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Environmental sustainability in dermatological surgery. Part 1: reducing carbon intensity

Fatima Ali,[1,2] BSDS Sustainability Subgroup Collaborative, Aaron Wernham[3] and Rachel Abbott[4]

[1]King's College London, London, UK
[2]Guy's and St Thomas' NHS Foundation Trust, London, UK
[3]Walsall Healthcare NHS Trust, Walsall, UK
[4]Cardiff and Vale University Health Board, Cardiff, UK

A full list of members of the BSDS Sustainability Subgroup Collaborative is provided in Appendix 1, and a list with affiliations in Appendix S1 (see Supporting Information).

Correspondence: Fatima Ali. Email: fatima.1.ali@kcl.ac.uk

Abstract

This two-part review addresses the pressing need for environmental sustainability in dermatological surgery, driven by the National Health Service's commitment to net-zero emissions. Part 1 focuses on strategies to reduce the carbon intensity of dermatological procedures by adopting low-carbon alternatives and optimizing operational resource usage. Key strategies for a system-wide reduction in environmental impact include leveraging local suppliers to reduce transport emissions, streamlining care models, promoting efficient waste management and using mindful prescribing practices. Another aspect is integrating sustainability into dermatological education while minimizing the carbon footprint of surgical education. Additionally, the review provides a comprehensive overview of optimizing resource use in dermatological surgery, focusing on efficient management of consumables, equipment and energy. This includes recycling, waste segregation, transitioning to reusable personal protective equipment and surgical instruments, and applying energy-saving and sustainable water use practices. By implementing these strategies, dermatological surgery can significantly reduce its environmental impact while upholding high standards of patient care.

Introduction

Growing environmental concerns have prompted a heightened focus on sustainability in the healthcare domain and, in particular, dermatological surgery. Climate change and dermatological surgery are (through complex and indirect pathways) causally connected, such that the delivery of the service itself is being affected by the unfolding crisis. This manifests in increased surgical rates due to a rise in skin pathologies related to climate change. The principles of planetary health guide our urgency to mitigate climate change and benefit the broader community served by dermatologists.

Sustainability involves meeting present requirements without compromising those of the future.[1] A sustainable dermatological surgical service delivers high-quality care while minimizing adverse environmental, social and economic impacts. In consequence, these services will adhere to the triple bottom line principle.[2] The National Health Service (NHS) is a major contributor to greenhouse gas emissions within the UK public sector and has committed to achieving net-zero emissions by 2045.[3]

Due to its resource-intensive nature, dermatological surgery generates a substantial carbon footprint.[4] This is further compounded by the escalating incidence of skin cancer. It is estimated that over 200 000 surgical excisions are carried out in UK dermatology services each year, with over 170 000 new skin cancer diagnoses each year.[5,6] Dermatologists acknowledge this dual impact of climate change on skin health and the broader environment.[7,8]

Sustainability efforts in dermatological surgery encompass the consumption patterns in service provision, the prevention of skin diseases, streamlining of care models, clinical decision making, and broader collaborative partnerships within the healthcare pathway. The Centre for Sustainable Healthcare has outlined key principles to improve sustainability by reducing activity, reducing carbon intensity through opting for low-carbon alternatives, and being cognizant of resource use, research and innovation.[9]

This review aims to identify effective strategies and practices that can reduce the carbon footprint of dermatological surgical services while maintaining high standards of patient care. The review consists of two parts. Part 1 discusses strategies to reduce the carbon intensity of skin surgery through electing for low-carbon alternatives and environmentally optimizing day-to-day operational resource use. Part 2 evaluates methods to reduce the overall activity of

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dermatological surgery and future environmental considerations within management, research and innovation.

Methods

These articles aim to formally publish the original British Society for Dermatological Surgery Sustainability Guidance 2022[1] as narrative reviews with an updated literature search (to 30 June 2024). Details of separate phases of the literature scoping, theme identification, analysis and mapping to the Centre for Sustainable Healthcare key principles can be found in Part 2 of this review. Figure 1 is a summary infographic from the British Society for Dermatological Surgery (BSDS) Sustainability Guidance 2022.[1]

