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Review

How Can UK Hospitals Transform to Net Zero Carbon Emissions?

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Abstract

Hospital-based healthcare is the most carbon intensive component of healthcare delivery. Mitigation in the face of the climate and ecological crises is urgent and required under law in England, yet comprehensive guidance is lacking. This review summarizes—by sector of emissions—current evidence on strategies that hospital trust executive boards can take to deliver decarbonisation. We identify variable maturity of evidence available per hospital speciality and emissions sector, limited translation of successful case studies across the sector and a lack of comprehensive guidance or policy to drive large-scale change. Strategies for hospitals to implement change need to be accompanied by cultural shifts in approaches to environmental sustainability backed up by leadership, governance and financial commitments. Crucially, long-term financial savings offered through environmental sustainability investments ought to be a driver, not a barrier, to change.

Keywords: sustainable development; carbon footprint; health policy; climate change; hospitals

1. Introduction

Responding to the unprecedented impacts of climate change and environmental degradation on human and planetary health is increasingly urgent [1]. The healthcare sector accounts for 4.4% of global net emissions, with per capita emissions of 0.6 tonne CO2e [2]. In the UK, under the Health and Care Act 2022, NHS England developed strategy to reach net zero by 2040 for greenhouse gas emissions under direct influence (called scope 1 & 2 emissions), and 2045 for those it influences (scope 3) across its operations [3]. Similar strategies exist in NHS Scotland and Wales [4,5]. Acute services (henceforth 'hospitals', excluding mental health and community services) make up over 50% of emissions from clinical activity in England, and of this, the biggest contributors are procurement (>60%) and building energy (15%) (Fig. 1, Ref. [3,6]).

To date, there is limited evidenced guidance on how hospitals should implement emission reduction plans. All National Health Service (NHS) Trusts in England are required to have a Green Plan, but our research finds variability in their content and specificity, evidencing immaturity in strategy [7]. As trusts renew their Green Plans, there is opportunity to proactively address this gap in effective strategy.

In this review we summarise current evidence and examples of strategies that executive boards at acute trusts in the UK can take to deliver emissions reductions. We describe, by emissions sector, evidence on actions to decarbonise, and discuss how these can be delivered. Given clinical system complexity and that the evidence base is nascent, broad, and rapidly evolving, our recommendations will require adaptation and application to specific settings.

Our literature searches were targeted to identify articles that evidence approaches to decarbonisation of acute hospitals within each of the emission sectors outlined in Fig. 1. Where available, evidence from academic peer reviewed literature was prioritised, but we also included relevant evidence not specific to healthcare (e.g., on transportation or energy use), and non-academic literature such as policy documents and priority case studies. Literature sources included databases (PubMed, Ovid), grey literature via Google search engine and a UK-based green healthcare case study repository [8]. We included available evidence published prior to May 2026 and from all geographies, where studies are applicable or adaptable to a UK setting.

Whereas the focus of our review is on delivery of mitigation in acute hospitals in the UK, many of the principles are transferable outside of this setting. We focus on carbon mitigation but are cognisant of the needs for healthcare systems to also adapt to the effects of climate change, and to recognise other harms, including environmental pollutants (e.g., in manufacture and disposal of pharmaceuticals), and labour abuse (e.g., in the production of medical supplies [9]).

