British Association of Dermatologists

healthy skin for all

BSDS SUSTAINABILITY GUIDANCE

Contents

Introduction

The British Society of Dermatological Surgery recognises the contribution of skin surgery and patient pathways to climate change. Dermatological surgery plays both a role in the unfolding ecological crisis and is equally affected through the consequent direct and indirect strain on its own service. Action to mitigate against climate change yields large benefits for our own health and the community that we serve, in addition to planetary health.

Whilst sustainability has many dimensions, it is fundamentally defined as meeting the needs of the present without compromising the future. A sustainable dermatological surgical service will be able to provide high-quality care whilst minimising negative environmental, social, and economic impact, in line with the Triple Bottom Line.[1]

The NHS contributes to one-fourth of the greenhouse gas emissions within the public sector in the UK.[2] The campaign "For a Greener NHS" was initiated in January 2020 to strengthen the effort of the organisation in the last decade in achieving net-zero emissions by 2040.[3] The Intergovernmental Panel on Climate Change (IPCC) concluded that to limit warming to 1.5°C, we need immediate transformation and strong accountability to the Paris Agreement4. With more than 4% of the global greenhouse gas emissions originating from the healthcare sector, we are uniquely positioned to lead from the front in attaining transformational change. To that end, the NHS has pledged to become carbon net-zero by 2045.[3]

Within skin surgery, the issue spans beyond consumption in service provision, and stems from the basis of models of care and key clinical decisions. To achieve a sustainable change, we need collaboration and partnership at all levels of the healthcare and wider system to move toward net-zero patient-centric care, prevention of skin diseases, efficient patient pathways and a focus on wellbeing.

Vision

The BSDS Sustainability Guidance aims to enhance the capacity of dermatological surgeons and their team members to protect and improve the health of themselves, their communities, and the planet, by enabling local sustainable practices.

How to Use this Guidance

This guidance evaluates the current evidence base and derives recommendations to act as a tool to facilitate and leverage local services to reflect standards of high-quality sustainable healthcare systems. The outlined recommendations can be used to educate, empower, inspire, or leverage local transformation.

The structure of this guidance is aligned to the priorities dictated by the Centre for Sustainable Healthcare principles, including prevention, patient empowerment, lean service delivery, and low carbon alternatives.

This guidance has been reviewed by the BSDS Sustainability Subgroup, British Association of Dermatology senior group, and has had patient and public reviewers.

Team

The British Society of Dermatological Surgery Sustainability Subgroup is committed to integrating sustainability within all levels of practice within dermatological surgery.
The subgroup aims to provide recommendations, work with key stakeholders, inform policy and guidelines, and develop key areas for research and innovation.

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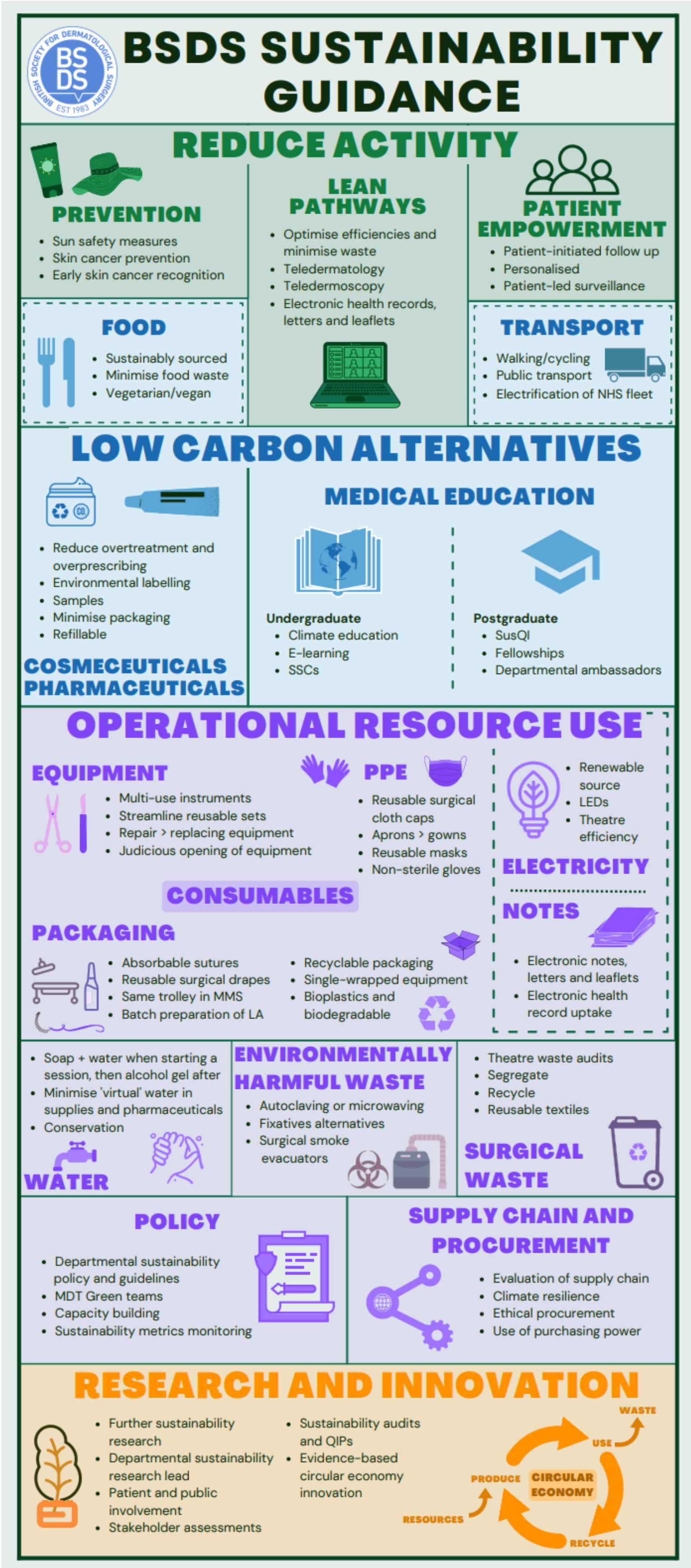
Summary Infographic



Recommendations

1. Reduce activity

Prevention

i. Engage and support effective local and national sun safety and skin cancer awareness campaigns in the community which encourage self-examination and raise awareness about the risks of excessive ultraviolet (UV) exposure from the sun and sunbeds causing skin cancer.
ii. Collaborate with multidisciplinary professionals, public sector and charitable organisations, and industry to educate the public about the UV index and advocate sun safety measures i.e., wearing hats, seeking shade, wearing protective clothing, and applying sunscreen.
iii. Facilitate community healthcare professionals shared learning opportunities to support early recognition of skin cancer.
iv. Adopt the GIRFT approach in the primary and secondary care setting to utilise every clinical encounter to provide useful skin cancer prevention information and sun safety advice to patients.

Patient Empowerment

i. Empower patients and encourage joint responsibility in managing the risk of skin cancer such as offering patient-initiated follow-up appointments and providing high-quality and systematic self-skin examination (SSE) education during initial follow up.
ii. Provide personalised care and consider tailored face-to-face follow up depending on confidence in the patient's ability to conduct optimal SSE.
iii. Enable prompt or fast-tracked medical review when patient reports identification of a concerning lesion or lymphadenopathy to aid early assessment and treatment.
iv. Evaluate the balance between resource-intensive clinician-led surveillance and the feasibility of safe patient-led surveillance taking into consideration demographic and geographical differences in practice area.
v. Encourage patients to take ownership of their health with the utilisation of advanced technology to monitor disease and skin conditions.

Lean Pathways

i. Encourage the integration of teledermatology pathways, such as teledermoscopy for skin lesions, by upskilling General Practice to take dermoscopic images or using peripheral medical photography hubs, to reduce face-to-face throughput and provide closer-to-home services.
ii. Where facilities and staffing allow, the use of 'See and Treat' clinics is recommended in skin cancer services.
iii. Mitigate against the challenges of 'See and Treat' clinics or use alternative means in the best interest of the patient, for issues including but not limited to capacity, consent, patients on anticoagulants or time constraints. Therefore, be mindful of when 'See and Treat' clinics may not be the best fit for some patients.
iv. Encourage patient appointment attendance through involvement in the selection and cancellation of appointments, including date and time, and modality such as face-to-face, online or telephone platforms.

v. Mitigate against the outlined administrative and convenience factors in causes of missed dermatology appointments.
vi. Use text appointment reminders to patients attending dermatology services to minimise missed appointments.
vii. Electronically communicating clinic letters to primary care practitioners through email, rather than posted paper letters, is recommended to reduce unnecessary paper waste.
viii. When possible, choose to email letters to communicate appointments, results and copies of clinic letters.
ix. Within the whole healthcare system context, advocate for the transition to electronic health records, and digital prescriptions.
x. Patient information leaflets (PILs) may also be emailed to patients, rather than printing, and again balancing the carbon cost of an attachment. Alternative options, such as the use of QR codes for leaflets should be considered.

2. Reduce Carbon Intensity

i. Low carbon alternatives

Cosmeceuticals

i. Aim to procure cosmeceutical/pharmaceutical products and surgical instruments that have been produced ethically, locally and sustainably where possible.
ii. Where possible, minimise overtreatment and overprescribing, by regularly conducting medication reviews with patients in the clinic.
iii. Provide patients with sustainably sourced samples to determine patient preference for emollients, before prescribing larger quantities of products such as emollients.
iv. Monitor departmental recycling and wastage of products used in clinics or surgery, as well as providing patient education for product wastage and recycling of product packaging.
v. UK dermatologists and supporting organisations to lobby for cosmeceutical/pharmaceutical companies to reduce plastic packaging, use plastic alternatives, encourage refillable products, and use carbon transparency reporting and environmental labelling of products. Also, if products developed are found to be hard-to-recycle and not processed by councils, for pharmaceutical companies to fund companies that enable products to be returned to the circular economy.

Transport

i. Encourage staff, patients, and visitors to consider alternative methods of transport where possible, such as walking, cycling, and using public transport.
ii. Dermatology departments to set up car-sharing schemes, walk/cycle reward schemes, travel reimbursements, priority parking for those car-pooling, and encourage working from home when possible.
iii. If vehicle transport is necessary, incentivise use of low, ultra-low and zero-emission vehicles, or incentivise staff to use electric vehicles
iv. Promote the electrification of NHS transport fleet / alternative fuels for hospital vehicle fleets and conduct regular auditing and service evaluation of NHS fleets.
v. Encourage changes in local infrastructures, such as improved cycle paths, storage and shower facilities.

Food

i. Support and promote the availability of healthy, sustainably sourced foods for department staff, patients, and visitors.
ii. Consider introducing measures to help reduce staff food waste within the dermatology department.
iii. Offer vegan/ vegetarian food at departmental meetings.