Reducing carbon intensity in dermatological surgery

Low-carbon alternatives

Low-carbon alternatives in dermatological surgery relate to treatment options and medical technologies with lower environmental impacts. The procurement process is carbon intensive and contributes to 22% of the NHS carbon footprint.[10] Dermatological surgery requires essential pharmaceutical agents such as local anaesthetics. However, it is important to consider whether there is a good indication for prescribing additional agents such as tranexamic acid and oral antibiotics.[11] A low-carbon alternative approach aims to decarbonize emissions-intensive areas of the supply chain, such as by using local suppliers to reduce transport-related carbon emissions. However, challenges arise due to increased legislation favouring mass manufacturing over local compounding.[12]

As the carbon emissions from procurement are directly correlated to supply chain demand, it is crucial to critically evaluate overtreatment practices. This involves determining whether specific interventions provide substantial benefits to patient outcomes and carefully prescribing the quantity and duration of treatments.[13] Such mindful prescribing practices can significantly mitigate pharmaceutical waste, which has an estimated monthly environmental impact of 15 kg CO_2 equivalent (CO_2e) in wasted prescriptions (akin to an average car travelling 88 km).[14]

Pharmacists play a vital role in efficient dispensing, improving pharmaceutical preparation procedures, streamlining dispensing processes through electronic prescriptions and minimizing waste through effective stock management.[15] This approach requires empowering patients through awareness of carbon footprint labelling and providing transparent information on a product's environmental impact, shelf life and recycling options.[16] Dermatological surgery departments, the broader NHS and legislative bodies should advocate for environmental labelling on pharmaceuticals and skincare products.[17,18]

Road travel associated with NHS activities significantly contributes to England's total emissions, accounting for 3.5% of all road travel and 14% of the NHS system's emissions.[19] This encompasses business travel, fleet transport, patient travel, staff commutes and visitor travel. The NHS