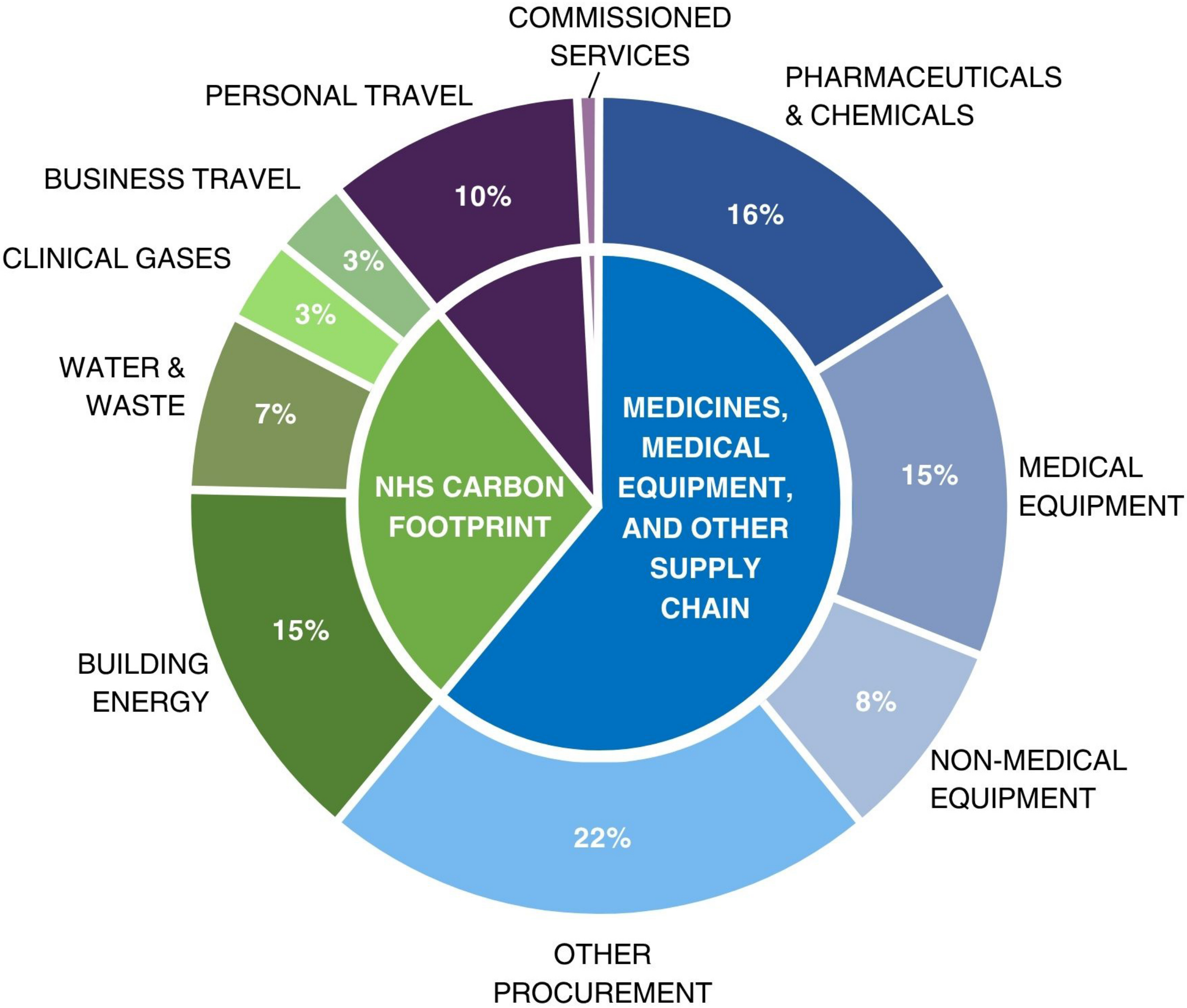

Fig. 1. Clinical activity-based greenhouse gas emissions by emissions category for National Health Service (NHS) acute services in England. Percentage contributions of the total by category are derived from data within Tennison et al. (2021) [6] where total greenhouse gas emissions of acute services were calculated as 12,960 kilotonnes of carbon dioxide equivalent (ktCO2e) in 2019 using a hybrid approach of top-down modelling with bottom-up data. Image format has been based on that used in the NHS Delivering a Net Zero NHS report ([3], p14). Accordingly, the NHS Carbon Footprint includes Scope 1 and Scope 2 emissions (in shades of green in Fig. 1). Medicines, medical equipment and other supply chain, alongside personal travel make up Scope 3 emissions and are known as the 'NHS Carbon Footprint Plus' (in shades of blue and purple). Further information on legend: The 'clinical gases' footprint is derived from anaesthetic gases and metered-dose inhalers. Personal travel includes patient travel, staff commute and visitor travel. Business travel includes that from NHS fleet. Commissioned services account for health services outside the NHS. Image created by the authors using Canva.com.

2. Actions Toward Zero-Carbon Hospitals by Emissions Sector

2.1 Principles of Low Carbon Care

Mortimer's principles of low carbon care [10] - illness prevention (public health approaches), patient empowerment for self-care, lean services, and low carbon technology - are considered the pillars of carbon mitigation. Notably, only a minority of specialities have specific guidelines, checklists or academic reviews based on these principles [11,12,13,14,15,16,17,18,19,20].

Low carbon technologies are often prioritised as solutions. However, an estimated 30% of health system use is of low-value [21]; rates of avoidable hospital admissions total up to 40% for some patient groups [22] and inpatient stays are the most carbon intensive form of hospital-based care [23], so it is just as important to consider where hospital care is not needed. That will likely have a greater effect on carbon emissions than any technological improvement. Wright et al. [24] recommend that hospitals become public health anchor institutions, and a movement toward community-based care is part of the current 10 Year Health Plan [25].

2.2 Supply Chain and Procurement

Procurement is the biggest single contributor to hospital emissions (Fig. 1). Here the best approach is to first identify opportunities for eliminating item use altogether, and second to maximise circular economies, which prioritizes reuse and low carbon alternatives: this could be defined as "…regenerative systems in which, through slowing, closing, and narrowing supply chain loops, material input, waste, and emissions are minimized" [26,27]. Circularity in procurement also helps build supply chain resilience, because linear supplies are vulnerable to disruptions in international supply chains [28].