Medical Education - Undergraduate

i. Integration of pathophysiology of dermatological conditions with climate-sensitive and climate-induced conditions such as skin cancers, atopic dermatitis, or vector-borne infectious diseases.
ii. Use of e-learning in dermatology teaching or incorporate eco-medical modules such as climate induced health burden.
iii. Offer student selected components (SSC) projects with an environmental sustainability theme in dermatology to students to ignite the passion in driving a sustainable and low carbon health care. For example, evaluating the sustainability of the reusable and single-use packs in skin surgery.
iv. Support student volunteering schemes and environmental societies in universities that encourage participation in green activities such as regular litter picks, canal waste cleaning and raising public awareness of environmental sustainability.
v. National dermatology departments and dermatological societies to support undergraduate prizes, essays, and publications on the theme of skin surgery sustainability.

Medical Education - Postgraduate

i. Trainees to adopt the sustainability in quality improvement framework (SusQI) developed by the Centre for Sustainable Healthcare (CSH) and Royal College of Physicians when carrying out QI projects, taking into consideration its environmental, social, and economic impacts.
ii. Learning about integration of sustainability into QI by participating in workshops organised by CSH such as "Sustainable Quality Improvement", "Carbon Footprinting for Healthcare" and "Teaching Sustainable Quality Improvement".
iii. Setting up and engaging with a sustainability scholarship or fellow schemes within the local hospital/trust/health board, that facilitates formal sustainability teaching, leadership opportunities and projects that contribute to healthcare improvement.
iv. Appointment of a 'Sustainability Ambassador' or 'Sustainability Champion' within the dermatology department to help educate colleagues in understanding the impact of healthcare's resource footprint and adapting to sustainable clinical practice.
v. Embracing virtual conferencing to allow lower carbon emissions as well as better accessibility for researchers and clinicians across the globe.
vi. If in-person or hybrid conferences are held, to consider sustainable locally sourced catering, encourage attendees to bring their own cups and bags.
vii. For national dermatological societies to establish sustainability groups, organise sustainable dermatology workshops, green prizes and support NHS commissioning groups to facilitate the transformation of practice to be climate smart.

ii. Operational Resource Use

Consumables - Equipment

i. Avoid skin biopsies unless there is diagnostic uncertainty and aim for excision of skin cancers at outset. However, if a biopsy is required, attempt to undertake this on the same day.
ii. For low risk / premalignant lesions consider less resource-intensive management approaches where possible, including active inaction.
iii. Promote the use of reusable surgical instruments over single-use equivalents.
iv. Encourage further research to evaluate the environmental, financial, and ethical cost of single vs reusable surgical equipment specific to the dermatological surgical setting.
v. Encourage further research to understand the reuse of single-use instruments in the UK and establish regulatory systems to ensure that patients are not adversely affected by this practice.
vi. Take time to identify and mark reusable equipment that is blunt or faulty, and facilitate a surgical devices team to repair or re-calibrate them.
vii. Reduce surgical instrument sets to regularly used equipment, for example, the customisation of bespoke sets for different procedures or preferences, and for infrequently used instruments to be packaged as singles.
viii. Avoid opening equipment unnecessarily, preferably for extra intraoperative surgical supplies and equipment to operate on a wait and see basis rather than opening in anticipation.

Consumables – Packaging

i. Absorbable sutures should be routinely used in preference to non-absorbable sutures for wound surface closure.
ii. Use reusable clean (ideally) or sterile drapes in dermatological surgery.
iii. Where local protocol ensures safety, use of the same instruments for Mohs surgery stages and reconstruction can be employed. When equipment is not in use a protective cover can be placed to reduce risks of airborne contamination.
iv. Consider the use of batch prepared local anaesthetic at the beginning of surgical sessions.
v. Consider the recyclability of packaging when procuring products, and reduce unnecessary plastic waste in packaging.
vi. Challenge suppliers on packaging type, recycling ability, labelling, and biodegradability.
vii. Support further evidence to establish if bioplastics could be applied to the clinical setting.
viii. The packaging of sterile surgical instruments should be interrogated to assess whether more sustainable packaging options could be used as alternatives, without compromising bacterial contamination of the contents.
ix. Promote good practices of waste management by educating staff on product labelling, correct disposal of surgical waste and provide the opportunity to do so by having clear waste management systems in surgical procedure rooms.

Consumables - PPE

i. Encourage home-laundered reusable surgical cloth caps.
ii. Use surgical aprons or clean scrubs when undertaking dermatological surgical procedures rather than surgical gowns.
iii. Consider the use of home-laundered, reusable EN 14683:2019 standards cotton masks in the clinic.

iv. Use non-sterile gloves for diagnostic biopsies, curettage and electrodesiccation, simple excisions, and tumour extirpation stages in Mohs micrographic surgery.
v. Consider the use of non-sterile gloves for use in outpatient dermatological reconstructive surgery.
vi. Avoid routine use of double-gloving for dermatological surgical procedures.

Electricity

i. Encourage hospital and trust-wide renewable electricity sources.
ii. Optimise theatre occupancy efficiency, with reduced zero occupancy rates.
iii. Reduce electricity used by using LED lights, and when not in use to turn off heating, air conditioning, electrical machinery.

Notes

i. Encourage hospital-wide electronic health record uptake, and substitute paper notes and forms with electronic alternatives
ii. Invest in computer software for electronic prescribing, referrals, patient notes and clinic letters.

Surgical Waste

i. Encourage regular theatre waste audits.
ii. Optimise methods to segregate waste at the time of generation.
iii. Ensure theatres have recycling bins and staff are educated on segregation practices.
iv. Seek opportunities for reusable textile use.

Environmentally Harmful Waste

i. Assess the suitability of alternative methods of incineration, such as autoclaving or microwaving.
ii. Assess the evidence base for alternative fixatives to be used in practice.
iii. Promote the use of surgical smoke evacuators in all skin surgery theatres.

Water

i. Disinfect hands with soap and water at the start of surgical sessions and then use alcohol-gel for disinfection between cases (unless hands are visibly soiled).
ii. Reduce the consumption of ‘virtual’ water by preventing overuse and waste of medical supplies and pharmaceuticals during surgical sessions.
iii. Support hospital and trust level efforts to conserve water through the installation of water-efficient taps and flushing systems.

Policy

i. Establish a departmental multi-disciplinary ‘green team’ to formulate department-specific guidelines and ensure implementation of hospital-wide energy and waste policies.
ii. Incorporate sustainability in departmental policy, including departmental education and training sessions.
iii. Monitor adherence to both department and hospital-wide sustainability policies through regular auditing.

Procurement/Supply Chain

i. Departments are encouraged to conduct an evaluation of their supply chain for commonly used dermatological equipment, to assess supplier sustainability, any areas of inefficiencies and where it is possible, to find alternatives.
ii. Improve supply chain resilience in the case of possible interruptions from climate change and other geopolitical events.
iii. Evaluate department procurement to assess if it meets the ethical procurement standards dictated by the International Labour Organisation.
iv. Encourage suppliers to fill out a sustainability questionnaire, and use purchasing power to leverage improvements in current procurement standards.

3. Research and Innovation

i. Encourage use of Patient and Public Involvement in various stages of sustainability research, considering stakeholder assessment and devising qualitative and quantitative research studies centred on sustainable service provision.
ii. Encourage departments to appoint sustainability research leads to mentor research projects and/or be lead investigators for the area in multi-centre research projects.
iii. Conduct regular sustainability-related audits and quality improvement projects, including life-cycle assessments, departmental tagging systems and research into offsetting.
iv. Organisation of sustainability research meetings, providing the opportunity for trainees and departments to share research and innovation.

1. Reduce Activity

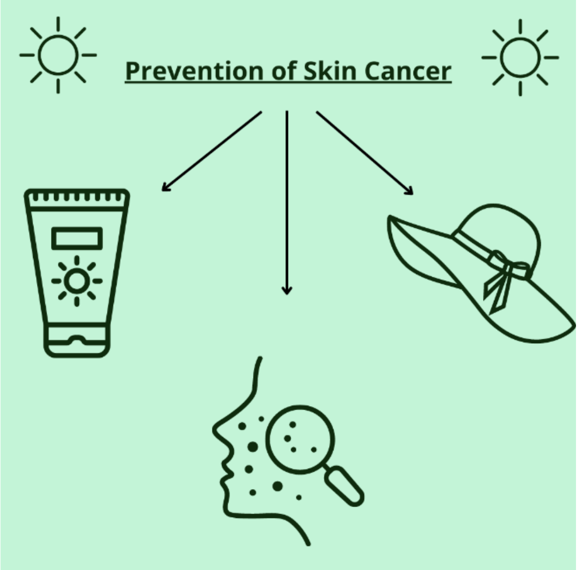
1.1 Prevention

A key principle in promoting sustainable clinical practice is prevention, in addition to patient empowerment, lean care systems and low carbon alternatives.[4] Prevention focuses on reducing or delaying the future potential need for healthcare resource consumption, thereby having a consequent impact on the whole healthcare system, in terms of disease, environment and financial burden.

Evidently, patient pathways and the average clinical encounter within dermatology results in energy and medical resource utilisation, as well as waste generation. Being a predominant outpatient specialty adds a further layer of consideration from a carbon footprint and energy consumption viewpoint. Namely, outpatient healthcare contributes significantly to the transport and travels sector in addition to energy utilisation. Over a 1 year period, the Dorset Renal Outpatient Service estimated a 22kg CO_2e of greenhouse gas (GHG) emissions per outpatient appointment based on the emission result from approximately 7800 appointments, taking into consideration building energy use, total travel, procurement, and waste.[5] This is equivalent of GHG emissions from 55.3 miles driven by an average passenger vehicle. In the NHS as a whole, travels and transports account for 14% of the total carbon emissions, with 5% and 4% attributable to patient travels and staff commutes respectively.[6] In Australia, with the highest incidences of skin cancer worldwide, dermatological surgery has contributed a total a total of 8641 tonnes CO_2e per annum[7] (equivalent to 944 homes annual energy use), according to a process-based life cycle assessment of Australia's mostly coal generated energy. However, this is likely an underestimation due to the study not considering Mohs micrographic surgery.

The importance of committing to prevention can be truly appreciated when considering the reciprocal relationship between global climate change and dermatology service provision. The exposure to elevated UV radiation, because of depletion of atmospheric ozone layer as well as the preference and increased outdoor activity with warmer climates, contribute significantly to the rising melanoma and non-melanoma skin cancer incidence.[8] This will in return contribute to the increasing need for dermatology review and surgery, consequently, impeding the decarbonisation of dermatology care pathways.