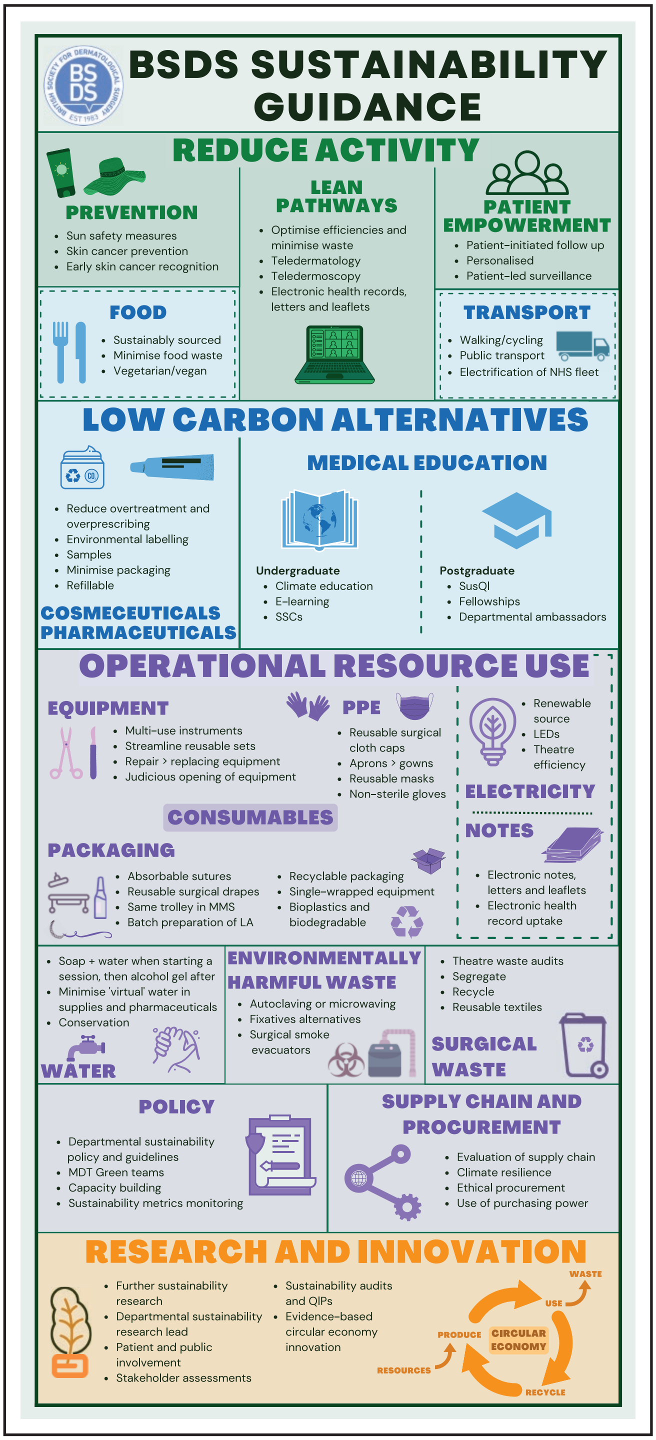

Figure 1 Summary infographic from the BSDS Sustainability Guidance 2022,[1] highlighting areas covered within this literature review. LA, local anaesthetic; LED, light-emitting diode; MDT, multidisciplinary team; MMS, Mohs micrographic surgery; NHS, National Health Service; PPE, personal protective equipment; QIP; quality improvement project; SSC, student-selected component. Figure reproduced with permission from the copyright holders.

transport fleet alone generates approximately 1000 kt CO_2e annually.[20] Transitioning from car usage to low-carbon alternatives such as public transport, cycling or walking for both the skin surgery team and patients could potentially reduce emissions by 461 kt CO_2e per year.[20] Strategies for implementation include car-sharing initiatives, bicycle parking facilities, reward schemes, travel reimbursements and support for remote work.

Additionally, adopting care models such as 'spot' clinics, where consultant dermatologists visit community sites, can significantly decrease the need for patient travel.[21,22] However, implementing strategies that involve changes to service models poses several challenges, including initial infrastructure costs, logistical complexities, need for robust support systems, and careful planning to ensure equitable access and efficient scheduling.

A low-carbon alternative approach in dermatological surgery also integrates sustainability principles into dermatological education, which fosters awareness and implementation of eco-friendly practices. While the General Medical Council emphasizes sustainability education for newly qualified UK doctors, currently undergraduate and postgraduate education pay limited attention to climate change in curricula.[23,24] Surgical education is also resource intensive as it often uses single-use materials akin to healthcare delivery, and plastic manufacturing models for simulation training. Methods suggested to improve this include reducing dependence on single-use materials, use of materials aligned with circular economy principles, and low-carbon alternatives such as immersive augmented or virtual technologies.[25] More research is needed as current technologies do not accurately replicate organic tissues or simulate real surgical scenarios, which create unrealistic training environments.[26]

Medical conferences also significantly contribute to medical education's carbon footprint through travel, energy consumption and food waste. Strategies to mitigate this impact include carbon-neutral conferences, virtual and hybrid formats, and reducing the carbon footprint of food.[27]

Optimizing operational resource use in dermatological surgery

Consumables

Consumables in dermatological surgery (equipment, packaging and personal protective equipment) contribute significantly to carbon emissions (Figure 2). Reducing unnecessary procedures can diminish use of all three types of consumables, as stated in the national specialty report for the Dermatology Getting It Right First Time programme.[5] Significant variation exists among UK providers regarding biopsies prior to definitive treatment of skin cancers, ranging from $< 10\%$ to over one-third of lesions. This variation causes greater resource use, excess waste and patient travel.[5] Strategies to mitigate this include avoiding unnecessary procedures such as biopsies, employing less resource-intensive approaches like topical therapies, and upskilling primary care providers to follow local referral pathways to reduce inappropriate referrals.[28]

Equipment

Life-cycle assessment

Life-cycle assessment is a 'cradle-to-grave' analysis that estimates the environmental impact of different equipment used in skin surgery. This includes raw material extraction, manufacturing and transport.[29] Evaluating raw material utilization and manufacturing locations is essential in determining the carbon footprint.[30]

Single-use vs. multiuse surgical instruments

Historically, single-use surgical instruments gained preference due to perceived advantages in sterility and sharpness.[31,32]

