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Environmental sustainability in dermatological surgery. Part 2: reducing activity and future ecological strategies

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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 2 of this review extends the discussion of sustainability in dermatological surgery by focusing on system-wide changes in service delivery and identifying future opportunities for reducing environmental impact. Building on the strategies outlined in Part 1, which explored low-carbon alternatives and operational resource optimization, Part 2 advocates for a comprehensive shift in the skin surgery service. Key strategies include reducing overall surgical activity, advancing research and innovation, and enhancing management practices to align with sustainability goals. Reducing surgical activity mainly involves the prevention of skin cancers, in addition to optimizing current patient pathways and empowering patients to take ownership of their follow-up. Outside of immediate clinical decision making at the individual level, the review highlights the importance of managerial policy, procurement practices and supply chain factors in driving broader national and international sustainability efforts. Advancing the sustainability agenda will also require targeted research and innovation, particularly in digital health solutions using evidence-based practices. By integrating these strategies, this review aims to provide a framework for reducing the environmental footprint of dermatological surgery and advancing towards a more sustainable healthcare system.

Introduction

Dermatological surgery both is impacted by and contributes to climate change. This has been exacerbated by the rising incidence of skin cancer, with an estimated 200 000 surgical excisions carried out in UK dermatology services each year.[1,2] As highlighted in Part 1 of this review, sustainability involves meeting present needs without compromising the future.[3] Within dermatological surgery this means ensuring high-quality care while minimizing adverse environmental, social and economic impacts.

The strategies surrounding reducing carbon intensity to minimize the environmental impact of dermatological surgery are discussed in Part 1, including electing for low-carbon alternatives and environmentally optimizing day-to-day operational resource use. This article is Part 2 of exploring sustainability within dermatological surgery. It discusses how this can be achieved through a system-wide shift in service delivery to reduce the overall activity of dermatological surgery and examines future opportunities in research, management and innovation. Combined, these reviews aim to provide dermatological surgeons and allied health professionals with a comprehensive overview of how skin surgery contributes to climate change and suggestions on how to mitigate this in practice.

Methods

These articles aim to formally publish the original British Society for Dermatological Surgery Sustainability Guidance 2022[3] as narrative reviews with an updated literature search (to 30 June 2024).

The BSDS Sustainability Subgroup (Appendix S1; see Supporting Information), established in July 2021, initially identified high-priority areas through scoping published and grey literature and subsequent discussion with expert subgroup members. The themes identified were analysed by the subgroup and mapped to the Centre for Sustainable Healthcare key principles.[4] Finalized themes and subthemes were used to guide literature searches. The four broad domains pertinent to the guidance include reduced

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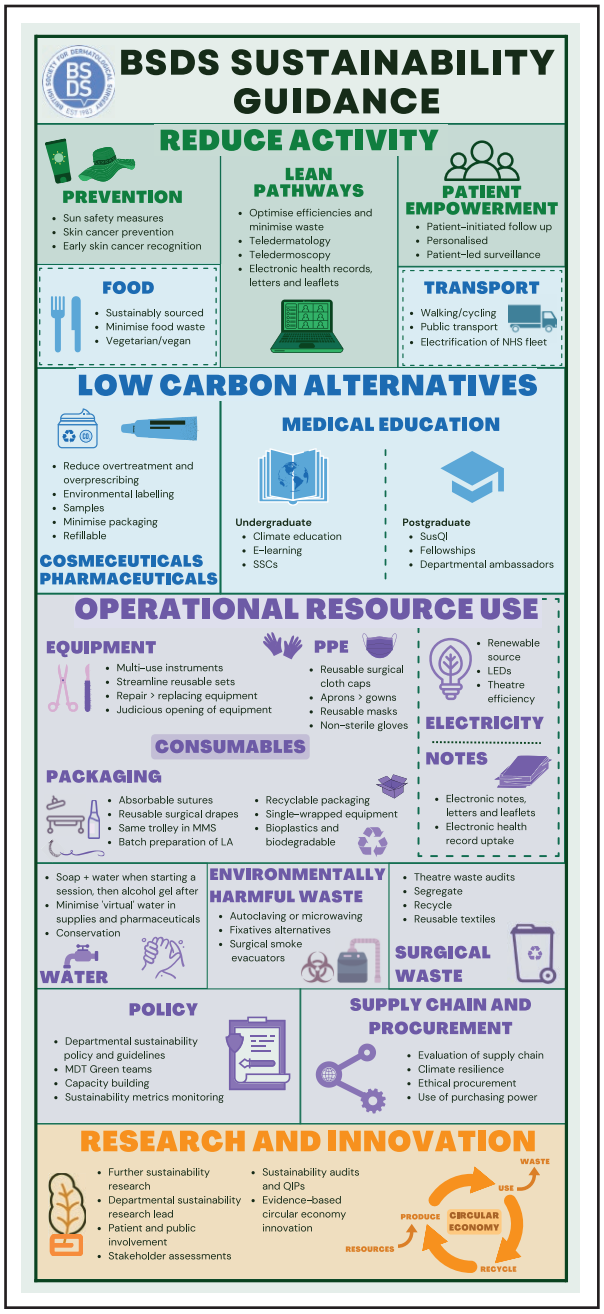

