

Main Article

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Cite this article: Spinos D, Doshi J, Garas G. Delivering a net zero National Health Service: where does otorhinolaryngology – head and neck surgery stand? *J Laryngol Otol* 2024;**138**: 373–380. <https://doi.org/10.1017/S0022215123001780>

Received: 13 June 2023

Revised: 13 September 2023

Accepted: 19 September 2023

First published online: 5 October 2023

Keywords:

Otorhinolaryngology; carbon footprint; environment; preventive medicine; public health

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Delivering a net zero National Health Service: where does otorhinolaryngology – head and neck surgery stand?

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Abstract

Objective. The National Health Service (NHS) recognised the risk to public health brought by climate change by launching the Greener NHS National Programme in 2020. These organisational changes aim to attain net zero direct carbon emissions. This article reviews the literature on initiatives aimed at mitigating the environmental impact of ENT practice.

Method. Systematic review of the literature using scientific, healthcare and general interest (public domain) databases.

Results. The initiatives reviewed can be broken down into strategies for mitigating the carbon footprint of long patient stay, use of operative theatres and healthcare travel. The carbon footprint of in-patient stay can be mitigated by a shift towards day-case surgery. The ENT community is currently focused on the reduction of theatre waste and the use of disposable instruments. Furthermore, supply chains and healthcare delivery models are being redesigned to reduce travel.

Conclusion. Future areas of development include designing waterless theatre scrubs, waste-trapping technologies for anaesthetic gases and a continuing investment in virtual healthcare.

Introduction

Climate change constitutes one of the greatest growing risks for public health, with a profound impact in deprived areas, leading to exacerbation of health inequalities. Worldwide, healthcare contributes to more than 4 per cent of the global net carbon dioxide (CO₂) emissions. In the UK, the National Health Service (NHS) is responsible for approximately 30 per cent of all public sector carbon emissions and for 5 per cent of the UK's total carbon emissions.^{1,2}

In 2020, the Greener NHS National Programme was launched,² which promoted a series of actions and organisational changes to attain the aspiration for net zero direct carbon emissions by 2040 and for net zero supply chain emissions by 2045. This endeavour required centrally led coordination and translation of the national strategy to the local level, leading to the implementation of a Green Plan in each NHS Trust, according to the 2021/22 NHS Standard Contract. This locally led strategy has fostered flexibility in innovation and initiatives relevant to the individual characteristics of each NHS Trust.^{2,3}

A common ground amongst NHS Trusts has been the focus on operating theatres, which make up as much as 25 per cent of the hospitals' contribution to total carbon equivalents generated, despite less than 5 per cent of hospital in-patients actually undergoing surgery.^{4,5} With an exponential increase in the volume of elective surgery, as part of the NHS post-coronavirus disease 2019 (Covid-19) pandemic recovery plan, green strategies are more important than ever to mitigate the environmental impact of hospitals.⁶

ENT – head and neck surgery represents a specialty utilising a plethora of novel technologies and single-use equipment. Inevitably, this correlates to a high CO₂ yield for ENT.^{4,7} This article reviews green initiatives introduced across the UK NHS and discusses which approaches may be of special value in reducing the carbon footprint of ENT activities.

Methods

A systematic review was conducted of the published literature reporting on initiatives in otorhinolaryngology – head and neck surgery developed to assist reducing the carbon footprint of ENT practice, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.⁸ An electronic database search was performed across a variety of databases, including the Cochrane Database of Systematic Reviews,

Medline via PubMed and Ovid, Embase, Emtree and Amed via Ovid, and Google Scholar. The search algorithms compiled differed slightly depending on the type of database reviewed (e.g. scientific, healthcare, as well as general interest databases available on the public domain, i.e. Google Scholar), consisting of the keywords: ENT, ear, nose, throat, otolaryngology/ototholaryngologic diseases, carbon footprint, conservation of natural (protect* OR conserve*), sustainab*, green or 'net zero' or recycl* or ecolog* (Appendix 1).

Inclusion criteria included any quantitative or qualitative data published associated with evaluation of the service's generation or mitigation of CO₂ in healthcare, specifically relating to ENT. Exclusion criteria consisted of non-English language publications, no full text available and where outcomes reported were not relevant to carbon generation and/or mitigation strategies. Amongst the 16 papers initially identified, only 8 were relevant after full text screening (Figure 1). Amongst these, two were reviews of previously published data, two were opinion papers based on surveys and only four contained primary data. Because of the limited results in the scientific literature, the search was further widened to include general interest publications available in the public domain (Google) and updates on official NHS websites. The search was conducted for the period of 1974 to August 2013. Institutional Review Board approval or patient written consent were not required for this study because it constituted a systematic review of published data.