The Getting it Right First Time (GIRFT) approach has demonstrated improvement in patient flow and efficiency.[9] Across the



surgical specialties, the GIRFT methodology has saved 60 kilotons CO_2e emissions per annum via reduction of 918,117 bed days and prevention of 91,538 admissions.[9]

Focusing on community care expertise, confidence and knowledge building allows timely effective primary prevention. For example, in Norfolk 42 practitioners engaged in learning events focused on community treatment of actinic keratosis, which improved early practitioner confidence in identification, management, as well as a net annual cost saving of £32,200. Indeed, prioritisation of disease prevention and health promotion is deemed a cost-effective method to reduce morbidity and mortality, subsequently leading to wider socioeconomic and environmental sustainability.[10] Ultimately, this can lead to leaner secondary care pathways and prevention of progression into skin cancer.[11]

Skin cancer is one of the most common types of cancers and the incidence is on the rise with global climate change. The expected cost per case of malignant melanoma is estimated to be £2560, while non-melanoma skin cancer is £1226.[12] Whilst melanoma follow up appointments range from 2-16, depending on the staging of disease,[13] late presentation and metastatic progression incurs greater resource-intense multidisciplinary management and higher cost for systemic therapy. Thus, effective skin cancer prevention programmes play a crucial role in reduction of disease burden, as well as conserving NHS resources. A systematic review conducted by *Gordon et al.* demonstrated the high cost-effectiveness in skin cancer prevention initiatives as well as melanoma early detection programmes targeting high-risk populations.[14] Systemic sunscreen use at a population level has also been found to prevent new skin cancer and related deaths when compared with early detection of melanoma (life years saved = 0.09% and quality-adjusted life years gained =0.10%).[15]

Whilst intense skin cancer prevention initiatives require initial investment, stakeholder buy-in and a system-wide alignment in education and direction of resources, the benefits are numerous, and not limited to the environment.

1.2 Patient Empowerment

Patient-centred care and patient empowerment within dermatological surgery gives patients more control over their own health. This includes self-monitoring of dermatological conditions, enabling shared decision making, reducing the frequency of follow up appointments, and the consequent impact on the environment.[16]

The NHS Long Term Plan (LTP) dictates decarbonation of care pathways can be achieved through a reduction in patient presentations to emergency departments, primary care and outpatient services, reduction in staff travels and patient mileage as well as reduced pharmaceutical prescriptions and procedures performed.[3] Paramount to this is the patient-initiated follow-up (PIFU) model, which offers flexibility and convenience to patients to arrange for follow-up care and access service with support when they need it.[17] This allowed greater control over each individual's own health, reduced commute and waiting time and also improved overall carbon saving of the NHS. Hence, embracing change in care provision within dermatology is essential in aligning with the greater aspiration of the NHS in reducing carbon footprint.

The prioritisation of patient empowerment in the context of skin cancer also considers the utility of skin self-examination. Routinely, following treatment, melanomas of stage 1B and beyond will be provided with at least 5 years of follow up with intervals ranging from 3-6 months, allowing for monitoring of recurrences or new primary cancers.[13] Clinician-led surveillance is presumed to facilitate early detection and treatment of recurrence or metastatic disease.

***EMPOWERING** patient's with control over their own health*

However, despite the ongoing reliance on clinician-led surveillance, studies have suggested that there is no direct evidence that clinician-led surveillance leads to improved survival.[18] There is also increasing confidence in adopting patient-led surveillance in self-management of monitoring post-surgical excision with more support on SSE. Indeed, a limiting factor that arises is the quality of effective skin self-examination education and practice.[19] The MEL-SELF randomised controlled trial aimed to evaluate the use of patient-led surveillance in previously treated localised melanoma when compared to clinician-led surveillance to reduce the need for clinician-led follow up.[20]

Case Studies of Innovative Outpatient Care Across Various Specialties

The Royal College of Physicians (RCP) published a report "Outpatients: The Future" in 2018 to re-evaluate the delivery of outpatient services23. The report stressed on the collaborative effort and partnership with our patients in improving service efficiency and minimising environmental impact. Examples of environmental benefits through patient empowerment and transformation of services[21]

- Home immunoglobulin therapy service provided by the Peninsula Immunology Service at the University Hospitals Plymouth NHS Trust has allowed 44% of their patients to self-infuse immunoglobulin without the need to travel an average of 75 miles per round trip to a hospital appointment. A total of over 31 tonnes of CO2e per year was avoided with reduction in day case visits.

- Inflammatory bowel disease service in East Surrey Hospital introduced a web-based patient management portal called Patients Know Best in 2014 to allow remote communication with the team based on patient-reported symptoms. Around 650 patient hospital attendances per year were saved with the redesigned service, this was equivalent to a carbon saving of at least 60 tonnes CO2e.
- The Berkshire West Integrated Care System remodelled their renal service to ensure patients are triaged to the appropriate clinic. They also support primary care colleagues to avoid unnecessary clinic visits. One-third of the new outpatient appointments were avoided in the first 7 months. Over 4 tonnes CO2e was saved on patients' journeys and consultants' travel.

NHS approved mobile applications:

A number of NHS approved mobile applications have been developed to empower patients with self-skin monitoring. For example:

- My Melanoma App – joint venture between Melanoma UK, Royal Marsden NHS Foundation and Vitacess for patients to manage their condition and connect with the online Melanoma UK community. The application includes a symptom tracker, knowledge feature and community feature. Data collected will also be utilised in research development.[22]
- Miiskin – First artificial intelligence powered skin application designed to track skin changes and aid SSE.[23]
- MoleCare – NHS approved application to monitor and compare moles and raise awareness about skin health.[24]

1.3 Lean Pathways

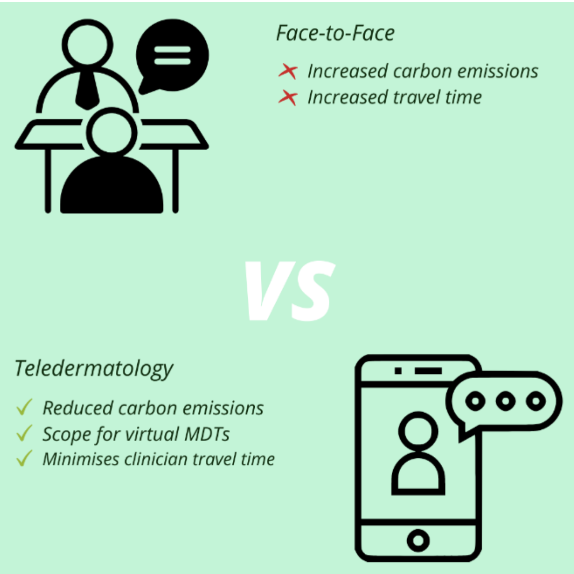
Lean care systems can be used in healthcare to provide better, safer healthcare in the least wasteful way.[6] Lean principles are well known with documented savings and productivity enhancements through the elimination of waste. Many organisations have found that a by-product of lean principles is enhanced "green" or environmental performance, even when lean activities were not initiated for environmental reasons.[25]

The use of lean patient pathways such as Teledermatology, 'See and Treat' clinics, and reduction of paper waste; can improve the environmental sustainability of dermatology services.

1. **Teledermatology *vs* in-person appointments**

Travel of patients, visitors and staff accounts for 18% of healthcare greenhouse gas emissions. Given the significant carbon emission contribution from the health and social care industry, and specifically the associated emissions from travel, visitors and staff, the role of teledermatology has become more critical in the shift towards sustainable skin surgery.[26]

A review of sustainability within dermatology, conducted by Allwright and Abbott, recommended providing healthcare closer to home to reduce patient travel distances.[27–29] Reduced carbon emissions are appreciated where teledermatology has been used as an alternative to face-to-face consultations, directly for that specific clinical encounter, as well as indirectly, through reduced referral rates.[27–29] A teledermatology programme evaluated by Vidal-Alaball et al[30] demonstrated an estimated reduction in carbon emissions by 21 tonnes over a period of 18 months. A more recent study



from Ireland by O'Connell et al, looking at the environmental impact of the Covid-19 pandemic showed a reduction of 15.37 metric tonnes of CO2, over a 3-month period in 2020.[31]

Overall, a large range of skin cancer teledermatology models have been developed nationally and are recommended in the recently published NHS Teledermatology Roadmap for 2020-2021.[32] Indeed, appropriate technology is a prerequisite to optimally facilitating timely teledermatology services. High quality dermoscopy images sent from GPs, in a Leeds and York pilot, have found approximately 10-30% of cases can be managed without a face-to-face consultation.[33] Further, in a Welsh study, the use of peripheral medical photography hubs for teledermoscopy, showed a striking 86.3% reduction in the need for FTF clinical attendance for skin lesions.[34]

2. **'See and Treat' on the same day services**

To meet the governmental aims of reducing wait time for surgery and outpatient appointments, many departments opted to use one stop 'See and Treat' services. Whilst there are significant improvements in wait time between referral and surgery, for example from 121 days to 60 days,[35] there are also other apparent positive externalities.[36–38] For example, no difference in the rates of complete excision of malignant and premalignant lesions between the two groups, with overall patient satisfaction of 95%.[35]

Despite there being a paucity in evidence of an environmental benefit, this can be appropriately extrapolated by virtue of the reduced total number of outpatient attendances.[36] More comprehensive evaluations of the impact of reduced encounters on efficiencies, include the absorption of transfer time, late arrivals, and failed encounters. Further, the expedited patient access to surgical services, reduces the risk of potential skin cancer progression or transformation.[37] On the whole, the 'See and Treat' service aligns closely with the principles dictated by Michael Porter's value-based healthcare model, of which carbon utilisation is a key facet.[39]

3. Minimising missed appointments

Missed appointments are a major cause of inefficiency in healthcare delivery with substantial monetary costs for the health system, leading to delays in diagnosis and appropriate treatment.[40]

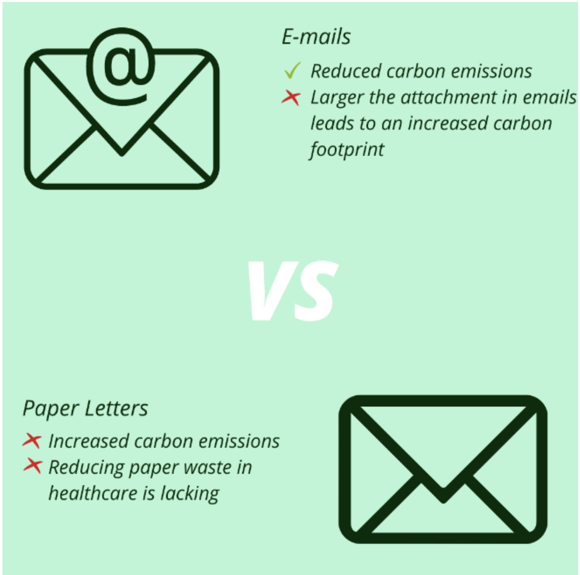
The RCP have divided the causes of missed appointments into two factors – administrative or convenience related.[41] Administrative factors include clerical errors in communication, difficulty in appointment cancellation, lack of appointment notification or no longer requiring an appointment. Alternatively, convenience factors include distance, cost, getting leave, childcare, organisation of clinics, time of appointment, transport and parking facilities.[41]

Whilst an older 2012 Cochrane review of mobile phone messaging reminders for appointments showed low to moderate quality evidence that text messaging reminders increase attendance compared to no or postal reminders,[40,42] more recent evidence conflicts this. A 2016 systematic review and meta-analysis concluded that not only was attendance improved, but that this could be further improved by sending multiple notifications.[43] This may be owing to the increased reliance on mobile technology.