Figure 1 Summary infographic from the British Society for Dermatological Surgery (BSDS) Sustainability Guidance 2022,[3] highlighting areas covered within this literature review. LA, local anaesthetic; LED, light-emitting diode; MDT, multidisciplinary team; MMS, Mohs micrographic surgery; NHS, National Health Service; PPE, personal protective equipment; QIP; quality improvement project; SSC, student-selected component. Figure reproduced with permission from the copyright holders.

activity, low-carbon alternatives, operational resource use, and research and innovation. Figure 1 is a summary infographic from the BSDS Sustainability Guidance 2022.[3]

Literature searches were conducted using PubMed, MEDLINE and Embase from inception until 30 November 2021. The literature review was then updated twice, first on 30 November 2022 and finally on 30 June 2024, with 34 additional academic articles incorporated because of relevant content. The level of evidence was evaluated and selected according to the Oxford Centre for Evidence-Based Medicine guidance.

Inclusion criteria comprised studies, reviews and reports published in peer-reviewed journals, conference proceedings and medical grey literature that addressed strategies and interventions aimed at reducing the environmental impact of dermatological surgery while maintaining or improving patient care outcomes. Publications in English were considered for the review.

In the initial scoping of themes, the literature search included a combination of search terms, synonyms and related terms for dermatological surgery (skin surg*, cutaneous surg*, dermatosurg*, dermatologic surg* or Mohs micrographic surgery) and environmental sustainability (climate change, greenhouse gas, pollut*, global warming, carbon footprint, hazardous waste, recycl*, biodegrad*). The symbol '*' indicates truncation.

A snowballing approach was also taken on relevant articles, where references from included papers were used if deemed relevant. Specific theme searches included the above combined with search terms related to the domains mapped to the Centre for Sustainable Healthcare key principles. Owing to the paucity of literature relating to dermatological surgery, relevant published or grey literature that was translatable to sustainability in skin surgery was also considered.

Reducing activity in dermatological surgery

Prevention

Prevention involves reducing or delaying demand on healthcare resources. Dermatological surgery patient pathways and clinical encounters contribute significantly to energy consumption, medical resource utilization and waste generation.[4] This is driven by elevated ultraviolet radiation due to depletion of atmospheric ozone, public preference for warmer climates, an ageing population, and suboptimal sunscreen use, causing a rise in the incidence of skin cancer.[5] Notably, 87% of melanoma is estimated to be due to excess ultraviolet exposure. A preventive approach becomes increasingly pivotal considering the variability in follow-up appointments for melanoma, ranging from 2 to 60 months depending on disease staging.[6] This requires intense skin cancer prevention initiatives, public and private sector investment, stakeholder commitment, and comprehensive system-wide alignment in education and resource allocation.