Results

Greenhouse gas protocol scopes in the NHS are described across a wide set of emissions to facilitate comparison internationally and encourage transparency.² Greenhouse gas protocol scope 1 relates to direct emissions from owned or controlled sources, Greenhouse gas protocol scope 2 relates to indirect emissions from energy and Greenhouse gas protocol scope 3 relates to indirect emissions from the production or transportation of goods and services.² Figure 2 illustrates the scopes with ramifications for ENT services.

As these scopes do not necessarily align with the organisational structure of the service from the clinician's perspective, the findings are categorised into activities concerning in-patient stay, theatre time, and patient and staff travel.

Carbon footprint of long patient stay

Traditional means of providing surgical care have been criticised as being outdated and outmoded, with the structure of the surgical ward in the modern NHS being reconsidered.⁴ Tennison *et al.* highlighted that a significant amount of carbon equivalents can be attributed to visitor travel, building energy consumption, food and catering, as well as the procurement of necessary pharmaceuticals and medical devices to support an active ward.⁹ Although acute wards are a necessity for emergency services, the CO₂ equivalent can be mitigated by reducing the number of running wards to the minimum

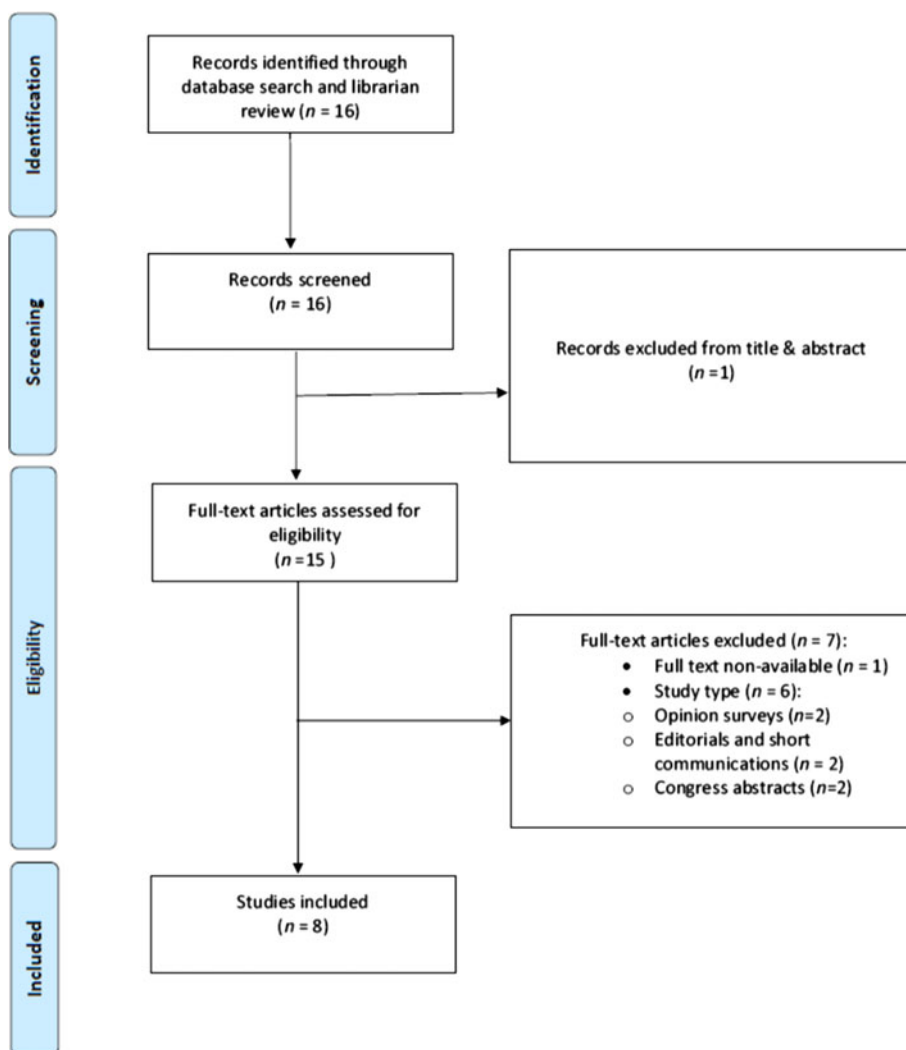


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

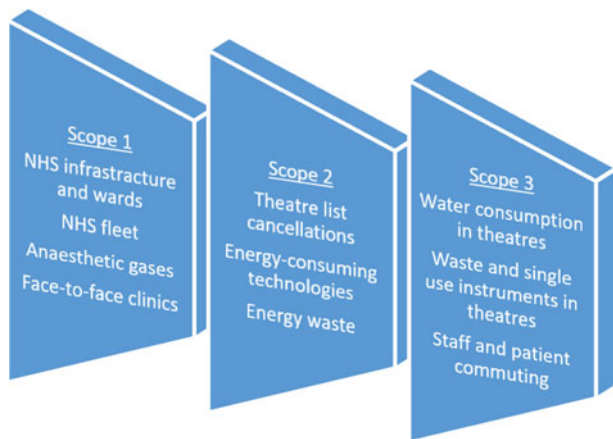


Figure 2. NHS Greenhouse gas protocol scopes.

necessary.^{4,6} Such a strategy would mandate the adoption of measures encouraging early ambulatory diagnosis, timely discharge and minimal hospital stays.

Most ENT diagnostic operations can be performed as day cases. Indeed, the Getting It Right First Time report for ENT surgery puts the emphasis on day-case treatment, highlighting the benefits of better patient experience and reduced reliance on bed availability, further supporting the NHS Green Plan strategy.¹⁰ According to the Getting It Right First Time report for ENT surgery, the average percentage of day-case activity across the country was 67 per cent, with some units exceeding 90 per cent. Pezier *et al.* quote 74 and 73 per cent rates of ENT day-case surgery in adults and children, respectively, with the rate surpassing 90 per cent for otology procedures.¹¹ Similarly, for rhinology, Navaratnam *et al.* reported an almost 80 per cent mean rate for functional endoscopic sinus surgery at a national level. No superiority of in-patient stay was demonstrated in terms of patient outcomes or readmission rates.¹²