If aligned with patients' preferences, texting appointment reminders to patients may represent a simple and efficient option for dermatology services to minimise missed appointments, thereby taking the pressure off already strained services and reducing unnecessary staff travel, further contributing to a lean pathway.

4. Use of email rather than postal letters to minimise paper waste

Data pertaining to the specific impact of reducing paper waste in the healthcare setting is lacking. The average letter has a carbon footprint of approximately 29 grams of CO_2, vs a normal text email footprint, which is approximately 4 grams of CO_2.[44,45] It, therefore, follows that, in general, emails may carry a lower carbon footprint than posted paper letters. Indeed, this assumes that emails are not subsequently printed. Also, if an email contains an attachment, it is important to bear in mind that the larger the attachment, the more energy consumed – a large attachment could have a footprint of up to approximately 50 grams CO_2.[44,45]



2. Reduce Carbon Intensity

2.1 Low Carbon Alternatives

2.1.1 Cosmeceuticals

Over a fifth (22%) of the NHS carbon footprint is related to the procurement of pharmaceuticals.[26] However, there may be opportunities to source local suppliers in order to reduce transport costs and carbon emissions.[46] The average cost of a wasted prescription for 4 weeks is £34 (15 kg CO_2eq) based on manufacturing processes, materials and packaging,[29] this is comparable to 88 km in an average car releasing 0.17 kg CO_2eq/ km.[47]

The pharmaceutical industry plays an important role within the field of dermatology. Whilst increased legislation has facilitated a larger amount of higher quality reliable formulations, it has also led to a decline in local dermatologist or pharmacist compounding, and international mass-manufacturing of private cosmeceuticals.[48]

To overcome the environmental burden of the pharmaceutical industry, it is important to first question if the department is engaging in overtreatment of dermatological conditions, where there is minimal to no incremental benefit in patient outcomes.[49]

Furthermore, from the patient perspective, increasing awareness through carbon footprint product labelling or patient information leaflets (PILS) describing the environmental journey of a product. Also, for example, educating patients on how to read pharmaceutical packaging to understand the shelf life of items and what can and cannot be recycled. Utilising market forces, skin surgery departments and the wider NHS can lobby for environmental labelling on pharmaceuticals and skincare products, as well as within legislation.[50,51]

2.1.2 Transport

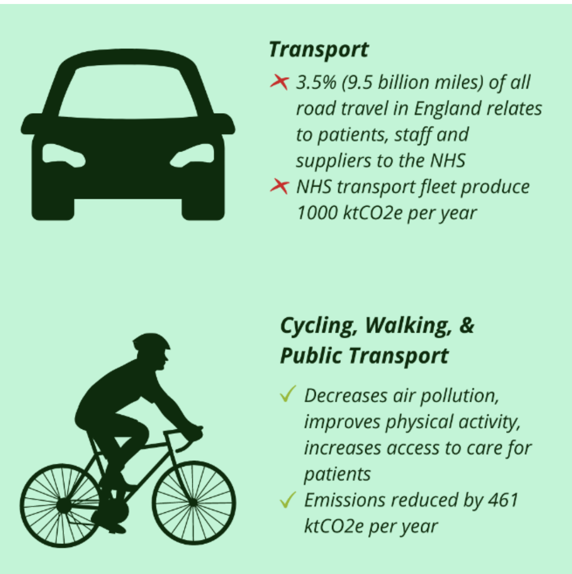
Approximately 3.5% (9.5 billion miles) of all road travel in England relates to patients, visitors, staff and suppliers to the NHS, contributing to 14% of the system's total emissions.[6] This is inclusive of 4% for business travel and fleet transport, 5% for patient travel, 4% for staff commutes and 1% for visitor travel. Additionally, the NHS transport fleet is reported to produce emissions totalling approximately 1000 ktCO2e per year.[52]

The large multidisciplinary team involved in skin surgery, as well as patients, can be encouraged to shift away from the use of cars and towards cycling, walking and public transport. This can decrease air pollution, improve physical activity and increase access to care for patients, reducing emissions by approximately 461 ktCO2e per year.[52]

Methods include car sharing schemes, bicycle parking spaces, reward schemes, travel reimbursements, working from home when possible.

National measures introduced to reduce the transmission of COVID-19 resulted in an increased number of individuals working from home, minimising travel and utilising technology.[52] Early estimates suggested that moving outpatient appointments online could have avoided 58,000,000 miles over three months' worth of travel.[52] Although Dermatology appointments comprise a fraction of this figure, this equates to a mass amount of carbon emissions.

With the advent of NHSX, teledermatology, artificial intelligence and medical photography, transport required could drastically be reduced within Dermatology patients to be triaged and seen.[53] Novel smartphone programmes could equip patients and community practitioners with the ability to communicate to Dermatologists remotely, minimising the need for transportation.

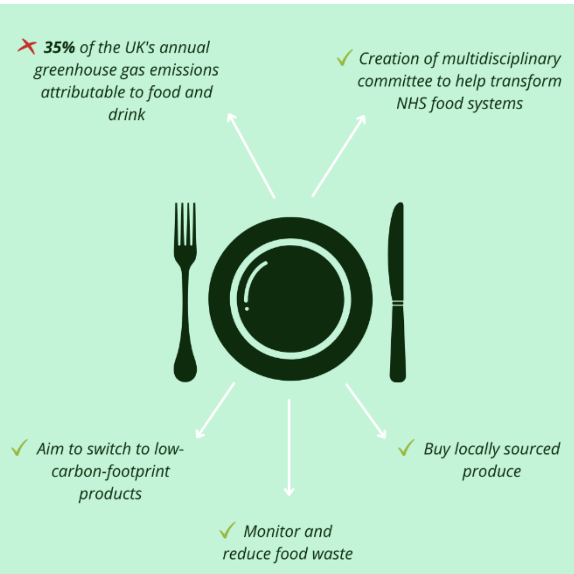


2.1.3 Food

Around 35% of the UK's annual greenhouse gas emissions are attributable to food and drink.[54] Within food-related emissions, 23% are the result of food waste.[54] A combination of dietary change and food waste reduction strategies can make a significant contribution to reducing the carbon footprint of our food systems and in improving food security.[55] The Lancet Commission on healthy and sustainable diets highlights the co-benefits of switching to diets high in products with a low-carbon footprint (pulses, nuts, seeds, fruits and vegetables) and low in carbon-intensive animal products (red meat and dairy products).[56] Notably, the carbon footprint from food is a generic NHS sustainability consideration and should be addressed at a national policy level, however, it is included here to allow teams to be mindful of simple local strategies for implementation.

As the UKs largest employer, the NHS has the power to help facilitate dietary transformation and, as a public body, is also committed to reducing its emissions under the Climate Change Act 2008,[57] which includes transforming its food systems. A report by the Independent Review of NHS Hospital Food made several recommendations as to how trusts can 'go green'. These include adhering to government sustainable procurement guidelines, monitoring and reducing food waste, buying locally sourced produce, and gaining sustainability accreditation for catering kitchens.[58] Given that 25% of hospital waste is thought to be related to food, the importance of reducing food waste in healthcare cannot be understated. The independent review on NHS hospital food also recommends the creation of a multidisciplinary committee to help transform NHS food systems, which could provide an opportunity for individuals to contribute to wider changes to the food systems within their trust.

Many hospitals are now transforming their catering facilities. Southampton University hospital now has a regular 'meat free Monday' across their catering services, whilst other hospital caterers are working towards gaining sustainability accreditation awards.[59,60] Improving the sustainability of our diets can have the co-benefit of providing an opportunity to improve dietary health. The Royal Bolton Hospital has worked to restrict access to high fat, salt and sugar items within vending machines in their trust. This included limiting the calorie content of the items available, limiting the size of chocolate bars available and removing items such as flapjacks which may be falsely interpreted as a healthy alternative.



Changes can also be made at a departmental and individual level. Reducing food waste within dermatology departments may be facilitated through the provision of better kitchen facilities and refrigeration, as well as educational posters. Waste and Resources Action Programme (WRAP) provides resources for a 'your workplace without waste' campaign, which could be utilised to help increase departmental awareness about food waste.[61]

Transforming food systems within the NHS will require a top-down approach that is likely to occur largely at a managerial level. However, staff may act as environmental stewards by asking for healthier and more sustainable options within their trust or becoming involved with trust committees aiming to promote healthy, more sustainable eating.

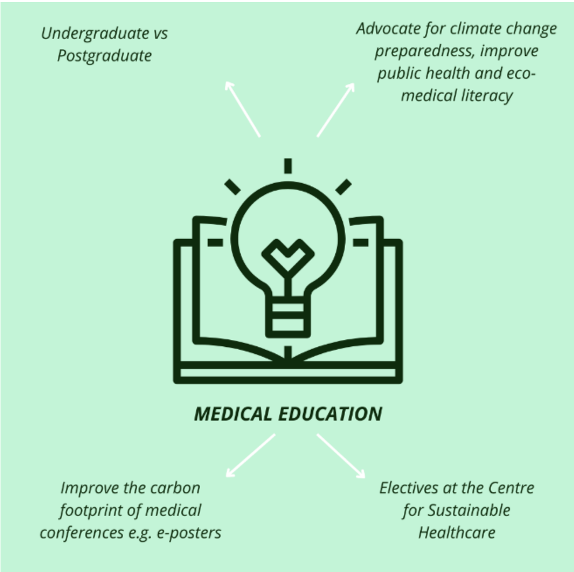
2.1.4 Medical Education

Despite the increased attention on climate change within the healthcare domain, little focus has been put into addressing the gaps in undergraduate and postgraduate medical education.

There is an increasing emphasis on learning about environmental health in the undergraduate level. In the UK, the GMC stated newly qualified doctors need to have learnt about sustainability and environmental health.[62]However , this is not mandated in the curriculum internationally. In the few medical schools which offer some form of exposure in environmental health, the inclusion of environmental health in the dense medical curriculum was thought to be challenging.[63] However, medical schools should be encouraged to spearhead climate change education and eco-medical literacy among students via integration of climate change teaching into current curriculum. Medical schools should also advocate for climate change preparedness, improve public health and eco-medical literacy, as well as strengthen graduate attributes.[64] Organisations such as the Centre for Sustainable Healthcare are leading the way by offering 4-8 weeks practical elective placements for medical students around the world to provide first-hand experience in green initiatives.[65,66]

Another major area within medical education with a large carbon footprint is medical conferences. Every year, more than tens of thousands of medical conferences across all specialties are held worldwide for healthcare professionals to learn about latest breakthroughs, broaden clinical knowledge, network with colleagues and improve clinical practice, however, these benefits should be balanced with their environmental impact.