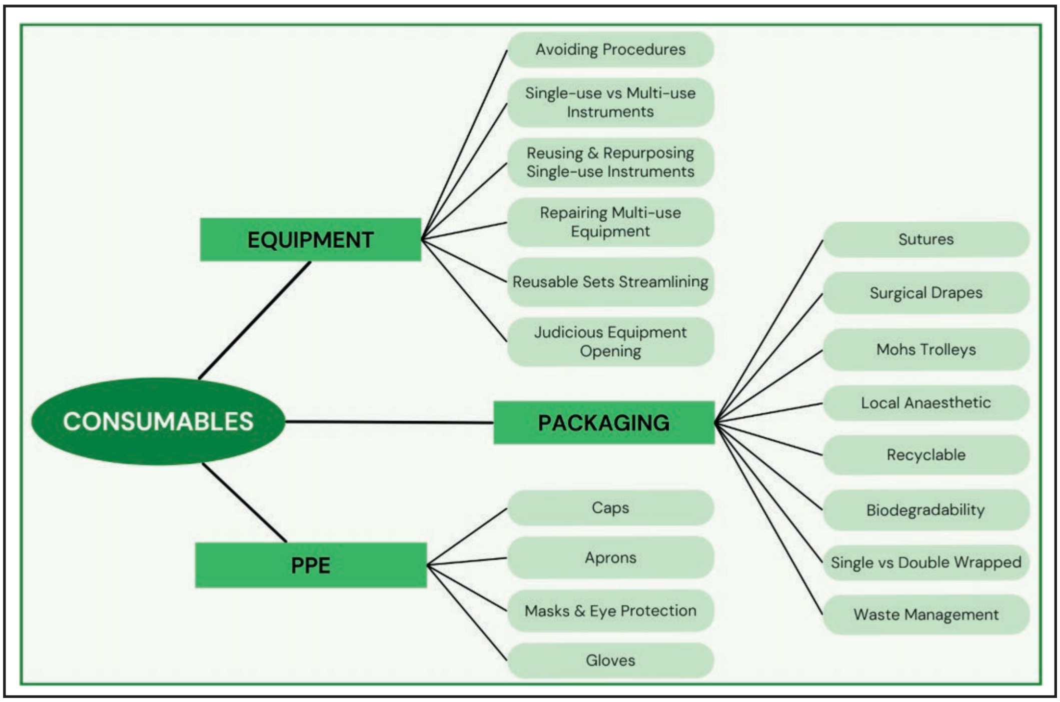

Figure 2 The multiple areas of intervention in our daily consumption in skin surgery that can mitigate impact of dermatological surgery on the climate crisis. PPE, personal protective equipment. Image used with permission from the copyright holders.[1]

However, reusable instruments also exhibit similar perceived attributes. They can be more cost-effective, while also having a lower carbon footprint that is as low as 25% of that of single-use instruments.[8,32] For example, reusable scissors cost £998 with a carbon footprint of 1.87 kg CO_2e, compared with £24 with 0.475 kg CO_2e for single use. However, as the reusable device can be used at least 500 times, the overall carbon footprint and costs are lower (£2.00, 0.004 kg CO_2e per use).[32] Nevertheless, the financial and environmental costs must be weighed between sterilization of reusable instruments, and sharp-bin incineration of single-use instruments.[33] Rizan *et al.* suggested methods to reduce carbon emissions from sterilization, making this a viable solution.[34] Hybrid instruments combining reusable and single-use components can be a cost-effective and environmentally friendly option.[32]

Reusing and repurposing used single-use instruments

Despite instruments being labelled as single use, there are global practices of reusing and reprocessing them for cost savings that raise concerns about patient safety.[35] A systematic review published in 2008 highlighted a lack of direct evidence of the effect of reusing single-use devices on patient outcomes.[35,36]

Repairing multiuse equipment

Repairing and recalibrating reusable instruments when they become ineffective is a sustainable and cost-effective practice, contingent upon suppliers making this option available.[37]

Streamlining reusable sets

Single-centre studies suggest that as much as 87% of instruments in surgical sets remain unused during operations, emphasizing the benefits of streamlining sets with fewer instruments.[38,39] Alternatively, using bespoke instrument sets for different procedures can streamline instrument use and ensure optimal equipment selection.[40,41]

Judicious opening of equipment

Efforts to minimize waste involve judiciously opening equipment when necessary, rather than based on anticipation. A prospective observational single-centre French study showed that more than one-third of surgical waste was caused by supplies prepared in anticipation but not ultimately used.[42] Waste reduction strategies involve waiting until specific phases of procedures to confirm equipment need, fostering better team communication and increasing awareness of supply costs.[42]

Sutures

A meta-analysis of 19 randomized controlled trials (in total, 1748 patients) demonstrated comparable surgical-site infection (SSI) rates and cosmetic outcomes with absorbable vs. nonabsorbable sutures for surface closure.[43] Absorbable sutures reduce plastic waste and obviate the need for suture removal visits.[44] Further research is necessary to explore the environmental impacts associated with the production of different suture materials.