Operating theatre CO₂ equivalent emissions

The Royal College of Surgeons of England recognised that operating theatres have a disproportionate environmental

impact as a direct result of their energy-intensive processes, consumption of resources, use of volatile anaesthetic agents and production of waste (Figure 3).^{6,13} ENT intraoperative practices are no different from other surgical subspecialties, with the possible exception of airway emergencies that require a shared airway plan and higher frequency of use of anaesthetic gasses for spontaneously breathing patients.

To be able to mitigate the environmental impact of operating theatres in ENT (and surgery in general), it is paramount to understand which sources are responsible for generating the most CO₂ equivalent emissions. Currently there is little standardisation in reporting the CO₂ equivalent emissions of specific procedures across different NHS Trusts in the UK. Researchers have increased awareness of the environmental cost of some of the common procedures, potentially adding new perspectives for ENT surgeons and NHS managers to consider. Reviewing five common surgical procedures, Rizan *et al.*¹⁴ demonstrated that for an operation such as tonsillectomy, table drapes and single-use items contributed almost two-thirds of the total CO₂ equivalent emissions, highlighting the importance of changes in practices and policies.

Anaesthetic gases

Inhaled anaesthetic agents have been estimated to account for 0.01–0.10 per cent of the total global CO₂ equivalent emissions and 5 per cent of the total NHS carbon footprint.^{15,16} As such, inhaled anaesthetic agents constitute a major source of CO₂ emissions and thus are a priority area that needs to be carefully looked at. The anaesthetic community is aware of the environmental impact of halogenated inhalational anaesthetics, and McGowan *et al.* recently reviewed the alternatives to reduce this impact.¹⁷ Although nitrous oxide (N₂O) significantly reduces the amount of anaesthetic gas needed, its impact is negligible as a result of its role in the destruction of the stratospheric ozone layer. Desflurane was assessed as having 15 times the impact of isoflurane and 20 times the impact of sevoflurane on greenhouse gas production.