Skin cancer prevention will directly reduce demand on the skin surgery patient pathways and carbon-intensive clinical encounters. The Dorset Renal Outpatient Service reviewed 7800 appointments annually and determined that they generated an average of 22 kg CO_2 equivalent (CO_2e) per appointment.[7] Within dermatological surgery, Tan and Lim's study in Australia employed a process-based life-cycle assessment methodology, which found that dermatological surgery in Australia contributes 8641 tonnes of CO_2e per annum.[8] Adopting a community-focused approach to skin cancer recognition has demonstrated clinicians' enhanced expertise and facilitated early intervention to prevent the

progression of dermatological conditions. For instance, an educational initiative for Norfolk community practitioners on actinic keratosis treatment improved practitioner confidence, reduced referrals and enabled substantial annual cost reductions (£32 200).[9]

Effective prevention programmes in dermatological surgery offer economic benefits by reducing the burden of skin cancer and conserving resources. The estimated cost per case of melanoma is £2560 (without immunotherapy-associated costs), while keratinocyte skin cancer costs £1226. These figures reflect the potential financial savings of preventing late-stage presentations and metastatic progression.[10] Skin cancer prevention programmes have demonstrated cost-effectiveness in targeted high-risk groups in Australia.[11] A population-level study highlighted the economic viability of systematic sunscreen use and photoprotection behaviours in Australia, offering substantial life-years saved and quality-adjusted life-years gained.[12] Further UK-specific research is required before extrapolation, considering our variable climate and sun-seeking behaviour.

Patient empowerment

In dermatological surgery, patient empowerment and patient-centred care are crucial for fostering environmental sustainability. Empowering patients through self-monitoring and shared decision making reduces follow-up appointments, thereby minimizing environmental impact.[13] The National Health Service (NHS) Long Term Plan emphasizes the importance of decarbonizing care pathways by addressing community care presentations, staff travel, patient mileage, pharmaceutical prescriptions and performed procedures.[14]

Patient-initiated follow-up models offer flexibility and convenience for arranging follow-up care, granting patients greater control and reducing waiting times while contributing to carbon savings.[15] While clinician-led skin cancer surveillance is traditionally employed post-treatment in targeted high-risk populations (e.g. patients diagnosed with two or more melanomas), single-centre studies challenge its efficacy in improving survival rates.[16] Indeed, the updated July 2022 National Institute for Health and Care Excellence melanoma guidelines have reduced the frequency of follow-up appointments, which is expected to reduce their carbon contribution.[6,17]

There is growing confidence in adopting patient-led skin self-examination, particularly in monitoring postsurgical excision.[6,16] However, the effectiveness of skin self-examination hinges on the quality of education and practice. The MEL-SELF randomized controlled trial found patient-led surveillance in localized melanoma to be potentially safe, feasible and acceptable and to reduce dependence on clinician-led follow-up.[18] Patient empowerment in dermatological surgery holds promise for environmental sustainability, but there must be rigorous evaluation of its efficacy and careful consideration of implementation challenges, including potential impacts on vulnerable or marginalized groups.

Lean pathways

Lean care systems, characterized by system efficiency and waste reduction, have gained traction in dermatological surgery, showcasing potential environmental benefits alongside operational improvements.[19]

The Getting it Right First Time (GIRFT) approach emerges as an effective strategy, demonstrating improvements in patient flow and efficiency across surgical specialties, leading to carbon emission reduction.[20] Triaging lesions using teledermatology can ease demands by allowing referral back to general practitioners without the need for a hospital visit. The GIRFT report also recommended moving skin surgery from day surgery to an outpatient setting. Hospital visits can be reduced through telephone consultations and home phototherapy and by providing results over the phone or by letter. Furthermore, avoiding unnecessary skin biopsies improves clinical efficiency and reduces consumption of surgical kits, thereby minimizing plastic waste.[1,20]

Teledermatology addresses the environmental impact of healthcare-related travel (including by the staff and patient), which constitutes 18% of healthcare greenhouse gas emissions.[21] Providing healthcare closer to home minimizes patient travel distances and reduces carbon emissions. Multicentre retrospective studies assessing teledermatology carbon emissions report substantial reductions, such as the 21-tonne reduction in 18 months demonstrated by Vidal-Alaball *et al.*[22] and a reduction of 15.37 metric tonnes over 3 months during the COVID-19 pandemic.[23]

A single-centre study in South East Wales reported an 86.3% reduction in face-to-face appointments using peripheral medical photography hubs for teledermoscopy.[24] The NHS Teledermatology Roadmap recommends various teledermatology models nationally, with technology playing a pivotal role in facilitating timely services.[25] This included many use cases of artificial intelligence technology within dermatology, particularly for triaging skin cancer referrals to reduce unnecessary secondary care referrals.[25] However, robust governance and policies are essential to ensure these systems operate safely and without discrimination.