Surgical drapes

Using clean reusable drapes rather than single-use sterile drapes can achieve sufficient infection control. A prospective study ($n=1000$) evaluated the rate of infection in Mohs micrographic surgery (MMS) using a clean technique (no sterile gloves, gown or drapes) for tumour extirpation and reconstruction. The study found a low incidence of SSIs (0.91%) when using clean (nonsterile) gloves and surgical drapes in MMS. The infection risk for flaps was highest at 2.7% (4 of 150).[45]

Mohs micrographic surgery trolley and instruments

Preserving the instruments on a trolley for each patient throughout Mohs stages and reconstruction ($n=332$) demonstrates low SSI rates (2.1%), reduces instrument changes and associated waste of packaging and drapes, and enhances the overall sustainability of the procedure.[46] This requires strict local protocols to avoid errors or contamination.[47]

Local anaesthetic batch preparation

Batch preparation of a large volume of diluted local anaesthetic can avoid packaging waste of individual syringes, reduce consumables used, and is more time-efficient than individual case preparation. However, utility depends on local context and case volume.[48]

Packaging

Recycling and waste management

Dermatology departments can significantly enhance sustainability by adopting efficient waste management practices through improving labelling, segregation and educational initiatives.[49] A UK-wide service evaluation reported a mean recycle rate of 16% for nonsharps in skin surgery.[50] However, a 2024 UK national sustainability audit with more included centres found a lower mean recycling rate of 8.6%.[51] Current products, prescriptions and devices have poor and inconsistent recycling labelling, leading to contamination and compromised recycling efforts.[40,49,52] The NHS must leverage its purchasing power to incentivize the industry to adopt appropriate recyclable packaging, consistent labelling and circular economy models.[40]

Bioplastics and plastics

Globally, most plastic is single use, with 40% of plastics used for packaging and 70% of collected plastics incinerated or sent to landfills.[8] Reducing plastic use in packaging in dermatological surgery will significantly enhance sustainability. Bioplastics are derived from natural resources and have varying degrees of biodegradability.[53] Although bioplastics provide an alternative to conventional plastics, their production still requires significant energy and resources; not all biodegrade efficiently in natural environments, and the transition involves higher costs and changes in supply chain logistics.[53]

Single- vs. double-wrapped surgical equipment

Studies indicate that single-wrapped sterile packaging carried no greater risk of bacterial contamination than double wrapping,[54] while providing cost savings and environmental benefits.[55] Reusable metal containers are emerging as sustainable alternatives.[34]

Personal protective equipment

Caps

Use of reusable surgical cloth caps in dermatological surgery has shown no discernible increase in SSIs.[56] Also, washable cloth caps exhibit less microbiological shedding than disposable bouffant hats.[57] This presents an environmentally favourable option.

Aprons

In a UK survey of 41 Mohs surgeons, 85% did not use sterile gowns during Mohs surgery for the tumour extirpation stage and 83% for the reconstructive stage of MMS.[58] Use of scrubs or polyethylene aprons had nonsignificant differences in SSIs and substantially lower costs.[59]

Masks and eye protection

A Cochrane review of 2106 patients found insufficient evidence to support or oppose the use of disposable masks in clean surgery from an SSI perspective.[60,61] Reusable masks offer personal protection against blood splatter and droplet spread and also reduce respiratory particle spread and waste compared with single-use masks.[62]

Gloves

A systematic review of over 10 000 patients indicated comparable SSI rates between procedures using sterile and nonsterile gloves in cutaneous surgery (including MMS), with an SSI rate of 2.2% in both groups ($P = 0.88$). For MMS specifically, nonsterile gloves have a low SSI risk ratio of 1.02 (95% confidence interval 0.78–1.34).[63] The risk of SSI with nonsterile gloves may increase with more complex reconstructions compared with simple excisions, with reported SSI rates varying widely (2.7–14.7%).[45,64,65] Nonsterile gloves are cost-effective (95% cheaper)[66] and are an environmentally sustainable alternative (80% reduction in climate impact).[67]

Electricity

Operating theatres utilize three to six times more energy than other hospital areas due to ventilation, heating, air conditioning and equipment demands.[68] With up to 40% of theatres being vacant daily, efficiency opportunities exist around occupancy and resource use. Transitioning from halogen to light-emitting diode lighting reduces energy consumption by 49%,[69] and switching off lighting, ventilation, heating/cooling and machinery when not in use can reduce energy waste in dermatological surgery operating theatres.[3]