Total intravenous anaesthesia, by contrast, generates four times less CO₂ equivalent, although specialised means are

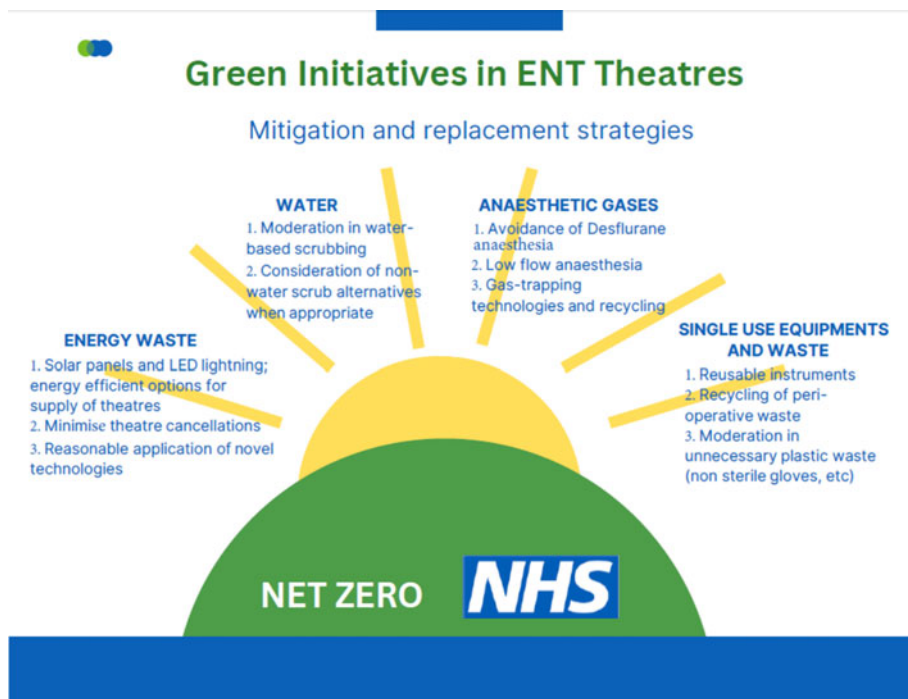


Figure 3. Environmental impact of operating theatres.

required to discard and sequester propofol's byproducts.¹⁵ University Hospitals Bristol and Weston NHS Foundation Trust are one of the first NHS Trusts to replace excessive use of desflurane with sevoflurane, thus reducing CO₂ equivalent emissions by 30 000 kg per month within 2 years.¹⁶ An alternative strategy is low-flow anaesthesia, in which at least 50 per cent of expired gases are returned to the lungs after eliminating CO₂ from the system through use of a CO₂ absorbent in a closed-circle system.¹⁵ This method traps any exhaled gases in a closed circuit and returns them after they become purified of CO₂.

Single-use equipment and waste

The Royal College of Surgeons of England, in its guidance on Sustainability in the Operating Theatre (May 2022),⁷ highlighted the importance of reducing waste from textiles and single-use instruments. Recommendations included opting for reusable textiles and personal protective equipment (PPE), reusable surgical trays, and disposable linings for containers and reusable instruments. The importance of encouraging local policies that promote reusable materials is also highlighted.⁶ Nasoendoscopes are commonly used in ENT practice. Jegatheeswaran *et al.* demonstrated that reusable nasoendoscopes had a clear cost-effectiveness benefit over the single-use ones, and ENT surgeons demonstrated a preference in engaging with more environmentally friendly alternative options.¹⁸

The increased use of PPE in response to the Covid-19 pandemic contributed significantly to an increase in the carbon footprint of ENT departments. A single-centre study demonstrated that there was an almost fourfold increase in the use of disposable plastic items in ENT out-patient clinics.¹⁹ Recently, Great Ormond Street Hospital launched a campaign against the use of non-sterile gloves, significantly reducing the use of plastic gloves and substituting hand-washing for any non-sterile procedures. Through this simple measure, the number of non-sterile gloves used was reduced from 11 million to 3.7 million per annum, thus saving 21 tonnes of plastic in 2021 alone.²⁰

Theatre waste accounts for anything between one-fifth to one-third of the cumulative hospital waste.²¹ Lui *et al.* demonstrated that ENT intra-operative waste can be reduced by 21 per cent by simply recycling the pre-operative waste from packaging and materials with limited patient contact, reporting up to 90 per cent of recyclable waste. Comparing the waste generated across ENT subspecialties in three tertiary units, they demonstrated that general ENT and rhinology generate the most recyclable waste and paediatric ENT the least.²²

