The Intraoperative Carbon Footprint of Burn Surgery

The first prospective, case-level analysis of intraoperative carbon emissions in burn surgery

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Background

Healthcare accounts for roughly **4–5% of global greenhouse-gas emissions**, and operating theatres are disproportionately carbon-intensive, consuming three to six times more energy than other hospital areas and generating high volumes of single-use waste.

Burn surgery is especially resource-intensive due to repeated debridement, grafting, dermal substitutes, advanced dressings, warming devices and prolonged theatre time. Despite this, **its carbon footprint had never been quantified at case level**.

Aim

To deliver the **first prospective, case-level quantification** of intraoperative carbon emissions in burn surgery, and to identify the key, potentially modifiable, drivers of those emissions.

Methods

Prospective observational study at a single UK regional burns centre (July 2025 – January 2026), including all consecutive adult and paediatric operative burn cases. For each procedure, the recorded TBSA, procedure type, operative duration, anaesthetic modality, ventilation, warming-device use, and consumable was noted.

Emissions were calculated in **kg CO_2e** using published life-cycle assessment data and NHS emission factors (100-year global warming potentials). Theatre energy used a high-intensity burn-theatre factor of 25 kg CO_2e/operative hour; TIVA was modelled at 3 kg CO_2e/hour. Total per-case emissions summed anaesthetic, ventilation, energy, warming and consumable sources.

Non-parametric tests compared groups (Mann–Whitney U). Simple linear regression assessed the TBSA–emissions relationship; multivariable regression identified independent predictors (TBSA, operative duration, grafting, advanced single-use adjuncts). Significance: **$p < 0.05$**.

Results

52 procedures analysed : 49 adults, 3 paediatric (30 male, 22 female). Burn size ranged **0.2–85% TBSA** (median 2.25%; right-skewed). Median operative duration 51 min (range 15–330). Debridement in all 52 cases; skin grafting in 39.

Emissions Scale with Burn Size

Mean intraoperative footprint was **158 kg CO_2e per case** (range 40–875). Emissions rose linearly with burn size **[+9 kg CO_2e per 1% TBSA]** with TBSA alone explaining 75% of the variance ($R^2 = 0.75$, $p < 0.001$). Grafting cases had higher absolute emissions, but not when normalised to burn size ($p = 0.81$): severity, not grafting per se, drives emissions.

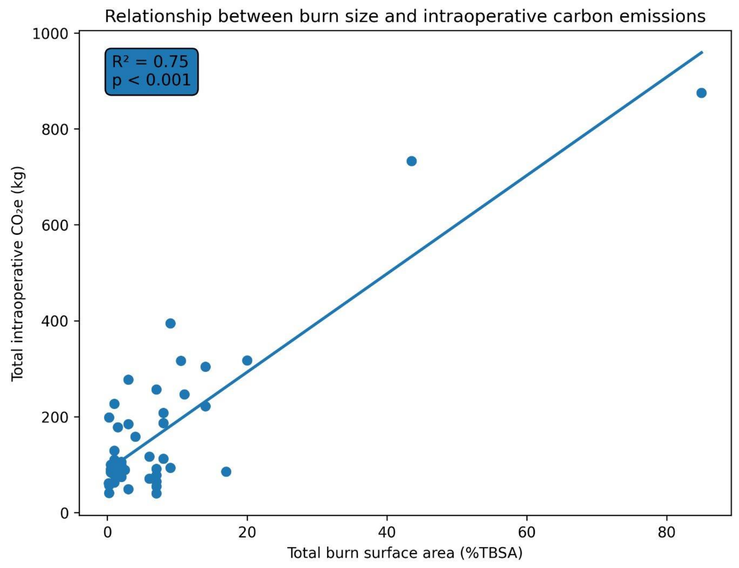

FIGURE 1. *Intraoperative emissions against total burn surface area (%TBSA). Each 1% TBSA adds ≈9 kg CO_2e ($R^2 = 0.75$, $p < 0.001$).*

Where Emissions Arise

Single-use consumables dominated, contributing **67% of total emissions**, followed by theatre energy (20%) and anaesthesia (13%). High-volume gauze, dressings, gowns, drapes, gloves and advanced adjuncts account for most of this embodied

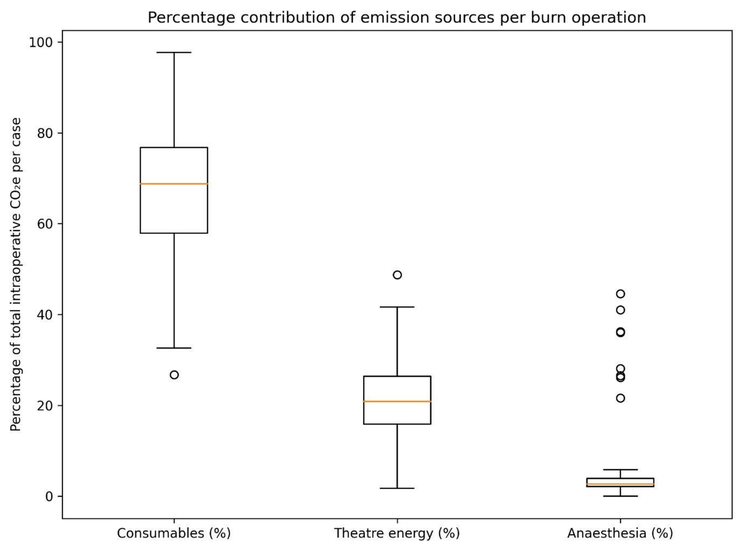

FIGURE 2. *Percentage contribution of consumables, theatre energy and anaesthesia per case (median, IQR, range).*

Independent Predictors

On multivariable analysis, **TBSA ($p < 0.001$)** and **operative duration ($p < 0.01$)** remained independent predictors. **Fibrin sealant kits** stayed significant after adjustment ($p < 0.01$); a material-related carbon burden distributed across all burn sizes. Autologous skin-cell suspension and BTM lost significance after adjustment, suggesting their effect is mediated by case complexity.

