Beyond Beauty:
A Life Cycle Assessment of Sustainability in the Aesthetic Industry

Quantifying the hidden carbon cost of aesthetic medicine through integrated product–clinic analysis.

Faculty of Medicine, Imperial College London · Laidlaw Research & Leadership Programme (2025) · Supported by the **Laidlaw Foundation**
Sivanky Uthayakumar · Supervisor: **Dr Alexander Shaw**

Background

Healthcare produces ~5 % of global CO_2 emissions, yet the rapidly expanding aesthetic outpatient sector remains under-quantified.

This study pioneers the first integrated environmental analysis of aesthetic medicine, combining a Life Cycle Assessment (LCA) of cosmetic packaging with **real-world clinic sustainability audits.**

Objective: Identify emission drivers and model practical decarbonisation pathways.

Key insight: Strategic shifts in materials, anaesthesia, and energy use could cut emissions **25–40 %**, redefining sustainability standards in elective healthcare.

Functional unit: *50 g packaging and per aesthetic procedure*

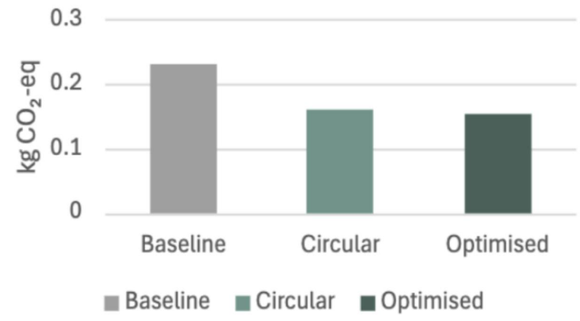

Figure 1. *Comparative Global Warming Potential (GWP) across Sustainability Scenarios in Aesthetic Clinics*

Methodology

Design: Multi-modal mixed-methods framework **aligned with ISO 14040/44** and **IPCC 2021 GWP (100-year horizon)** standards. Integrated a **comparative, attributional Life Cycle Assessment (LCA)** of cosmetic packaging with **pilot clinic sustainability audits** to capture both *product* and *practice* emissions.

Modelling: Total CO_2-equivalent footprint modelled in **Excel**, combining **clinic-reported consumable use** (packaging, PPE, syringes) with **published emission factors** (*Ecoinvent 3.9*). Compared **Baseline → Circular → Optimised** scenarios, showing **≈ 35–40 % emission reduction** through dematerialisation, recycled content, and improved end-of-life recycling.

$$\text{Total GWP} = \Sigma(\text{Mass} \times \text{Emission Factor} \times \text{Scenario Modifier})$$

System model included production, transport, clinic use, and end-of-life phases modelled separately

Audits: Two anonymised UK clinics evaluated across six domains—**energy, consumables, anaesthesia, waste, procurement,** and **governance.** Observation and staff interviews identified **behavioural barriers** such as habitual overuse of disposables and limited recycling infrastructure.

Analysis: Primary and secondary datasets **triangulated** within a **hybrid systems boundary** to pinpoint emission hotspots. Outcomes informed development of the **Aesthetic Environmental Performance Index (AEPI) -** a proposed audit tool (emissions, waste & energy metrics) for quantifying sustainability in aesthetic practice.

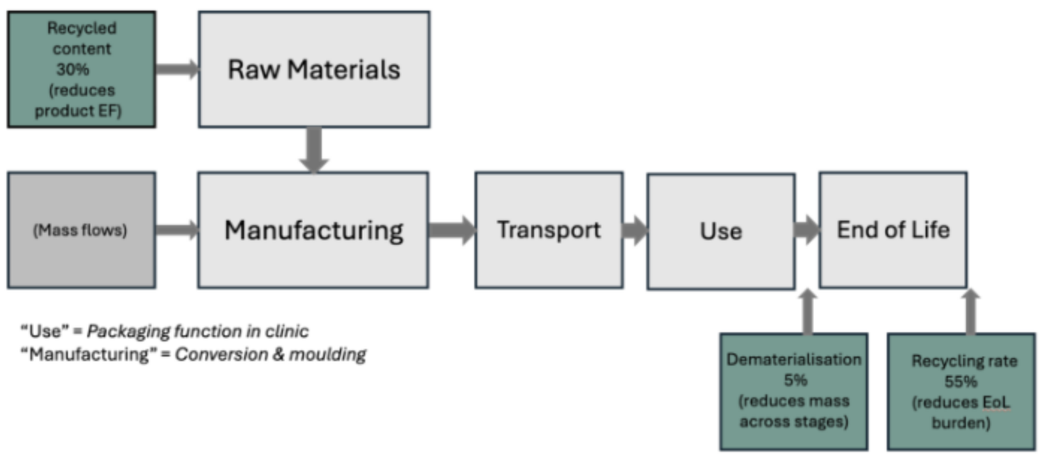

Figure 2 *shows the cradle-to-grave system boundary used in the packaging LCA. Scenario parameters act at specific stages: recycled content reduces production impacts, dematerialisation reduces mass across all stages, and the end-of-life recycling rate decreases disposal impacts.*

Results

Packaging LCA: *Polypropylene (PP)* showed the lowest cradle-to-grave impact (≈ 38.8 kg CO_2e / 50 g pack) compared with *ABS (74.2)* and *PET (63.5)*. Introducing **30 % recycled content + 5 % lightweighting** achieved an **≈ 40 % GWP reduction**.