Ryan *et al.* examined 22 procedures across four ENT subspecialties, reporting almost 200 kg of waste, out of which only 20 per cent was recyclable.²³ The authors highlighted that the mismatch with Liu *et al.*'s earlier work is due to most recyclable waste being generated pre-operatively. Across different subspecialties, facial plastics produced the most waste, and the head and neck team the least. Notably, the head and neck team also produced proportionally the least amount of recyclable waste. The role of head and neck surgeons in mitigating the environmental impact of their practice was highlighted by Sanabria *et al.*, who suggested that a change of attitude towards the environmental impact is needed, along with a reassessment of unnecessary waste.²⁴

These interventions further highlight the importance of appropriate waste sequestration, in line with the Royal College of Surgeons of England agenda, to minimise the

waste that is destroyed as hazardous and maximise opportunities to recycle packaging and other domestic waste.

Water in theatres

According to the Royal College of Surgeons of England report, almost 18.5 l of water is consumed per staff member, per pre-operative scrub.⁶ Waterless scrubbing has been investigated as an alternative to current standard practice. Ho *et al.* undertook a meta-analysis of 11 randomised controlled trials involving more than 5000 participants and comparing the outcomes of traditional scrubbing with those of chlorhexidine and povidone-iodine scrubbing. No significant differences were demonstrated between the number of colony forming units or surgical site infection rates for these two techniques.²⁵

Theatre energy waste

Operating theatres have steep requirements for heating, ventilation and air-conditioning systems, and these account for 90 per cent of theatre energy consumption.²⁶ NHS dependence on fossil fuel energy is a known issue and generates concerns because of the current fuel crisis. However, there are individual organisational initiatives for alternative, renewable sources of energy. A notable example is Milton Keynes University Hospital, which renewed its 35-year-old infrastructure by installing photovoltaics in the roofing structure and replacing old lighting fixtures with LED ones. The initial investment of £2.75 million for the installation of 2586 solar panels was shown to decrease the CO₂ equivalent emissions of the infrastructure by 181 tonnes. After re-roofing and installation of a further 900 solar panels, the Trust's overall energy cost is estimated to have reduced by more than £200 000 per annum.²⁷

The advent of laser and robotic surgery in ENT has raised questions about the environmental implications of such procedures,⁴ but they offer shorter operative times and reduced duration of patient hospital stays.²⁸ For example, transoral robotic surgery and transoral laser microsurgery are minimally invasive surgery approaches that result in overall energy savings and reduced CO₂ equivalent emissions compared to open head and neck surgery.

Travel carbon footprint

The CO₂ equivalent emissions impact of NHS travel represents 17 per cent of the NHS carbon footprint, whilst the supply chain adds up to 24 per cent to the total NHS CO₂ equivalent emissions (Figure 4).^{2,3,22,29} There are over 9.5 billion NHS-related road miles per year in England, which makes up around 3.5 per cent of all road travel in England per annum. Staff, visitor and patient travel negatively affect air quality, with an estimated economic impact of £345 million for the potential mortality effects and costs to society of air pollution resulting directly from NHS-related travel. Adopting active transport can have health benefits for staff, and changing where healthcare is delivered through, for example, the provision of virtual consultations remotely for select healthcare services can reduce the number of car miles and therefore the CO₂ emissions associated with patient travel.

The Covid-19 pandemic generated opportunities to explore the benefits of virtual consultations and one-stop clinics. One-stop neck lump clinics were introduced to the spectrum of services offered across different hospitals in response to National Institute for Health and Care Excellence Improving Outcomes Guidance for head and neck cancer services in 2014.³⁰ These clinics have been shown to reduce the time to

