43/pack, equating to £28,324.80 per year
- **Scrubbing**: Reducing water usage will save £0.23 per case, saving £672.19 per year.
- **Surgical Sets**: Financial impact not yet available.

Post Operatively:

- **Bottled Water**: £2,160 per year
- **Medications**: £914.36 per year

Overall the projected financial saving is £32,702 per year.

This figure does not account for efficiency savings from reduced staff time required and improved workflow. For example, using hand disinfectant instead of a full scrub saves an average of 4.5 minutes per staff member per scrub. Saving an average of 720 scrubs per month is therefore a time saving of 54 hours in just one month. The supplier of our hand disinfectant estimates that organisations can save over €1.2 million (£1.04 million) from staff time savings, water savings and equipment (water filters, brushes and sterile towels), based on 10,000 procedures per year.

Social sustainability:
There have been no disruptions to patient experience.

There has been positive staff feedback and improved morale. Staff report improved awareness of environmental issues indicating greater understanding of environmental responsibility. Sustainable practices have been embedded into team culture. As mentioned above, there is potential for time and efficiency savings for staff, with the change of scrubbing to hand disinfectant alone saving approximately 648 hours per year (81 8-hour shifts).

Discussion:
This project demonstrates that significant cost and environmental benefits can be achieved without compromising safety or standards of care. Key factors contributing to success included whole-team engagement, structured education, and clear communication.

Challenges were encountered during implementation. Procurement delays and time for Trust sign off slowed progress on streamlining packs, although this did not prevent implementation. For TTO packs, patient expectations at discharge initially presented a barrier. Education and reassurance for patients, alongside staff engagement at all stages of the process, proved effective. Pre-operative discussions in the Emergency Department also supported this by advising patients about analgesia early in their pathway.

For visors, there were initial concerns about whether the reusable product offered equivalent quality. These concerns were largely resolved through staff education. Bottled water changes were implemented smoothly with no issues reported. Surgical sets and hats remain ongoing challenges. Progress with hats is dependent on securing charity funding, while barriers for surgical set redesign include communication with the sterilisation department, uncertainty regarding costing processes, and limited awareness among surgeons about set contents.

Several interventions, such as the introduction of reusable hats, visors, prep solution, and sterile packs, could be scaled up and implemented across all theatre specialities within the Trust.

Future plans include:

- Introducing reusable hats and monitoring their impact.
- Continuing the surgical set review, with a focus on reducing unnecessary sterilisation cycles, completing set redesign, streamlining equipment, and fully implementing changes.
- Sharing learning with other surgical units to encourage wider adoption.

Conclusions:

This initiative has delivered substantial financial and environmental benefits while maintaining high standards of patient care.

Key successes include:

- No complications or negative outcomes.
- Strong staff engagement.
- Transferable model for other units seeking similar gains.

Next steps will focus on sustaining improvements, expanding initiatives, and quantifying total CO2e and cost savings for reporting and organisational planning.

References

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Appendix: Table Results

Table 1: GHG emissions of paracetamol and ibuprofen packs

	Cost (2025)	Cost (2022)	Carbon emissions per pack (kgCO2e)	Amount supplied per year (24-25)	Cost per year (£)	GHG emissions per year (kgCO2e)
Paracetamol	1.64	1.44	0.35	380.00	623.20	131.66
ibuprofen	1.16	1.02	0.25	251.00	291.16	61.51
Total					*914.36*	*193.17*

Table 3: Summary

	GHG emissions per pack (kgCO2e)	Cost per pack (£)
Orthopadeic hand pack	4.70	12.47
APU minor hand pack	1.81	4.04
Difference	*2.89*	8.43

Number of orthopeadic hand packs switched to APU minor hand packs per year	500.0
GHG emissions savings per year (kgCO2e)	1,445.8
Cost savings per year (£)	4,215.0

Table 1: Annual savings by switching from single use to reusable gowns

Number of single use gowns used per year	500
GHG emission saving per year of switching to reusable (kgCO2	302.76

Table 2: GHG emissions per gown

	GHG emissions per use (kgCO2e)
Reusable surgical gown	0.299
Disposable surgical gown	0.905
Difference	*0.606*

Critical success factors
Please select one or two of the below factors that you believe were most essential to ensure the success of your project changes.

People	Process	Resources	Context
☐ Patient involvement and/or appropriate information for patients - to raise awareness and understanding of intervention X Staff engagement ☐ MDT / Cross-department communication ☐ Skills and capability of staff X Team/service agreement that there is a problem and changes are suitable to trial (Knowledge and understanding of the issue) ☐ Support from senior organisational or system leaders	☐ clear guidance / evidence / policy to support the intervention. ☐ Incentivisation of the strategy – e.g., QOF in general practice X systematic and coordinated approach ☐ clear, measurable targets ☐ long-term strategy for sustaining and embedding change developed in planning phase X integrating the intervention into the natural workflow, team functions, technology systems, and incentive structures of the team/service/organisation	X Dedicated time ☐ QI training / information resources and organisation process / support ☐ Infrastructure capable of providing teams with information, data and equipment needed ☐ Research / evidence of change successfully implemented elsewhere ☐ Financial investment	☐ aims aligned with wider service, organisational or system goals. ☐ Links to patient benefits / clinical outcomes ☐ Links to staff benefits X 'Permission' given through the organisational context, capacity and positive change culture.