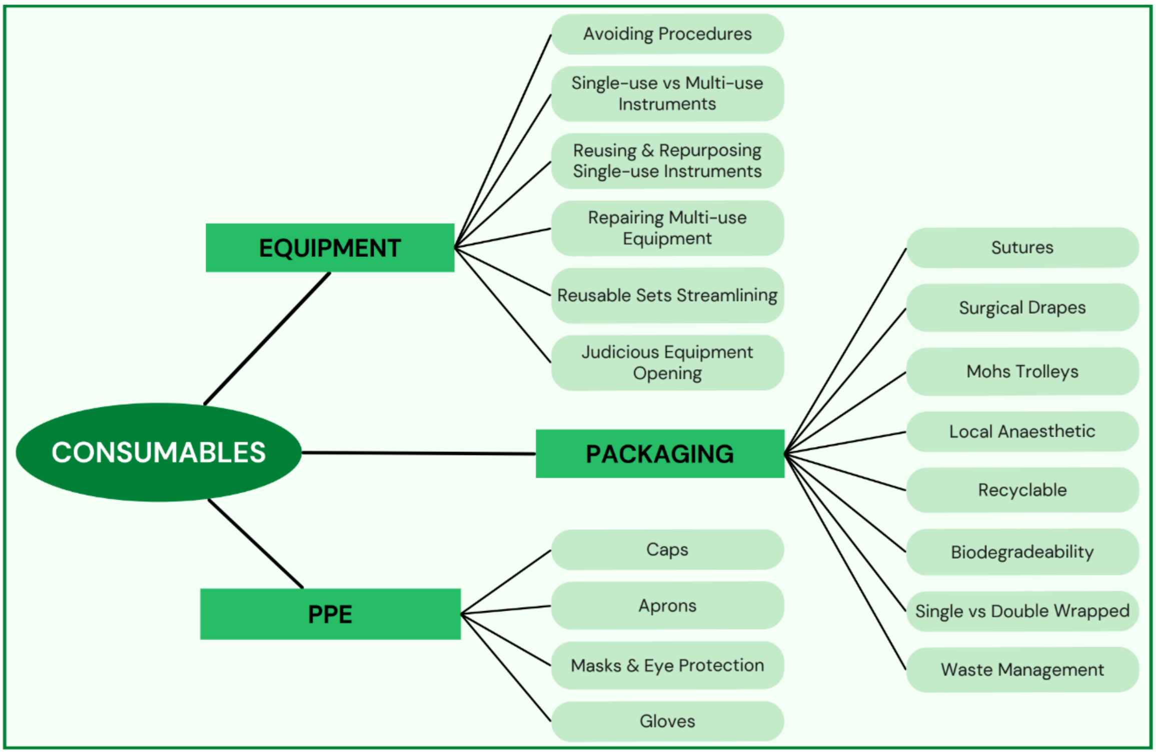
International conferences lead to hundreds of attendees flying intercontinentally and use intensive energy in hotels and conference venues. Also, the use of catering services provides plentiful amounts of carbon-intensive food wastage, as well as utilisation of disposable cutlery or cups. A retrospective review of the significant carbon emissions from previous American Psychiatric Association annual meetings estimated an equivalent of burning 500 acres of dense forest.[67] Nevertheless, it is possible to become carbon neutral. A successful organisation that has achieved a carbon-neutral and environmentally responsible conference through reducing avoidable emissions and waste and using offsetting as a last resort, includes the International Federation of Medical Students' Associations in 2018.[68] A retrospective review on the impact of COVID-19 pandemic on international dermatology conferences in 2020 emphasised that virtual and hybrid conference formats are environmentally friendly, time and cost saving.[69] The BSDS Clinical meeting in March, in line with this consideration, was held virtually. Indeed, the in-person British Association of Dermatology July 2022 meeting is also focusing on reducing the environmental impact of the meeting and is astutely being held at the home of the COP26, the SEC Centre, in Glasgow.[70]



2.2 Operational Resource Use

2.2.1 Consumption and Waste

2.2.1.1 Consumables



<u>**Equipment**</u>

Avoiding Procedures

Avoiding unnecessary procedures will improve sustainability. As the Dermatology GIRFT Programme National Specialty Report highlights there is wide variation across English providers regarding biopsies prior to definitive treatment of skin cancers.[71] Data highlights these can range from <10% to up over one third of lesions being biopsied within 6 months of extirpation depending on the provider.[71] Sometimes, skin biopsies in dermatology confirm the clinical picture and may add little or are booked when a simple excision would have provided both a diagnosis and definitive treatment. Judicious use of procedures will avoid unnecessary use of equipment, clinician time, patient travel, and excess waste.

Furthermore, procedures such as curettage and electrodesiccation are used when the diagnosis is not in doubt, but a less resource-intensive approach could have been used such as topical therapies or cryosurgery. Indeed, some low-risk lesions can be left if the diagnosis is clear given the risk to the patient is very low and treatment may result in more morbidity than the condition - e.g. low risk site sBCC, Bowens, and AKs.[72] Patient, visitors, and staff travel account for 18%

of healthcare greenhouse gas emissions, so efforts to reduce this activity will improve the healthcare carbon footprint - this involves reducing unnecessary appointments and procedures as highlighted by the Dermatology GIRFT Programme National Specialty Report.[71]

Changes can be made in secondary and primary care to facilitate this. Within secondary care, this may involve greater supervision of junior colleagues and allied health professionals which reduces the likelihood of unnecessary diagnostic procedures being performed.[73] Within primary care, a focus on adhering to local agreed referral pathways and checklists to minimise inappropriate referrals and increase in utilisation e-advice or teledermatology services prior to referral.

Single-use vs Multi-use Surgical Instruments

Within surgery, there is increasing unease about the use of single-use instruments from a sustainability and ethical perspective and the carbon footprint of surgery overall.[74,75] Historically, single use instruments have been preferred due perceptions regarding sterility and effectiveness of instruments, such as their sharpness.[76,77] Subjective evidence indicates that concern about the quality of reusable instruments could lead to the use of multiple reusable instruments per case which could be an unnecessary waste, but also concern about inferior instruments resulting in inferior cosmetic outcomes.[76]

With regards to sterility, an article published by the Royal College of Surgeons in England recommended that single use items should be reserved for when there is evidence demonstrating the risk of infection, the risk associated with reusable equivalents, or when there is no reusable alternative available.[66]

Many studies document that the carbon footprint of reusable items used in surgery, such as scissors, gowns, drapes and sharps bins, is lower than that of single use items.[77] The reduced environmental impact of reusable items in comparison to single use items must be balanced with the financial and environmental cost of sterilising and reproducing reusable surgical items for reuse. An Indian study calculated the costs of sterilising a minor operative set typical to that used in dermatology; the total costs to process each set was $1.35, including 2.485 kWh ($0.41) of electricity, water costs of $0.04, and consumable costs (sterilisation fluid, packaging, etc) $0.48, furthermore, labour and depreciation costs were also included.[78] In the UK the cost of autoclaving a 10-piece carpal tunnel release set (similar size to skin surgery set) was calculated at £11.77.[79]

Hybrid instruments are those which are mostly reusable but have some components which are single use. A study looking at the cost of hybrid versus single use instruments in laparoscopic cholecystectomy found that total cost of using hybrid instruments was less than half in comparison to using single use equivalents (GBP £131 vs £282). In addition, it demonstrated that the carbon footprint of using the hybrid instruments was approximately 25% of the carbon footprint of the single use equivalents.[77] Labib et al's unpublished results comparing cost and carbon footprint of reusable and single-use instruments for laparoscopic appendectomies found initial costs were higher, but overall cost and carbon footprint was lower. For example, reusable scissors cost £998.23 with a carbon footprint of 1.873kgCO2e versus £24.00 with 0.475kgCO2e, but since the reusable device can be used for at least 500 times, the overall carbon footprint and costs were lower (£2.00, 0.004kgCO2e per use). Notably, this does not include the costs of sterilisation - including transportation and personnel. However, using the values from Basu et al we can go some way to realise the environmental impact of sterilisation.[78] In 2021 in the UK 2.485kWh of electricity had a carbon footprint of 0.522kgCO2e and 6.67L of water equated to 0.00199kgCO2e per set. This would give a cost of 0.534kgCO2e per use of a reusable set but excludes the carbon footprint of consumables and personnel. These calculations are crude given the lack of other variables, and notably for single-use instruments do not include the cost of incineration of the sharps bin - which is where most single-use instruments end up - including transportation and subsequent waste management which will also have its own carbon footprint. In fact, the sharps disposal costs are the highest-cost waste-category costing financially £1000-£1200/tonne. Furthermore, in the UK the national grid becomes cleaner every year with a subsequent reduction in the carbon footprint of a kWh, so the electricity footprint of sterilisation is reduced each year.

Given the many variables of different clinical settings and procedures, and cost, the environmental savings are difficult to apply more generally. For example, a study evaluating the economic impact of single-use procedural packs in total knee arthroplasty in the USA found that the cost of single use compared to reusable instruments was considerably less, with the median cost saving per case being $994; the main cost saving factor was the cost of sterilising equipment.[80] However this study did not evaluate the potential environmental saving of using the reusable items. Further research is needed to compare these outcomes for single use and reusable instruments in the context of dermatological surgical procedures.

Reusing and Repurposing used Single-use Instruments

Despite items being labelled as single use, evidence suggests that globally many are reused in the clinical setting and repurposed for other uses. Potential risks of reuse include possible risk to patients, the cost of reprocessing single use devices, and legal liability problems.[81] A study in the USA demonstrated that awareness of this practice by both patients and clinicians is low.[82]

A systematic review published in 2008 highlighted how there is a lack of direct evidence of reusing single use devices on patient outcomes. A survey of Canadian hospitals reporting that 40% of those that reuse single-use devices do not have a written policy on doing so.[81] In Australia, a study found that reuse of single use devices was common, but 41% of hospitals in the survey did not have satisfactory cleaning or sterilisation, increasing the potential risk of transmissible infection. The primary reason for reuse of devices was cost saving.[83] Reusing single use devices is more common in developing nations.[84]

With regards to repurposing single use items, creative initiatives in the USA have included using items in art displays or using surgical blue wrap to create items such as sleeping bags. These initiatives can help to raise awareness of sustainability projects and promote staff engagement with sustainability.[84]

Repairing Multi-use Equipment
When reusable instruments become blunt or ineffective, rather than being tolerated or being circumnavigated, if these pieces of equipment are marked, then surgical devices unit can service, repair or re-calibrate them.[85] Indeed, this requires staff prompt engagement with trust reporting mechanisms for instruments that need repair, but this is dependent on individual trust policies.

Streamlined use of Reusable Sets
Studies in surgery demonstrates that as much as 87% of the instruments in surgical sets are not actually used during the operation.[82,86] Each instrument costs an estimated $0.51-3.19 to fully reprocess including labour, cleaning, repackaging, and running costs.[82,87] . By streamlining the contents of a set, less instruments require reprocessing; this is more environmentally friendly and less costly. Basu et al highlighted minor procedure instrument sets are four-times less resource-intensive (electricity and water) to clean and process than surgical procedure sets - highlighting the environmental benefits of streamlined sets.[78] Wernham and colleagues reported the streamlining of their Mohs surgical sets to reduce less-used instruments which can be requested as single items.[88] A systematic review in paediatric surgery demonstrated sets could be reduced by 40-70% and this yielded cost savings of 20%.[89] The process of streamlining surgical sets in a single-centre for orthopaedic surgery not only reduced the environmental footprint, but saved 20% in costs overall - amounting to over $270,000 cost savings.[90] Bespoke instrument sets can be organised for different procedures in order to streamline the instruments and provide the most suitable equipment. Furthermore, important but less used instruments can be supplied as singles.