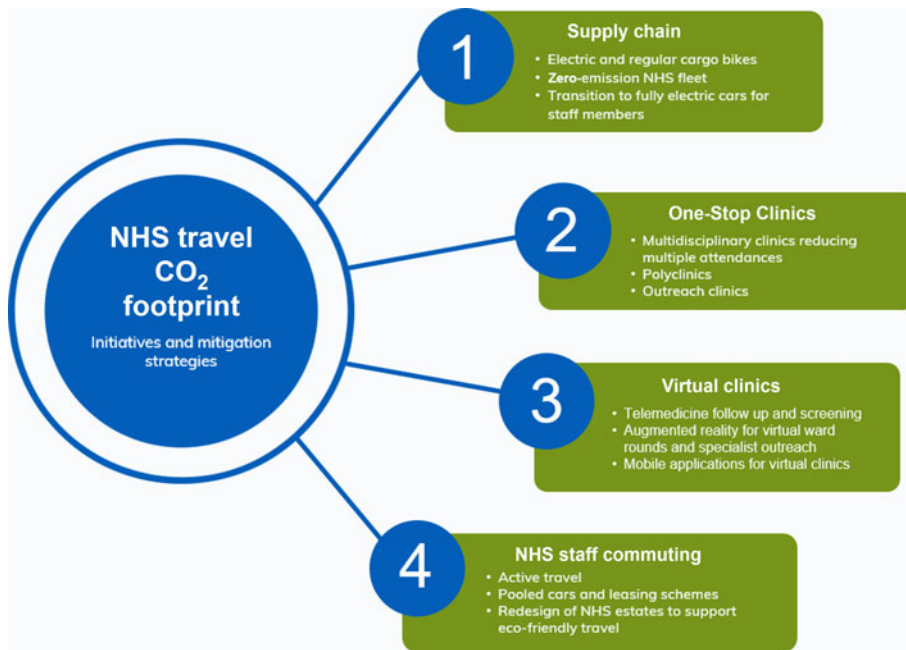


Figure 4. The carbon dioxide equivalent emissions impact of NHS travel

treatment and increase the number of patient appointments.^{31,32} They also have the potential to reduce the amount of patient transport required, thus reducing its environmental impact, as shown by Al Hamarneh *et al.* in a district general hospital.³³

Although a relatively new entity in the UK, surgical outreach clinics have flourished in other countries. Forner *et al.*³⁴ assessed patient travel and the CO₂ equivalent benefit of combining clinics for head and neck patients using a Google Maps algorithm to assess travel distances. Overall, they demonstrated that combining clinics into a single patient visit in an outreach clinic was associated with a decreased carbon footprint compared to regular care in a regional centre.

Virtual clinics also directly contribute to a reduction in patient and staff travel. The Royal College of Surgeons of England have recognised the potential environmental benefits of virtual clinics and have published guidance on standards for conducting them.⁶ The Covid-19 pandemic led to an increased interest in conducting such clinics across multiple ENT departments.^{36,37} These measures led to a drop in the number of patients attending ENT out-patient clinics and increased overall patient satisfaction, especially when a structured consultation model was followed.³⁷ A comparative study on benign rhinology out-patient clinics demonstrated that there was no statistically significant difference in patient satisfaction amongst patients who attended virtual clinics compared to those who were seen face to face,³⁸ highlighting the non-inferiority of virtual clinics from a patient experience perspective.

The advent of virtual reality and augmented reality have opened up a myriad of possibilities in this domain. Proximie (<https://www.proximie.com/>) is a London-based start-up company that is among the first providers that aspired to develop software to improve access to clinics and surgery. Imperial College Healthcare NHS Trust's ENT department recently introduced HoloLens2 as an educational adjunct through the Covid-19 pandemic;³⁹ the next steps would be to trial similar equipment in a clinical ENT setting. The Babylon GP At Hand tried to revolutionise access to primary care services for the public, providing a platform for 24/7 access to virtual consultations.⁴⁰ Conflicts generated around NHS contracts led to an

early exit of Babylon GP At Hand from the UK market, opening up the pathway for augmented reality technologies.⁴¹

Probably the most common initiative across multiple NHS Trusts around the country concerns the reduction of employee travel by car. This is often attained by offering alternative methods of commuting, including encouraging cycling, pooled car sharing, and public means of transport use or active travel.² There are several examples where the application of these initiatives has led to a significant reduction in CO₂ equivalent emissions, including Sussex Community NHS Foundation Trust's introduction of electric bikes for their clinical community team, which has saved around 2 tonnes of CO₂ equivalent emissions.⁴² Manchester University NHS Foundation Trust launched a scheme that provides facilities on their campus to improve the cycling experience and discounts for staff using public transport; the outcome of these interventions led to an increase of 40 per cent in the number of staff using sustainable means of transport compared to 2013.⁴³