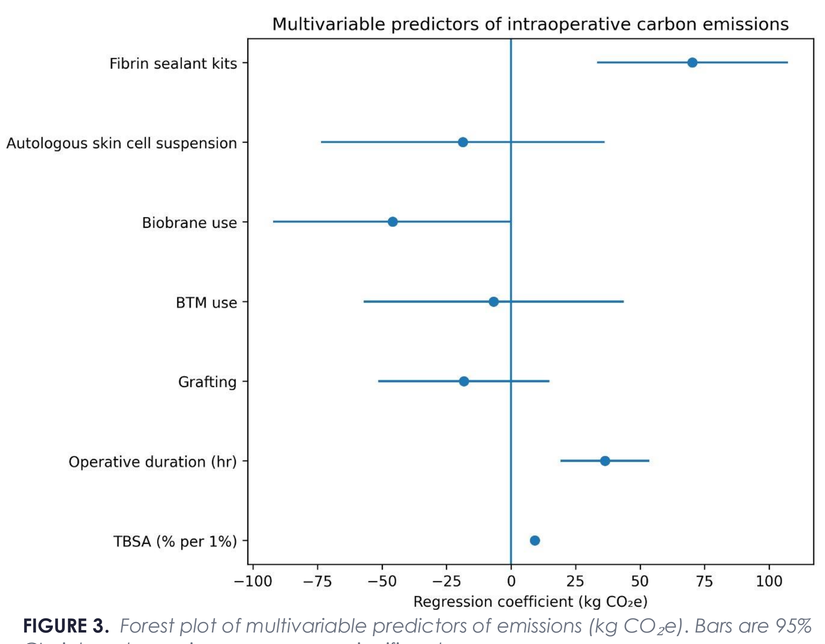

FIGURE 3. *Forest plot of multivariable predictors of emissions (kg CO_2e). Bars are 95% CIs; intervals crossing zero are non-significant.*

A Tangible Benchmark

On average, one burn operation generated emissions equivalent to **≈800 miles of petrol-car travel**. Burn surgery thus exceeds laparoscopic surgery (20–60 kg), is comparable to caesarean section or joint replacement (100–300 kg), and at its upper range approaches cardiac surgery (450–800 kg).

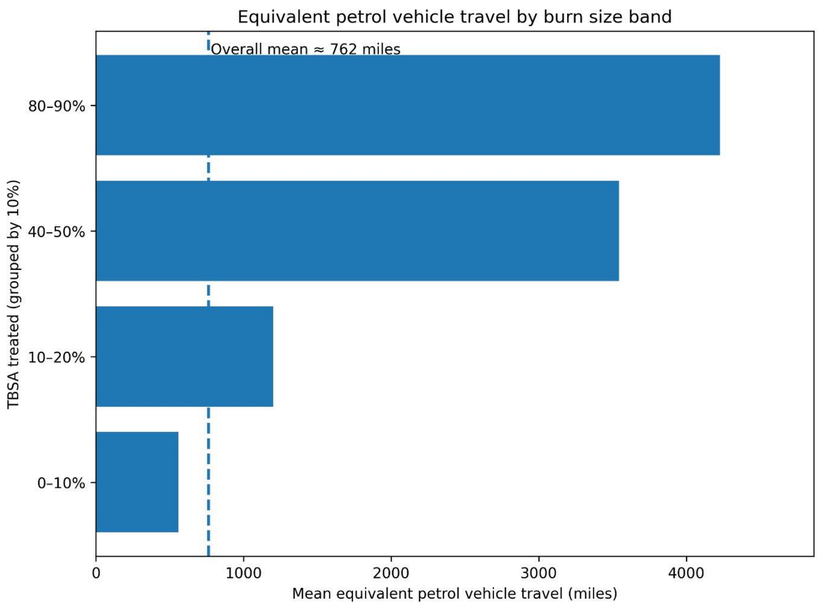

FIGURE 4. *Mean equivalent petrol-vehicle travel by TBSA band (10% increments); overall mean ≈ 762 miles.*

What We Can Change

- **Reusable textiles.** Switching disposable gowns and drapes to reusable systems cuts emissions up to ~66% (≈3–5 kg CO_2e/case); for a 300-case unit, ~0.9–1.5 t CO_2e/year ; an estimated 5–10% of case emissions with no change to care.
- **Optimise energy & warming.** Setback ventilation when theatres are idle, sensible scheduling, and moderating ambient temperature in small-burn cases reduce the 20% energy share.
- **Rationalise consumables.** Audit and reduce single-use items opened per case, especially high-impact kits such as fibrin sealant; standardise dressing packs to avoid over-opening.
- **Prefer TIVA.** Where clinically appropriate, choose TIVA over high-GWP volatile agents; avoid desflurane and nitrous oxide entirely.

Conclusion

Burn surgery is a **carbon-intensive specialty** whose emissions scale with burn size and consumable use. Single-use materials are the most modifiable target. Sustainable change is feasible without compromising patient care.

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