Judicious Opening of Equipment
In a French study of wasted supplies in various surgical disciplines, 33% of waste was caused by supplies being prepared in anticipation of the surgeon's needs, but not used.[91] Furthermore, equipment such as sutures were opened pre-emptively at the beginning of surgery 37% of the time.[91] It would be much more

resourceful to wait for specific phases of the procedure to confirm the correct equipment. In a survey 68% of 60 health professionals agreed that knowing supply costs would change their behaviour to waste and that the most appropriate way to prevent waste was team communication.[91] Furthermore, for unused clean sutures they can be kept and used for educational purposes.

Packaging

Sutures

The use of absorbable suture materials for surface sutures in dermatology has been building particularly since COVID-19.[92] A meta-analysis of 19 RCTs involving 1748 patients of absorbable vs non-absorbable sutures for skin closure demonstrated that SSI were not significantly different, and there was also equivalence in other domains such as dehiscence and cosmesis.[93] These findings are echoed in other meta-analyses and primary studies.[94–97] Given using absorbable sutures are not made of plastic, are cost-equivalent, and do not involve the travel, inconvenience, and health professionals' and admin team's time for suture removal (and further consumables), clinicians should consider using these in preference to non-absorbable sutures for wound surface closure. This includes advanced reconstructions including flaps.[95]

Surgical Drapes

The discussion around the use of reusable surgical drapes in surgery has already begun.[75] The WHO suggests in non-dermatological surgery that either disposable or reusable drapes and gowns can be used.[98] However, there is evidence that clean drapes in dermatological surgery is sufficient. A prospective study of 1000 patients undergoing MMS for 1204 tumours using clean gloves and surgical drapes as opposed to sterile and a single set of instruments for MMS stages and reconstruction demonstrated an overall SSI incidence of 0.91%.[99] The risk for flaps was highest 2.67% (4/150) which was still nonetheless low.[99]

Using Same Trolley in MMS

During MMS, one study highlighted very low risk of SSI when keeping the same trolleys and instruments for extirpation stages of MMS and also reconstruction.[100,101] Specifically, SSI was 2.1% 7/332 overall.[100] Preserving the instruments on a trolley for each patient rather than switching them for Mohs layers and for reconstruction would be substantially more sustainable.[74] Enacting this change would make a huge difference for the sustainability of the Mohs procedure since it would remove the need for at least one change of the entire set of instruments (the reconstruction stage) and associated packaging and drapes, and could remove the need for several instrument changes for patients requiring follow up Mohs stages. However, despite the benefit of using one trolley and set of instruments this must be employed in the context and suitability of local factors. A robust setup must be employed if the same instruments are to be used across the course of the day, in order to mitigate risk of the wrong instruments being used.[102] Depending on the operative setup, this risk could be negligible - i.e. patients stay in the same procedure room with their instruments across the course of Mohs procedures.

Drawing up Batch of Local Anaesthetic
As has been reported, local anaesthetic with dilution can be batch prepared. In some circumstances, making up a large volume of local anaesthetic avoids using more needles and syringes, and other consumables and is more time-efficient than individually preparing anaesthetic per patient.[103] The utility of this is best assessed in a case-by-case basis.

Procuring Products and Labelling of Recyclable Packaging
Products, prescriptions and devices used with dermatology and dermatologic surgery have been demonstrated to have generally poor and inconsistent labelling regarding recycling.[88,104,105] This results in staff and patients not being confident in recognising what products can be recycled, and so can result in the inappropriate disposal of waste. In addition, some packaging is not able to be recycled at all, for example, aluminium sachets of sample products, packing containing mixed plastics and pump heads containing metallic parts.[104,105] Evidence suggests that product information provided about recyclable materials is poor and there is a lack of transparency regarding this issue.[104] This is a clear area in need of improvement, as we know that having clear labelling on packaging can help promote recognition that a product can be recycled.[104] NHS purchasing power can help incentivise recyclable packaging and appropriate labelling with suppliers and providers.[88]

Bioplastics and the Biodegradability of Plastics
Bioplastics are plastics derived from natural resources, rather than the much more commonly used thermoplastics (such as polyethylene terephthalate or PET) which contribute to 60% of the total plastic demand in Europe. Bioplastics can be further differentiated on their biodegradability.[106]

The majority of plastic produced globally is single use, with 40% of this ending up in packaging. Moreover, in the EU, 70% of collected plastic waste is either incinerated or put into landfill - hence why reducing unnecessary plastic packaging and addressing the type of materials used for packaging should be addressed to reduce pollution and promote a sustainable circular economy.[88,107]

Changing packaging to biodegradable types could further reduce the carbon footprint of surgery, however this should be considered in synergy with promoting reuse of plastics and reducing the amount of plastic waste, rather than an excuse to allow us to continue in our current habits.[106]

Single vs Double Wrapped Surgical Equipment
It is crucial that surgical items are packaged in a way that maintains their sterility. There are variations in the methods used to do this, with single or double wrapping methods used.[108] In

addition to sterility, package costs and labour costs should also be considered. Indeed, alternatives to wrap are also being increasingly employed by sterilisation units, such as reusable metal containers which yield cost and carbon savings.[109]

A small study in Australia was conducted on 400 packs containing 1199 items to assess whether a single wrap with Kimguard sterile wrap was more or less effective than a double wrap with linen and the sterile wrap. Results demonstrated that the single sterile wrap carried no greater risk of bacterial contamination of the items inside the pack, and additionally resulted in cost savings from reduced packaging and reduced labour costs associated with double wrapping.[110] A second study in Germany had similar results, demonstrating that a single sterile wrap was the most cost-effective packaging method in their cost analysis of packaging of sterile items.[108] A third study demonstrated that wrapping autoclaved orthopaedic screws in either a double-wrap of linen or a wrap of paper and then a paper-plastic outer envelope did not affect bacterial contamination, with no organisms being cultured from the screws in either group after 96 weeks.[111]

Recycling and Waste Management of Surgical Consumables

It is estimated that 59% of the NHS carbon footprint is associated with its supply chain, with operating theatres being a significant contributor given that they are resource-intensive environment.[66] Waste is an important factor in the carbon footprint of hospitals and choosing the correct waste recycling stream for defunct consumables and packaging not only makes the least environmental impact but also the least fiscal cost.[112]

A service evaluation in the UK in a single centre highlighted the many opportunities within a dermatology department to improve sustainability, with waste management being one of them. They demonstrated that in their dermatology department 0.31kg of non-sharps waste was produced per procedure, all of which was disposed into orange clinical waste bags which were then incinerated. On reintroducing recycling bins into their procedure rooms they found that 16% of total non-sharps waste could be recycled as per local recycling policy.[113] Improving waste management in dermatology could have a significant positive impact on sustainability by reducing the carbon emissions from unnecessarily incinerating recyclable waste.[27] A significant proportion of operative room waste is recyclable.[27,114] However, it has been demonstrated that many staff are not able to easily recognise what items can be recycled; improved labelling of items, clear segregation of waste management systems and education initiatives could help to improve recycling uptake.[84,115]

PPE

Caps

The evidence demonstrates that the use of reusable surgical cloth caps results in no obvious increase in SSI.[116] In fact, washable cloth surgical caps produce less microbiological shedding to disposable bouffant hats.[117] Given the low risk of SSI in dermatological outpatient surgery in general, there is little in the way of evidence to dismiss the use of reusable cloth caps. In other disciplines the cloth hats are a recommended option for use in theatre.[118]

Environmentally since cloth hats can be home-laundered and reused they are a sustainable option, far more than the disposable options which not only use resources to produce, but are discarded after each session. Cloth surgical caps can also have names embroidered on them improving communication in procedural settings.[119,120]

Aprons

In a UK survey of 41 Mohs surgeons 85.4% did not use sterile gowns during Mohs for the tumour extirpation stage and 82.9% for the reconstructive stage of MMS.[101] In a study by Lilly and Schmults 670 patients underwent MMS via a low-cost infection control protocol, including use of MMS expiration stages with clean gloves and scrubs without sterile gowns being worn for Mohs stages and reconstruction demonstrated wound infection rate of 0.7% compared to 0.9% SSI of 585 patients on a higher cost protocol including sterile gloves and gowns throughout.[121] Given the significant cost difference and resource input for these disposable items it would appear that given the lack of any significant difference in SSI that clinicians migrate to polythene aprons.

Masks and Eye Protection

A Cochrane review in 2016 with three RCTs with 2106 patients concluded that there was insufficient evidence to recommend or refute the use of disposable masks during clean surgery from a perspective of SSI.[122,123] There was no significant difference between SSI between the masked and unmasked groups.[123] That said, masks offer personal protection and in the era of COVID-19 reduce the spread of the virus.[124–126] Postoperatively, the incidence of facial blood splatter occurs in 15-35% of dermatological operations and thus it is important that measures are taken to protect ourselves.[124,125,127] The use of reusable masks has been demonstrated to reduce respiratory aerosol and also acts as protective barrier against blood splatter.[128] There is evidence to suggest that after 4 hours of use there is significant bacteria accumulation inside both previously sterile disposable masks and reusable masks.[129]

Gloves

Sterile gloves have been standard practice in dermatological surgery for some time. The evidence however, for their use in dermatological surgery in particular has been called into question. A systematic review on the use of sterile vs non-sterile gloves in cutaneous surgery suggests that sterile gloves may not be required. The systematic review and meta-analysis from 2016 included 4 RCTs and 5 comparative observational studies totalling nearly 10,000 patients. SSI occurred in 2.2% (97/4404) of procedures undertaken with non-sterile gloves in contrast to 2.2% (119/5448) with sterile gloves (p=0.88) in cutaneous surgery (including MMS).[130] The RR of SSI was 1.02 (95% CI, 0.78-1.34) between arms.[130] Specifically for MMS procedures the RR was 1.15 (95% CI, 0.68-1.97) with 1 RCT and 5 observational studies, with recorded SSI in 1.3% (35/2760) of procedures with non-sterile gloves vs 1.1% (23/2139) with sterile gloves (p=0.60).[130] However, it is noteworthy that for some of these studies the use of non-sterile gloves was limited to taking MMS stages, with sterile gloves donned for reconstructions.[121,131] Furthermore, the breadth of the studies included emergency department traumatic wounds.[132,133] Despite these limitations, other studies have confirmed particularly in the MMS setting that non-sterile gloves for reconstructions can be employed with a low rate of SSI (0.91-3.3%).[94,99,134,135] The risk of SSI with non-sterile gloves with more complex reconstructions could be higher than simple excisions however, there is large heterogeneity in reported SSI (2.67%-14.7%).[99,136,137] Furthermore, even with sterile gloves the risk of SSI is higher in complex reconstructions compared to primary closures.[136,138] The low risk of SSI using non-sterile gloves in conventional dermatological surgery studies confirmed from a number of studies.[135,139,140] Non-sterile gloves are cheaper and more sustainable. A study highlighted that switching from sterile gloves ($2.45) to non-sterile ($0.1) would save $11,750 per every 5000 patients.[141] Moreover, latex sterile gloves have 11.6x the climate change impact than non-sterile gloves.[142] Sterile gloves are more resource intensive to produce than non-sterile, with greater packaging used, produced using more water, and production results in more pollution.[142,143] Switching from sterile to non-sterile gloves would result in an 80% reduction in environmental impact across multiple domains.[142]

Finally, the use of double-gloving has been a practice for perceived higher risk procedures. A study evaluating the use of glove perforation in dermatological surgery demonstrated 3.0% (20/660) of sterile gloves had perforations postoperatively.[144] Similarly, in 2.3% (8/350) non-sterile gloves a perforation was identified following shave biopsies.[122] From an older study in dermatological surgery here is evidence to suggest double-gloving does reduce the risk of sterile glove perforations, with none of the 54 double glove pairs having both inner and outer layers punctured compared to 5.5% of 144 of single glove pairs.66 That said, the use of double-gloving uses more resources, reduces manual dexterity and is more costly.[145] Circumstances for the use of double-gloving depend on the procedure, practitioner factors, and patient factors, however, routine use is best avoided.