Several NHS Trusts have reshaped their supply chain to further reduce their carbon footprint by reducing the CO₂ equivalent emissions of their pharmaceutical providers and couriers. Newcastle upon Tyne Hospitals NHS Foundation Trust introduced an electric cargo bike courier delivery scheme, leading to a deduction of 848 kg of CO₂ equivalent emissions per annum from the Trust's environmental impact, while also contributing to a reduction in expenses of almost £25 000 per annum.⁴⁴ Similarly, Oxford University Hospital NHS Foundation Trusts arranged with their local supplier of chemotherapy drugs for them to be delivered via cyclist couriers, saving up to 10 tonnes of CO₂ equivalent emissions per annum.⁴⁵

The current aspiration of the Greener NHS initiative is to transition the NHS fleet, including ambulances, to low- and zero-emission choices.^{2,46} The first step towards this aspiration has been the recent scheme offering discounts to NHS employees buying fully electric cars at reduced prices. To fully support this shift towards electric vehicles, a significant re-design of NHS estates needs to be undertaken as both parking slots and charging stations should be readily available to further encourage staff members to support the electric fleet plan.⁴⁷

Discussion

The Royal College of Surgeons of England has highlighted the importance of central leadership in coordinating the plethora of individual and organisational initiatives across the NHS. They have identified the potential risks of implementing these interventions in the form of lack of communication, insufficient staff engagement, misconceptions regarding reusable instruments, and perceived cost and workload.⁶ A drastic refurbishment is required to bring the aging NHS installations into line with the current zero-net ambition, which should be led from the top and then accepted and adopted across the whole structure of the NHS to be effective.²

With the exception of major head and neck oncological operations and complex skull-base surgery, ENT encompasses a wide spectrum of procedures that can be performed as day cases, which is crucial in reducing the CO₂ equivalent emissions of in-patient stays. Key aspects to facilitate this include a consultant-delivered service and carefully designed pre-assessment triaging to flag up patients with significant comorbidities where contingency plans and bed availability will likely be necessary.^{6,10}

A major contribution to the CO₂ footprint in ENT comes from theatres. Idle theatres represent a waste of resources.^{48,49} It is neither practical nor realistic to stop and restart the heating, ventilation and air-conditioning systems of a theatre when a cancellation occurs, which highlights the importance of focusing on measures likely to reduce the frequency of such occurrences.

The National Confidential Enquiry into Perioperative Deaths requires that each hospital must have one or more emergency theatre operational and running at any point in time.^{50,51} Although there is little space to improvise regarding emergency theatres' energy consumption, by maximising the consecutive cases that are accommodated in an elective theatre session, the overall energy waste can be reduced.

Another opportunity may lie within the novel technologies incorporated in ENT. More research is needed in this area, especially in view of the dissemination of transoral robotic surgery and transoral laser microsurgery in modern ENT practice.⁵²

Despite efforts to shift towards non-inhaled anaesthetic alternatives, ENT emergency airway cases often require a spontaneously ventilating patient.⁵³ The environmental benefits of using sevoflurane and especially desflurane have been recognised and highlighted by the anaesthetic community.

The biggest limitation of desflurane relates to the cost of its production, which also needs to be considered when accounting for the CO₂ equivalent emissions generated by its application. The logical next step would be to create waste trapping technology for inhaled gases widely accessible in the NHS. Deltasorb, developed by Blue-Zone Technologies Ltd, is an example of a canister compatible with current scavenging circuits that can trap anaesthetic gases, providing the opportunity to recycle them in centralised facilities.⁵⁴

Arguably the most problematic aspect of achieving a net zero operating theatre is the excessive use of water.⁴ Since Lister, water-based scrubbing has been the 'gold standard' in modern surgical practice. Although the current practice is established on the fundamental belief that water-based hand-washing is superior in minimising surgical infection risk, perhaps it is time to critically review this perception. Although it will take robust data and high-level evidence to generate a change in practice that deviates from the recognised gold standard, water remains a critical resource in many parts of the world, and restricting its use has ramifications for safeguarding the hygiene of entire countries and even continents, thus preventing future pandemics.