Water

A life-cycle assessment of an Australian dermatological surgery department estimated that a typical skin excision procedure consumes 10 L of water (including hand washing and cleaning equipment), equating to 0.07 kg CO_2e emissions.[4] Switching from soap to alcohol-based hand rubs between surgical cases significantly reduces water use. A Cochrane database meta-analysis found that the method of hand disinfection does not affect the incidence of SSIs.[70] Indeed, current National Institute for Health and Care Excellence guidelines on the prevention of SSIs recommend that soap and water be used for disinfection at the start of the surgical session, with alcohol gel being sufficient for hand disinfection between cases thereafter (unless hands are visibly soiled).[71]

While ‘blue’ water consumption (direct use for washing and drinking) constitutes 3.7% of the health sector’s water footprint, addressing virtual water (used for equipment and pharmaceutical manufacturing) is also crucial.[19] Implementing streamlined theatre packs and reusing surgical instruments reduce both carbon and water footprints.[40,72,73]

Paper notes

The NHS produced the Five Year Forward View with the aim of going paperless by adapting, streamlining and reducing the environmental burden of using paper in hospitals.[74] This initiative aims to reduce paper waste and mitigate the environmental impacts of paper production, including deforestation, water consumption and energy use. For instance, producing 1 kg of paper requires two to three times its weight in trees.[75]

Waste

Surgical waste

Waste in dermatological theatres falls into clinical and general categories. McGain *et al.* audited six theatres, revealing 45% general waste, 32% clinical waste and 23% recyclable waste, with 40% of the general waste being recyclable.[76] Wernham *et al.* highlighted an annual carbon emission of 26 kg CO_2e from material waste for one treatment centre, translating to 644 kg CO_2e across 25 UK centres.[40]

Contaminated or infectious clinical waste requires expensive and energy-intensive autoclave treatment before landfill disposal. Segregating waste at the time of generation and ensuring clear labelling to prevent misclassification of nonhazardous waste are vital for reducing the carbon footprint.[77] A US centre found that addressing the lack of education on waste classification and recycling through a waste management education module yielded a 25% reduction in daily hazardous waste.[78] A carbon footprint analysis by MacNeill *et al.* across three hospitals suggested that refining guidelines to restrict the definition of ‘hazardous’ can reduce theatre waste further.[68]

It is evident that well-executed recycling programmes within operating rooms significantly mitigate the environmental impact by diverting waste away from landfills.[79] Estimates suggest that up to 90% of theatre waste is nonhazardous and potentially recyclable, including items such as surgical gloves, masks and tubing. Recyclable plastics are often wrongly discarded as general or clinical waste.[80] However, a national audit of 30 UK trusts found that only 57% had recycling bins in their skin surgery rooms.[51] A proposed solution is the incorporation of recycling bins in theatres, improved labelling and education on waste segregation. Also, prepackaged supply kits contribute to waste, but optimizing them, as seen in Potera's study, can avert a substantial amount of this.[80] Appropriate disposal of sharps is crucial, as glass bottles can increase waste volume.[77]

Environmentally harmful waste

Incineration of clinical waste contributes to pollution and carcinogenic by-products.[81] Melamed suggested that alternatives like autoclaving or microwaving can be more sustainable, but further research is required to determine the safety and efficacy of this.[82] Formalin, a prevalent fixative for histological specimens, presents a toxic and carcinogenic challenge. Formal handling, storage and disposal protocols for chemicals in MMS are pivotal. Lab atmospheric sampling revealed formaldehyde levels exceeding national standards and identified numerous hazardous or carcinogenic substances.[83] Studies suggest alternatives like sealing tissues under vacuum and specific fixatives such as RCL2 and ethanol, emphasizing the need for ongoing exploration of safer options.[84]

A surgical plume contains over 80 toxic chemicals and poses inhalation health risks, such as respiratory pathologies and potential infections (human papillomavirus, HIV, hepatitis B virus).[85] To address this, healthcare providers should use smoke evacuators and personal protective equipment, and select advanced bipolar electrocautery or ultrasonic devices with lower health risks.[75,86] Waste generated from equipment use, notably in Mohs surgery, has prompted the use of more environmentally sustainable alternatives like hyfrecators over electrosurgical units (including electrocoagulation and electrosection), which has significantly reduced per use waste generation.[87]

Discussion and conclusions

In part 1 of this review, we discuss the urgent need to enhance environmental sustainability in dermatological surgery, primarily through reducing carbon intensity. This involves analysing the necessary processes required to undertake high-quality skin surgery and evaluating methods to reduce their carbon emissions. Areas identified where dermatological surgery must reduce carbon intensity include procuring goods, transport for staff, patients and materials, and operational resource usage and waste.