2.2.1.2 Electricity

Research has shown that theatres use three to six times more energy than the hospital as a whole, primarily due to heating, ventilation, machine electrical expenditure and air conditioning requirements.[146] The central concept of initiatives which aim to reduce surgical waste is to avoid using resources which are not needed; this includes turning off machines and lights, only ventilating theatres when occupied.[146]

Kagoma et al. (2012) reported that theatres may be unoccupied 40% in a 24-hour period, thus changing lighting from halogen to light-emitting diode (LED) lights, which reduce lighting energy by 49%, provides an efficient alternative.[147] Additionally, renewable energy sources of electricity, as outlined in the NHS Net Zero proposals, will also provide solutions for reducing theatre carbon footprints.[148]

2.2.1.3 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 for the main form of hospital communication.[149] This initiative is still ongoing and results in a reduction in the waste of paper, as well as the environmental impacts of producing paper, including deforestation, water consumption and energy; for example, producing 1 kilo of paper requires 2-3 times its weight in trees.[150]

2.2.1.4 Surgical Waste

Analogous to the rest of the hospital environment, theatre waste is broadly divided into clinical and general waste. Clinical waste includes infectious or pathogenic waste, sharps, pharmaceutical material, cytotoxic and radioactive.[115] Contaminated or infectious clinical waste requires expensive and energy-intensive autoclave treatment before it can be safely transferred to landfill; therefore, appropriate segregation of waste at the time of generation, ensuring that non-biohazardous waste is not treated as hazardous waste via clear labelling, is vital for reducing carbon footprint. McGain et al. conducted a prospective audit across six theatres over one week and found that 45% was general waste, 32% clinical waste, and 23% recyclable waste (cardboard, paper, and plastics); of the general waste, 40% was paper or cardboard and 58% plastics, meaning that one-third of clinical waste was in fact general waste, with most of the paper and cardboard being discarded without transfer to recycling bins.[151] Appropriate disposal of sharps is also vital; the space-occupying characteristics of glass bottles accelerate the filling of sharps bins adversely impacts financial and environmental costs of waste disposal of these items.[115] Macneil et al. investigated the carbon footprint of surgery across three hospitals in three different countries, and found that whilst segregation practices vary, guidelines can be reshaped to include more stringent definitions of hazardous waste, resulting in a smaller proportion of theatre waste being disposed.[146] For example, surgical gowns and drapes that are not heavily soiled with bodily fluids could be excluded from hazardous waste, whilst working with local waste companies can help reduce road miles.[146,152]

Wernham *et al*. found that annual carbon emissions from material waste alone were 26kg CO2eq for one treatment centre, which amounted to 644 kgCO2eq across 25 UK centres.[153] Pre-packaged supply kits may also result in waste as often parts of these kits, such as sterile towels, surgical gloves and gowns may be discarded as waste.[147] Potera et al. found that through a redesign of surgical kits to include only necessary equipment, and reducing overage, over 2.5 tons of waste was avoided in a US medical centre.[154] Similarly, syringes could be re-designed to be smaller, resulting in less plastic or glass waste.[154]

Macneill *et al.* found that when reusable surgical gowns were used, a lower carbon footprint was attained;[146] this was mirrored by Kwakye et al., who found waste to be reduced by 23,000 kg in one hospital by switching to reusable surgical gowns over a 12-month period.[155]

It is estimated that up to 90% of theatre waste is non-hazardous and potentially recyclable,[154] this includes surgical gloves and masks, ventilator tubing, and indwelling catheters.[155] Recyclable plastics are often included in the general or even clinical waste in theatres.[156] The World Health Organisation estimates that 2–3 million skin cancers are diagnosed each year, most of which will be treated by excision.[157] Given the fast turnaround of excision surgical cases and the volume of plastic and paper waste generated, this poses danger to the carbon footprint of dermatology theatres. An effective, yet simple solution would be to include recycling bins in theatres.

2.2.1.5 Environmentally Harmful Waste

Over a fifth of the NHS carbon footprint is related to the procurement of pharmaceuticals.[158] A 4-week wasted prescription is equivalent to 15 kg CO2eq;[159] strategies to reduce carbon footprint include choosing local suppliers, giving a shorter supply of treatment or using samples of emollients initially and having a system to monitor expiry of medications in the department.[158]

Incineration of clinical waste contributes to pollution and creation of many toxic and carcinogenic by-products, such as dioxins; Melamed et al. suggests that incineration could be replaced with newer and more environmentally friendly technologies, such as autoclaving or microwaving.[160] However, further research is required to determine the safety and efficacy of this.[156]

Whilst Formalin is the most largely used fixative for histological specimens, its benefit must be balanced with its toxic and carcinogenic status. The correct handling, storage, and disposal of chemicals used in the processing of tissue for Mohs micrographic surgery are essential. A study showed that following atmospheric sampling, formaldehyde readings at one of the laboratories were up to eight times the national exposure standard; ten out of 25 chemicals were identified as hazardous substances, six had specific disposal requirements, and four were potential carcinogens.[161] Di Novi *et al* found that under-vacuum sealing (UVS) tissues into plastic bags was superior to formalin with regards to preservation of surgical specimens.[162] Similarly, Sarot et al identified two alternative fixatives (RCL2® and ethanol), which exhibited better performances than formalin.[163] Such studies are important in identifying efficacious alternatives to formalin going forwards.

A further harmful surgical waste is surgical plume. Repeated inhalation of surgical plume, containing over 80 different toxic chemicals, may cause congestion, pneumonia, bronchiolitis and emphysematous changes in the respiratory tract and precipitate the infection of HPV, HIV and hepatitis B.[164] Lewin et al. and Ball et al. advocate the use of smoke evacuators and personal protection equipment.[150,165] Ball et al found that appropriate smoke evacuation practices improved when leaders supported the use of smoke evacuators.[165] Additionally, more advanced bipolar electrocautery devices, are thought to produce less plume than monopolar devices; with ultrasonic devices posing the least dangers to health.[164]

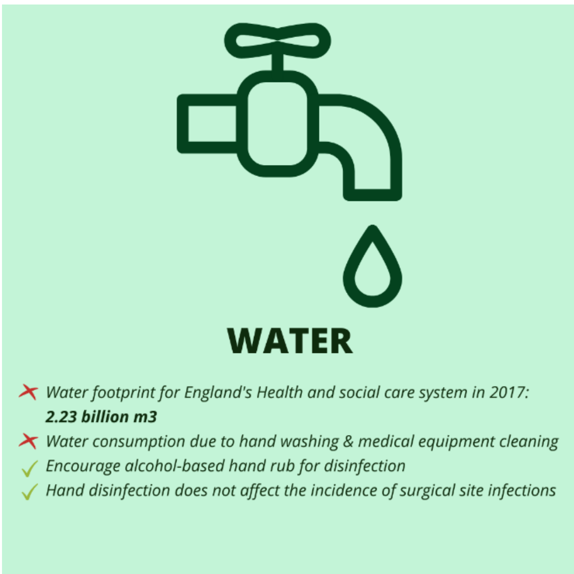
A further consideration includes the waste generated as a result of equipment use. Notably, a recent correspondence outlining the steps towards an environmental sustainable Mohs surgery, recommended use of a hyfrecator over the use of a full electrosurgical unit capable of electrocoagulation and electrosection, which uses a grounding pad and haemostatic pencil.[166] In addition to cost, Leonard argues that the considerable difference in per-use waste generation warrants opting for the hyfrecator when clinically indicated (e.g. flaps on highly vascularised areas).[166]

2.2.1.6 Water

In 2017, the water footprint for the health and social care system in England was estimated at 2.23billion m3, a value greater than the total water consumption of Estonia.[6] The UK's water supply is under increasing pressure, with the environmental agency estimating that, under a business-as-usual scenario, water demand will exceed supply by 2050.[167] Improving water efficiency not only aids water security, but also supports climate mitigation efforts, through minimising the energy used in the supply and provision of water. Excess water use also has financial implications for the NHS. For example, Barts Health, the UK's largest trust, spends over £1million on water per year, accounting for 20% of its utility expenditures.[168]

A life-cycle assessment of dermatological surgery (in an Australian setting) estimates that 10L of water is consumed during a typical skin excision procedure,[7] which equates to around 0.07kg CO2 equivalent emissions (note that the study did not include an estimate for Mohs procedures). The consumption of water during surgical sessions primarily stems from hand washing and cleaning of medical equipment.[7] Encouraging the use of alcohol-based hand-rub for disinfection between patient cases could thus help to reduce water consumption during surgical sessions. These savings can be significant: switching from soap to alcohol-gel based disinfection between cases across theatres in one American hospital is estimated to have decreased annual water consumption by 2.7 million litres.[169] Concerns regarding the efficacy of alcohol-based disinfection for preventing surgical site infections could form a barrier to changing hand-washing behaviours. However, a Cochrane database meta-analysis found that the method of hand disinfection does not affect the incidence of surgical site infections.[170] Indeed, current NICE guidelines on the prevention of surgical site infections 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 the hands are visibly soiled).[171] WHO guidelines also do not mandate the use of soap-and-water for disinfection between operations.[172] The use of alcohol-based hand-rubs also eliminates the need for paper hand-towels and hand driers, further reducing the waste and energy costs associated with handwashing.

Although it is important to reduce the consumption of 'blue' water (water used directly for washing, drinking etc.), this only accounts for 3.7% of the Health and Social Care sector's water footprint.[6] There is thus a need to consider how to reduce the health sector's use of virtual water (water utilised in the manufacturing and distribution of goods). Within healthcare, the majority of virtual water use stems from the wastage and overuse of pharmaceutical and medical



equipment.[6] Taking action to prevent the overuse and waste of medical equipment and medications during surgical procedures through introducing stream-lined theatre packs[153,173,174] and reusing surgical instruments,[175] will both reduce the carbon and water footprint of dermatological surgery.