- Climate change constitutes one of the greatest risks for public health, with healthcare accounting for more than 4 per cent of global net CO₂ emissions
- This systematic review investigated the existing initiatives aimed at mitigating the environmental impact of ENT practice plus future directions to attain the transition to a net-zero NHS by 2045
- These initiatives comprise strategies for moderating the carbon footprint associated with in-patient stay, operative theatre use and healthcare travel
- Current interventions include a shift towards day-case surgery, reusable instruments, recycling, and redesigning supply chains and healthcare delivery models to reduce travel
- Future areas for development include waterless scrub alternatives, waste-trapping technologies for anaesthetic gases and continuing investment in virtual healthcare

Our current reliance on disposable instruments in the post-Covid-19 pandemic era also needs to be challenged.^{6,13} The use of disposable fiberoptic nasoendoscopes over reusable ones needs to be urgently reviewed in light of the huge amount of plastic waste this produces. Similarly, employing single-use specula, forceps and other specialised ENT equipment to prevent the spread of the Creutzfeldt-Jakob disease, cases of which were last encountered decades ago, could be regarded as an

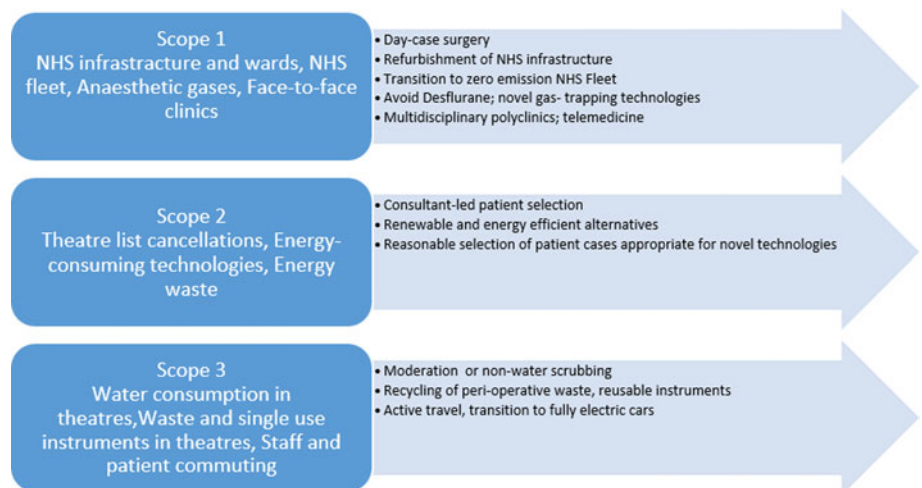


Figure 5. Initiatives to reduce ENT carbon dioxide equivalent emissions.

unnecessary precaution.⁵⁵ These practices generate large quantities of packaging and equipment waste, contributing to the carbon footprint of the ENT activity.

The initiatives discussed so far may appear disjointed, but attempts have recently been made to implement holistic net zero practice, with the University Hospitals Birmingham NHS Foundation Trust colorectal team successfully completing the first net zero operation in Solihull Hospital in May 2022. That was achieved through multilevel interventions, starting from patient and healthcare provider travel to the hospital, then reducing waste and selecting appropriate means of anaesthesia, and ensuring recycling where possible. At the end of the operation, the estimated reduction of CO₂ equivalent emissions was 80 per cent, and the other 20 per cent of CO₂ emissions was offset by CO₂ mitigating projects, including planting trees on the University Hospitals Birmingham hospital campus.⁵⁶ This is an exceptional example of how a unit incorporated multiple interventions and set up a carefully structured plan to bring about substantial change. A synopsis of the different initiatives across ENT can be found in Figure 5.

Conclusion

It is now a legal requirement for all NHS Trusts to present their respective Boards with or appoint an approved Green Officer who will oversee the implementation of the Greener NHS National Programme. It is also critical that national specialty organisations start to play an increasing role in this collective effort. ENT UK has already recognised the need for organisational leadership in achieving climate change mitigation and have published their strategy, Inspiring Excellence and Shaping the Future, to provide guidance to the ENT community and encourage changes aimed at reducing CO₂ equivalent emissions.⁵⁷ The current priority involves promoting the use of flexible nasoendoscopes and other single-use instruments whilst a number of further interventions expected to be more impactful in the longer term are in the pipeline.

Acknowledgements. The NHS logo in Figure 3 is the intellectual property of the National Health Service (NHS). The other figures were designed by DS. We would like to acknowledge the support of Karen Johnston (University Hospitals of Derby & Burton NHS Foundation Trust Library and Knowledge Service) for her support with the systematic literature search.

Competing interests. None declared

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0022215123001780>.

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