'See and Treat' services represent a lean approach by reducing waiting times and the number of outpatient attendances.[26] Services must also evaluate the impact on efficiency metrics, such as transfer time, late arrivals and failed encounters. A 2023 cross-sectional study in a dermatology department investigated CO_2 emissions linked to patient travel for skin surgeries, including 2358 procedures on 2184 patients. Notably, 18% had same-day surgery, reducing travel by 35 275 km and saving 6.02 metric tonnes of CO_2.[27]

Consultant-led rapid-access diagnostic 'spot' clinics operate in the community and offer streamlined evaluations for patients referred to secondary care (2-week-wait or non-2-week-wait referrals).[28] These clinics provide community treatment provision, discharge with or without a plan, direct surgery bookings, or pathway upgrades. A successful pilot study in Lincolnshire showcased noteworthy results over the span of 100 days: 43% of the 73 patients seen in four spot clinics avoided further investigations in secondary care, with only 7% requiring referral to the 2-week-wait pathway.[29] This model reduces unnecessary hospital referrals, minimizes travel and resource use, and enhances efficiency in managing suspected skin cancer cases.

Missed appointments contribute to inefficiencies, diagnostic delays, increased travel and costs.[30] Transitioning from postal letters to email or text communication in dermatology services can potentially minimize paper waste

and achieve an 86% reduction in the carbon footprint.[31,32] Ultimately, lean pathways present promising strategies for dermatological surgery, demonstrating potential environmental benefits alongside improved operational outcomes.

Management, research and innovation in sustainable dermatological surgery

Policy

Challenges such as a lack of leadership and accountability hinder the enhancement of sustainability in dermatological surgery.[33] Establishing a departmental 'green team' is instrumental, as evidenced by the success of a multidisciplinary 'green operating room committee' in achieving significant waste reduction and emissions savings in a US hospital.[34] Monitoring environmental policy compliance and conducting life-cycle assessments through sustainability audits or quality improvement efforts align with the legal obligations of the NHS for fostering a sustainable healthcare service.[35]

Surgeon preferences dictate instrument and equipment selection in theatres, highlighting the importance of involving all department multidisciplinary teams when discussing sustainable procurement.[36] Integrating dedicated sustainability educational sessions into routine staff training programmes addresses knowledge gaps and improves waste segregation.[37] These efforts are crucial for fostering a culture of sustainability within departments. Exploring additional avenues for policy development in auditing and quality improvement supports NHS net-zero goals.[38]

Procurement and supply chain

Environmental adaptation of procurement and supply chains in dermatological surgery considers the entire life cycle from raw materials to end-user consumption.[39] The NHS encounters distinct challenges at each stage, with procurement alone contributing up to 65% of its carbon footprint.[40] Sustainable procurement, despite initial cost hurdles, offers long-term benefits through cost efficiencies, improved health outcomes and fair workers' rights.[41] This requires tailored local approaches due to the unique factors that influence supply chains at individual hospitals.[42] However, national collaboration and cross-departmental information sharing can yield valuable insights into effective practices.[43] Specifically, departmental collaboration can enhance purchasing power with suppliers, especially if they identify the same organization or system as a preferred sustainable solution.[44]

Ethical considerations play a pivotal role in procurement decisions, prompting departments to establish policies prioritizing reduced packaging and ethical sourcing practices. Environmental and ethical concerns are intertwined, urging responsible departments to assess manufacturers' policies, especially when sourcing from global vendors.[45] Questioning manufacturers on employment conditions, workers' rights and safety practices is essential, particularly when trying to instil resilience in the supply chain for global surgical instruments produced under challenging geopolitical conditions.[46]

Departments are encouraged to question manufacturers on sustainability practices, including component materials, manufacturing location, packaging, recycling and overall carbon footprint.[41] One example is to highlight a preference for reusable instruments with manufacturers and explore the viability of reusability when no existing option is available. Furthermore, publishing responses to manufacturer sustainability questionnaires on trust websites or including them in patient information leaflets enhances accountability and promotes transparency.[47] Also, implementing robust stock management mechanisms for surgical equipment can mitigate expired or wasted items and contribute to overall sustainability efforts.[48]