Key strategies for adopting low-carbon alternatives include selecting environmentally friendly suppliers, reducing pharmaceutical waste, and optimizing resource use by employing reusable instruments and waste segregation strategies. Additionally, sustainability education among healthcare professionals is vital, incorporating eco-friendly practices into medical training to reduce carbon footprints. Ultimately, achieving meaningful progress requires a system-wide strategy that encompasses reducing carbon intensity, minimizing surgical activity, and incorporating environmental considerations into management, research and innovation.

The second part of this review will explore strategies to reduce surgical activity and future environmental considerations, aiming to integrate sustainability comprehensively into dermatological surgery and effectively mitigate climate change impacts while maintaining patient care standards.[88]

Learning points

- The substantial carbon footprint of dermatological surgery demands urgent sustainable practices, particularly as climate change escalates skin cancer rates.
- Opting for sustainable travel choices and educating patients and staff on the environmental impact of the pharmaceutical industry can help reduce the carbon intensity of dermatological surgery.
- Utilizing reusable instruments, judicious opening of equipment, and efficient management of consumables in dermatological surgery have proven cost-effective and environmentally friendly.
- Implementing effective recycling, reducing single-use plastics and ensuring proper waste segregation can minimize environmental impact.
- Water can be saved in operating theatres by using alcohol-based hand rubs.
- Energy consumption in operating theatres can be reduced by adopting energy-efficient lighting, equipment and practices, such as switching off unused devices.

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Conflicts of interest

The authors declare no conflicts of interest.

Data availability

No new data were generated or analysed in support of this research.

Ethics statement

Not applicable.

Patient consent

Not applicable.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website.

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Appendix 1

BSDS Sustainability Subgroup Collaborative

The BSDS Sustainability Subgroup Collaborative consists of Fatima Ali, Rachel Abbott, Aaron Wernham, Yasmin Nikookam, William Hunt, Sophie Holloran, Catriona Chaolin, Eshen Ang, Maria Charalambides, Ashima Lowe, Luke Brindley, Christopher Bower, Sandeep Varma, Minh Lam, David Veitch, Hilmi Recica, Wen Ai Woo, Simon Tso and Claire Doyle.

CPD questions

Learning objective

To become more familiar with environmental sustainability in dermatological surgery.

Question 1

Which category contributes the most to the National Health Service's carbon footprint?

(a) Medical equipment.
(b) Paper notes.
(c) Patient travel.
(d) Staff travel.
(e) Supply chain and procurement.

Question 2

Which of the following is an effective strategy to minimize water use in dermatological surgery?

(a) Adopting alcohol-based hand rubs between cases.
(b) Increasing the water temperature for hand washing.
(c) Not washing hands between cases.
(d) Using disposable hand towels.
(e) Using soap and water for all hand disinfections.

Question 3

How can dermatological surgery departments reduce their electricity consumption?

(a) Always keeping operating theatre lights and equipment on.
(b) Extending operating theatre hours.
(c) Implementing energy-efficient light-emitting diode lighting and turning off unused equipment.
(d) Installing additional air conditioning units in rooms.
(e) Using halogen lighting in operating theatres.

Question 4

Which of the following practices helps in reducing waste in dermatological surgery?

(a) Disposing of unused sterile equipment after each surgery.
(b) Enhancing recycling efforts and proper waste segregation.
(c) Ignoring the segregation of waste types.
(d) Increasing use of double-wrapped instruments.
(e) Using more single-use instruments instead of reusable ones.

Question 5

What are considered sustainable travel options that reduce carbon emissions of healthcare?

(a) Encouraging the use of diesel vehicles for all travel.
(b) Increasing the use of cars for patient and staff transport.
(c) Allowing staff and patient transport only using hybrid vehicles.
(d) Promoting the use of cycling, walking and public transport.
(e) Relying solely on traditional taxis for patient and staff transport.