Life-cycle drivers: Emissions were dominated by **production (≈ 68 %)**, followed by **transport (20 %)** and **end-of-life (12 %)** (**Fig. 4**).

Clinic audits: *Single-use consumables (~65 %)* were the major contributors, with **energy (20 %)** and **anaesthetic gases (10 %)** *also* significant (**Fig. 8**). Staff cited limited recycling and low sustainability awareness.

Ethics classification: Service evaluation; no patient data collected

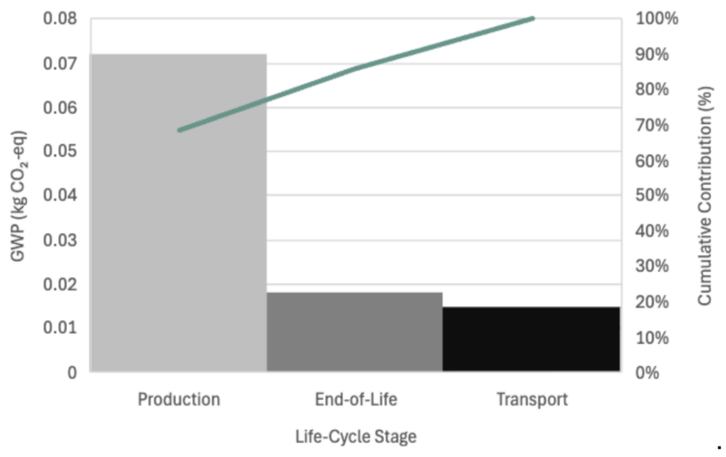

Figure 4: *Life Cycle Stage Contribution to Total GWP (Pareto Analysis)*

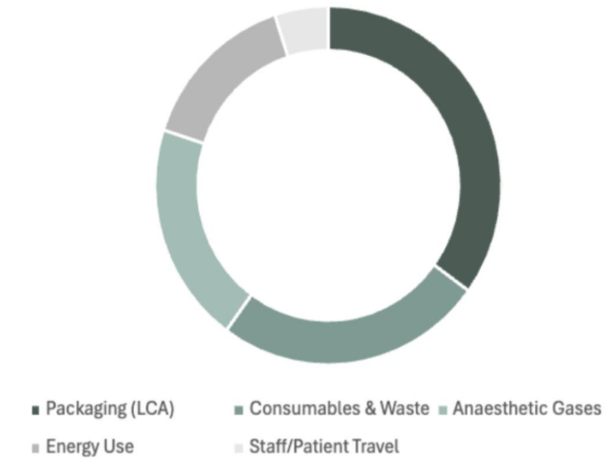

Figure 8. *Relative Contribution of Packaging and Clinical Operations to Total Carbon Emissions.*

Discussion

Behavioural insights: Staff interviews showed that **over-reliance on disposables** and limited recycling stem from ingrained workflow habits rather than necessity. Quantitative data alone missed these barriers—underscoring the value of coupling LCA with qualitative auditing.

Integrated synthesis: Adopting **recycled polypropylene packaging**, **low-flow / TIVA anaesthesia**, and **energy optimisation** could **cut clinic-level emissions by 25–40 %** (**Fig. 3**). *PP* proved the most efficient polymer—low embodied carbon, high recyclability, and minimal performance loss.

Broader significance: Even small outpatient clinics can achieve measurable decarbonisation without compromising sterility or outcomes. This pilot establishes the foundation for an **Aesthetic Environmental Performance Index (AEPI)**—a framework to benchmark and accelerate sustainability in elective healthcare. *Limitations: Pilot data (2 UK clinics); excludes infrastructure & capital emissions; uncertainty ±20 % (energy & transport).*

Conclusion

Aesthetic medicine is a key pathway for healthcare decarbonisation.

Simple measures—recycled packaging, low-flow anaesthesia, energy optimisation—can cut emissions **25–40 %**, forming the basis of the **Aesthetic Environmental Performance Index (AEPI).**

Future Directions

Next Step: Audit **≥30 clinics** to refine emission factors & set **procedure benchmarks**.

Innovation: Build **digital AEPI dashboard** for automated carbon tracking; integrate into **clinic accreditation & supply chains**.

Alignment: Map to **NHS Greener Pathways** & **UK Net Zero Healthcare**.

Impact: Launch **open-access tool** making sustainability **quantifiable, comparable & actionable** across outpatient care.

Contact: Sivanky Uthayakumar · Imperial College London
su223@ic.ac.uk

Scan for full report →

Acknowledgements: Laidlaw Research & Leadership Programme (2025) · Supervisor Dr Alexander Shaw · Thanks to participating clinics

· All references cited for both the report and poster are mentioned in the report

Scan for Report