Research and innovation

Research and innovation play a pivotal role in aligning dermatological surgery's commitment to sustainability, as outlined in the NHS Long Term Plan and NHS research strategy.[49] This requires collaboration with industry, research centres and key stakeholders, including patients.[50]

Dermatological surgery demonstrates innovative practices such as transitioning to teledermatology, use of reusable equipment and leveraging technologies to minimize plastics in supply chains. Importantly, this needs to be evidence based, where life-cycle sustainability assessments with environmental, social and economic considerations guide decisions towards more sustainable products.[51]

Digital solutions enhance efficiency, patient outcomes, cost reduction and emission control. In clinical research, digitalization minimizes reliance on paper-based processes, physical meetings and travel, thereby lowering carbon emissions.[52] For example, electronic data capture eliminates the need for paper forms, cutting down the carbon footprint associated with paper production and transportation. Virtual clinical trials and remote monitoring also eliminate travel requirements.[53] Additionally, cloud computing and electronic communications (e.g. email and video conferencing) reduce the carbon footprint linked with server usage and in-person meetings. This is particularly the case if renewable sources are used to generate the electricity. Digital transition can significantly reduce the carbon footprint of clinical research, ensuring study quality and promoting sustainability.[53]

Limited published research on the environmental impact of dermatological surgery highlights barriers of lack of available information, and reluctance among healthcare providers to implement changes.[54] Overcoming these challenges requires involving patients and the public throughout the research process, emphasizing the need for advocacy training for skin surgeons to integrate sustainability considerations into research and policy. Education initiatives and open dialogue concerning environmental and financial implications of sustainable practices are essential for effective implementation of changes. Resources such as SusQI (Sustainability Quality Improvement) and sustainable healthcare initiatives can offer support in developing sustainable data and research.[55]

Since the BSDS Sustainability Guidance 2022 became available, there has been an increase in measurement of resource use at local centres and publication of sustainability practices through audits and service improvement projects.[56,57] This enhances transparency and encourages involvement in national audit processes, filling a knowledge gap in primary data surrounding dermatological

surgery sustainability practices and helping to identify limitations preventing current services from achieving net zero. Formalized methods to assess local sustainability include performing sustainability audits, using recently created performance-based decision tools, or organizational integration of environmental management systems into governance and operations.[57–60] Assessing alignment to sustainability guidance is essential in highlighting the department's role in engaging in academic activities to inform and educate dermatologists, patients and policy providers on environmentally sustainable practices.[3]

Discussion

The BSDS Sustainability Guidance 2022[3] highlighted key areas of intervention to initiate a system-wide improvement in the sustainability of dermatological surgery. One significant concern was the paucity of primary data on sustainable practices in skin surgery, which was notably insufficient compared with other surgical specialties. While there have not been new themes or focus areas identified since the release of the 2022 guidance, there has been notable progress in the sustainability landscape, with more specialty-specific primary data collection and the topic gaining more prominence in the literature and within local, national and international dermatology communities.

Part 1 of this review highlighted the importance of reducing the carbon intensity of surgical practice through low-carbon alternatives and resource optimization. Part 2 extends this discussion by addressing strategies for reducing overall surgical activity and exploring future ecological research and innovations. Despite these insights, it remains challenging to predict overall carbon emission savings or to objectively identify the most impactful interventions within skin surgery. Currently, no healthcare studies have directly compared the environmental impact of reducing activity or optimizing it under controlled conditions. A robust evaluation of environmental impact should consider carbon emissions, water waste and air pollution. The Centre for Sustainable Healthcare identified reducing overall activity as the foundation of sustainability.[4] For instance, prevention strategies can potentially reduce the 87% of melanomas that are estimated to result from excess ultraviolet exposure.[61]

The heterogeneity in sustainability methodologies and reporting has impeded the ability to interpret and generalize findings across different studies. Most systematic reviews in sustainability rely on qualitative synthesis due to differing scopes and algorithms for carbon emission calculations.[62,63] This inconsistency highlights the necessity for establishing standardized national audits, as recommended in the BSDS Sustainability Guidance.[57] Standardization would streamline data collection and analysis, allow comparisons across various settings, and enable benchmarking to foster continuous improvement.