Water-savings will be made both through everyday small-scale changes in behaviour, but also through large-scale infrastructure projects. Installing flow-restricting and motion-activated taps can achieve water efficiency savings of 50%.[176] Although dermatological surgeon's may not always be in a position to control such infrastructural changes, if consulted on improvements to theatre or department facilities, it is valuable for individuals to have an awareness of devices which might help to preserve water and improve efficiency within their work environment.

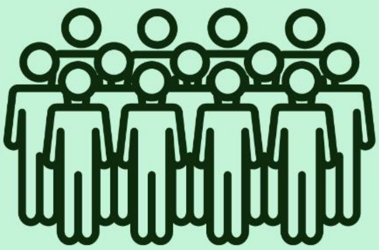
2.2.2 Policy

A lack of leadership and accountability are key barriers to improving sustainability within surgery.[156] Assembling a group of individuals tasked with the responsibility of developing, implementing and monitoring policies is crucial in any health improvement project,[177] including those focused on the environment. Hospital or trust-based sustainability policies can offer a valuable guide to good practice; however, they will not target specific areas of waste or inefficiencies that occur during clinical tasks. Establishing a departmental 'green team' provides the opportunity for department-specific guidelines to be developed. Such a team should include representatives from all healthcare positions working in the department. The formation of a multi-disciplinary 'Green Operating Room Committee' in one hospital in the US, enabled the introduction of initiatives which delivered annual reductions in medical waste of 6.5 tonnes and savings of 234 tonnes CO2 emissions.[169]

Auditing and quality improvement projects relating to patient care are an inherent part of good clinical practice.[178] Adherence to environmental policies should similarly be monitored on a regular basis and given a comparable level of importance as audits relating to patient care. As a public body, the NHS are legally required to work towards reducing their carbon footprint in line with government targets under the 2008 Climate Change Act.[179] Patients also want to see a more sustainable health service, with 92% of the general public agreeing that the NHS should work in a more sustainable manner.[180] Ensuring adherence to sustainability guidelines is thus an issue of both legal and public importance. Department and organisational culture has been identified as an important influencer of NHS staff behaviours in relation to sustainability policies.[181] Auditing environmental practices regularly may help to generate a culture where sustainability issues are considered higher up the agenda.

The type of instruments and equipment used within theatre is determined primarily by surgeon preference. It is thus important for all surgeons within a department to be involved in discussions regarding sustainable procurement and the prevention of medical equipment overage. Sustainable procurement may range from simple measures, such as switching to recycled-paper, to more complex measures, like the development of stream-lined pre-packaged surgical kits.[153] Increasing the use of reusable materials including reusable cotton surgical gowns and re-processable medical equipment can also contribute to reducing dermatological surgery's carbon footprint.[7] Decisions regarding substitutions and alterations to theatre equipment and packs will require a departmental-level approach.

Dedicated time for training and education is included as a regular feature of most department timetables. Incorporating educational sessions on sustainability as part of the teaching programme, including sessions on specific issues identified in the department, may help to improve adherence to new policies. For example, a lack of understanding regarding the management of theatre waste leads to poor segregation of recyclable, clinical and sharps waste, and excess materials being sent to landfill or undergoing energy intensive processing procedures.[155] Ensuring staff are educated about waste segregation can have a significant impact. In one Spanish hospital, basic education on waste segregation reduced the volume of waste sent to landfill by 6.2%.[182]



Formation of a responsible group of individuals

- ✓ *Develop, implement and monitor policies*
- ✓ *Establish a departmental 'green team'*
- ✓ *Audit and QIPs relating to patient care and adherence to policies*
- ✓ *Incorporation of educational sessions on sustainability*
- ✓ *Life cycle assessments*
- ✓ *Generation of a sustainable culture*

NHS related travel accounts for around 3.5% of all road travel in England,[148] making a significant contribution to air pollution. It is has been estimated that healthcare-associated air pollution may be responsible for up to £345million in morbidity and mortality costs.[6] In dermatology, a life-cycle assessment of a typical skin excision found that staff and patient related travel made the largest contribution towards the procedure's total carbon footprint.[7]

Whilst some travel is unavoidable, much can be done to reduce the NHS's carbon footprint related to transport. Possible measures at a departmental-level may include establishing carpools and encouraging active travel to work (walking or cycling) by providing staff with improved cycling facilities. Under plans for a 'Net Zero' NHS, all trusts will be required to have a green travel plan for staff and patients.[148] Although actions towards greener travel are harder to implement at a departmental level, generating a culture of active travel within a department can help to support wider trust efforts.

2.2.3 Procurement and Supply Chain

The supply chain encompasses all activities related with the flow and transformation of goods, from the procurement of raw materials, all the way to consumption by the end user.[183] Each step of the supply chain can have its own adverse impact upon the environment.[184] The effects of climate change can impact the supply of materials, with severe adverse weather events impeding the production and transportation of goods.[185] It is estimated that up to 65% of the carbon footprint of the NHS is related to the procurement of goods and services.[28] The NHS is subject to unique external pressures at each stage of its supply chains, with numerous commercial organisations intrinsically linked.[186] Sustainable procurement within the health service can often come into conflict with the need to save on cost in the short term.[46] While the challenge of sustainable procurement may seem daunting, successfully addressing this issue can ultimately lead to the additional benefits of eventual lower costs, improved health, the enhancement of developing economies and improvement of workers' rights.[187]

Due to the unique factors that impact the supply chains for each individual hospital site, it is suggested that solutions for tackling environmental issues are made locally.[158] Health care providers can use regional knowledge to work with local suppliers to address sustainability concerns at each step of the supply chain. While the approach to sustainable supply chains should be determined locally, there are potential benefits from the collaboration and sharing of information between departments on a national level; to develop a deeper understanding on what practices work well.[188] If there are scenarios whereby multiple departments identify the same organisation as the best solution, then those departments could consider collaborating together to increase purchasing power with suppliers.[189]

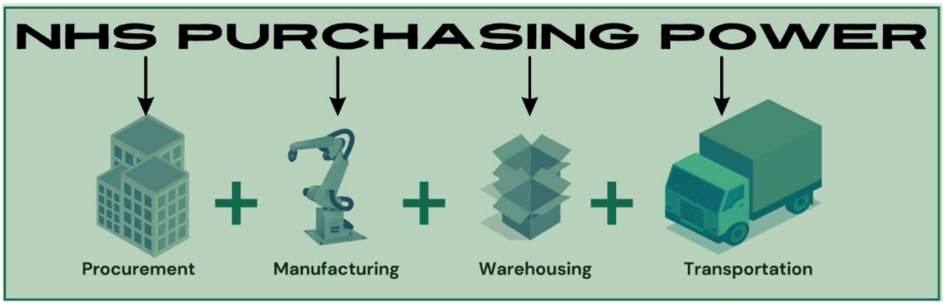
At every step of the supply chain, it is recommended to consider the ideologies and ethical practices of the external organisations involved. Departments can create specific policies for contracts; for example, insisting on the reduction of unnecessary packaging, and only working with those organisations that meet these set criteria, thereby further incentivising those that do not.[190] When planning supply chains for surgical services it is recommended to consider the possibility of interruptions to that chain. These could arise from rising costs of finite resources, geopolitical events, adverse climate events and reduced production. Efforts to mitigate such events can help prevent disruption to services.

In addition to environmental considerations, responsible departments should aim for ensuring ethical procurement. When items are purchased from global vendors, the polices of manufacturers should be interrogated to ensure employment conditions, workers' rights and safety comply with legislation and internationally recognised conventions.[191] It is estimated that two thirds of the global supply of single use and reusable instruments are produced in Pakistan, where working conditions can be poor, and many workers suffer injuries and receive inadequate wages. More concerningly, many children are also employed in this work, receiving no formal education as a consequence.[192]

When considering which products to use, departments are encouraged to question manufacturers on their practices in relation to sustainability. Areas including component materials, site of manufacture, packaging, recycling and total carbon footprint are all relevant. To facilitate this departments could develop a questionnaire to be completed by the manufacturer, prior to the purchasing of any products.[187] For complete transparency consideration should be given to publishing the responses to ethical sourcing questionnaires. This could be done on trust websites or included with patient information leaflets. Such practices are already adopted in other areas of healthcare provision, for example in optometry.[193]

When purchasing surgical items, it is recommended to consider whether single use items are necessitated. Where possible re-usable items should always be considered first line, provided that they are equally safe and effective as well as meeting all regulatory requirements. In instances where no reusable option is available, then there is an opportunity to liaise with manufacturers to see if such a solution might be viable.

When purchasing new surgical equipment for a department, it is encouraged that there are robust mechanisms for stock management, to reduce the likelihood that equipment with a finite shelf life is still present beyond its expiry.[194]



3. Research and Innovation

The NHS has set out commitments within the NHS Long Term Plan[195] the 2020 NHS Operational Planning,[196] and Contracting Guidance and the Standard Contract in order to shift the NHS into a more sustainable manner.[197] There are four key areas the NHS evaluates in order to reduce carbon emissions and deliver against the NHS' net zero ambition, these are: estate and facilities; travel and transport; supply chain; and medicines. Research, innovation and offsetting is essential to the guidance of the NHS to net zero. Net zero is included in the NHS' research strategy, and informs engagement with industry, research centres of excellence and other key partners to clarify areas of unmet need and highlight areas where innovative solutions are of need, and help inform the Accelerated Access Collaborative (AAC).[198]

In Dermatological surgery, innovations include switching from disposable to reusable equipment , and the use of technologies to avoid plastics in medicines supply. Life cycle sustainability assessments refers to the evaluation of environmental, social and economic negative impacts and benefits in the decision-making processes towards more sustainable products throughout their life cycle.[199] This may also refer to the utilisation of reusable surgical equipment. A lack of measurable information may stagnate potential approaches to perform comparative analyses and guide future practices.[166] Research and innovative schemes assessing sustainable practice can be aided through resources such as 'SusQI,'[200] and sustainable healthcare.[201] Moreover, innovative proposals could be submitted to the UKDCTN for evaluation and dissemination of the trial across the UK.[202]

At present, there is limited published research evaluating the environmental impact of dermatological surgery and sustainable solutions. There are unique barriers to environmentally sustainable practices and reporting within the medical field.[166] A major obstacle is the reluctance of healthcare providers and organisations to implement changes that have the potential to negatively affect patient outcomes. However, reluctance to address environmental sustainability among healthcare providers may also be due to a lack of available information, and evidence-based recommendations regarding the appropriate use and elimination of healthcare resources.[166] Key to overcoming this includes patient and public involvement (PPI) in all

dermatological sustainability research throughout various stages of the process and dissemination.[203] Further, advocacy training of skin surgeons and allied healthcare providers is required for the consideration of sustainability in all research.

Overall, education efforts and open dialogue regarding the environmental and financial impacts of sustainable practices will aid leaders to implement change effectively and efficiently. At the beginning of this document are recommendations to be considered by the department to engage in academic activities that will inform and educate dermatologists, patients, and policy providers regarding environmental sustainable practice.

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