Although many dermatological surgeons recognize their contribution to climate change, this has not always led to measurable change in practice.[64] Transforming systems requires significant shifts in culture and ingrained behaviours. Many measures discussed in this review, such as clinical decisions or reducing water consumption, can be practically implemented by dermatological teams. However, initiatives such as transitioning to reusable equipment with sterilization facilities demand long-term strategies, economic consideration and infrastructure changes. Consequently, meaningful change also requires the engagement of a broad spectrum of stakeholders and partnerships with external organizations.[65] This complexity is compounded by variability in management practices across UK NHS trusts, highlighting the need for tailored trust-specific sustainability policies.

We acknowledge several limitations to this review. Owing to the paucity of environmental sustainability literature related to dermatological surgery and the lack of specific higher-level evidence, single-centre observational studies and grey literature were included in keeping with the aim to provide a comprehensive overview of themes within sustainable dermatological surgery. However, these sources are prone to bias, necessitate cautious interpretation and highlight the need for further rigorous investigations in this field. While the review briefly addresses health and cost considerations to illustrate benefits related to the triple bottom line[66] (people and profit), a thorough exploration falls outside its scope and requires cost–utility analyses, including the environmental perspectives of resource use, pollution reduction and population impact. Research in this area will facilitate the development of an environmentally conscious pathway for skin surgery that does not compromise patient care outcomes.

Conclusions

This two-part literature review provides a comprehensive exploration of sustainability in dermatological surgery, offering a nuanced understanding of the challenges and opportunities.[67] The identified strategies provide a roadmap for healthcare providers and policymakers to integrate sustainable practices into dermatological surgery. The review offers a multifaceted approach that considers reducing activity through prevention, patient empowerment, lean pathways, reducing carbon intensity through evaluating consumption or waste, and finally consideration of management, research and innovation in dermatological surgery. These themes reflect a commitment to achieving environmental, social and economic sustainability. We hope this serves as a foundation to foster a culture of sustainability within dermatological surgical practice, contributing to the broader goal of achieving a sustainable and resilient healthcare system.

Learning points

- Investing in skin cancer prevention initiatives in the public and private sectors can reduce the number of patients requiring dermatological surgery and therefore align with sustainability goals.
- Patient-initiated follow-up and patient-led skin self-examination models in dermatological surgery empower patients, reducing follow-up appointments and environmental impact.
- Implementing lean care systems, teledermatology and 'See and Treat' services minimizes carbon emissions and waste.

- Partaking in national audits can standardize data collection and analysis and allow comparisons to enable benchmarking to foster continuous improvement.
- Establishing 'green teams' to help integrate sustainability into policy and research can help educate dermatological communities and promote a culture of environmental responsibility.
- Continued further research and innovation are crucial for developing sustainable practices in dermatological surgery.

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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

What does the concept of 'lean pathways' in healthcare primarily aim to achieve?

(a) Higher patient throughput.
(b) Improved surgical precision.
(c) Increased use of specialized surgical equipment.
(d) More surgical interventions.
(e) System efficiency and waste reduction.

Question 2

Which of the processes below would make your dermatology service more aligned with lean principles of healthcare?

(a) Increasing the number of in-person consultations.
(b) Not using See and Treat skin lesion services.
(c) Using double-wrapped equipment.
(d) Using single-wrapped equipment.
(e) Using teledermatology.

Question 3

What can significantly reduce the carbon footprint of clinical research in dermatological surgery?

(a) Electronic data capture.
(b) Paper-based processes.
(c) Physical meetings.
(d) Traditional face-to-face patient follow-ups.
(e) Utilizing multiple shipping methods for study materials.

Question 4

What is one recommended method for assessing local sustainability practices in dermatological surgery?

(a) Advocating for sustainable travel for healthcare professionals.
(b) Counting the number of reusable instruments used in one surgery.
(c) Hanging up sustainability posters.
(d) Measuring the temperature of the operating rooms.
(e) Performing sustainability audits.

Question 5

As highlighted by the Centre for Sustainable Healthcare, what forms the foundation for sustainable healthcare?

(a) Increasing the use of disposable medical supplies.
(b) Reducing overall activity through prevention of disease.
(c) Reducing travel.
(d) Renewable energy sources.
(e) Turning off lights and machinery when not in use.