2.2.1 Pharmaceuticals

Hospital spend on pharmaceuticals is increasing annually, reaching over £11 billion in 2024/25 in England [29]. One decarbonization mechanism is to minimise over-prescription, which is when prescribed medications are unnecessary or where the benefit of medication is outweighed by its harm. While the scale of over-prescribing in acute care is unknown, one analysis of community prescribing in England estimated 10% of medications could be considered 'over-prescribed' [30]. That is a key target to reduce carbon emissions related with the life cycle of medication production, use and disposal, but moreover to potentially reduce emissions associated with managing in secondary care the harms of medication overuse (For example, one economic analysis estimated avoidable adverse drug reactions result in use of over 180,000 hospital bed-days per annum in England [31]).

Strategies to reduce low-value or harmful prescribing are well-documented [30,32,33], but evidence of effective, large-scale and sustainable interventions is limited, despite much potential. For example:

• Several deprescribing tools exist to address polypharmacy (prescribing of five or more medicines to a single patient), which affects 45 to 97% of hospitalized patients and is associated with patient harm [34], but the evidence on real-world effectiveness of such tools is limited [35].

• Specific pathways could be targeted to stop prescribing outside of best practice. For example, a recent trial showed no evidence to support routine use of proton pump inhibitors to manage throat symptoms, despite these being widely prescribed [36].

• In reducing antimicrobial prescribing (accounting for £719 million of hospital spend in England in 2024/25 [29]), a UK cluster randomised trial of a multifaceted behaviour change intervention reduced antibiotic use by nearly 5% [37].

Hospitals could also reduce pharmaceutical waste through re-use and stock management. One multi-centre Dutch study estimated reductions of 1.9 kilograms of carbon dioxide equivalent (kgCO2e) per patient per year through re-dispensing of unused oral anticancer drugs [38], but regulatory and policy barriers may prevent uptake of such ideas in the UK [39], and more evidence is needed on how such systems could be more widely implemented. Emerging evidence also suggests that digital medicines stock management could reduce waste [40], and that many 'expired' medicines could in fact be safely used [41].

Strategies targeted at reducing usage of medications associated with the highest carbon emissions are also a potential mechanism to reduce pharmaceutical emissions. For instance, using oral instead of intravenous paracetamol in elective surgery could amount to a UK emissions reduction of 932 tonnes of carbon dioxide equivalent (tCO2e) [42]. Another example is inhalers, which are covered in a separate section in this review. Whereas detailed life-cycle analysis (LCA) is currently lacking for most medicines, tools are emerging to estimate the carbon impact of different classes of medications, for example, the Medicine Carbon Footprint Classifier [43,44]. Such tools could potentially support hospitals to target high-impact therapeutic areas, in balance with clinical and economic considerations, whilst being cognisant of the limitations of such methods, including inaccuracy in estimated impacts, the complexities of prescribing behaviour both within and outside of acute settings and the current lack of guidance to support hospitals to implement at scale.

2.2.2 Medical and Non-Medical Equipment

Hotspots of medical equipment use include intensive care [18], operating theatres (accounting for around 30% of hospital waste [45,46]), renal dialysis units [47] and laboratory services [48]. Hospitals can identify hotspots through material flow analysis [49] at the level of department, clinical pathway or specific procedure.

Once hotspots are identified, the principle of the three R's is then applied: reduce use, reuse (and repair) products, and recycle [18,50,51]. Reducing equipment use has the biggest impact on mitigation. Examples include optimising patient selection for tests/treatments (e.g., 12 to 44% laboratory tests ordered are considered unnecessary [52]), avoiding opening products during surgery that may not be required (for example, 981 items of equipment were wasted over 85 cases of hand surgery in one U.S. centre [53]), removal of unnecessary equipment from procedure-packs, and avoiding unnecessary paper and electronic documentation. One specific example to reduce avoidable waste in surgery is through using surgical preference lists, tailored procedure packs and opening equipment as needed instead of by default – as stated in the Intercollegiate Green Theatre Checklist [11,54].

Although context specific, reusable medical products have a lower carbon emission profile compared to single-use items in almost all instances, with typically 40 to 50%

less carbon than the disposable equivalent [11,55]. Additionally, reuse prevents other environmental degradation (e.g., from raw materials extraction) and improves supply chain resilience. In most cases, reuse also brings financial savings. Our analysis of the five most common operations performed in the NHS found that 14% of the carbon emissions could be eliminated through a reduce and reuse strategy, using existing technology [55].

The uptake of reusable devices can be hampered by infection risk perceptions, policies and practice, non-availability of reusable alternatives, and lack of human and physical resource for decontamination [56]. There is support for reuse in the NHS: through the UK Department of Health Design for Life programme (which aims to eliminate all avoidable single-use medical products by 2045), and through instigation of the Circular Economy Healthcare Alliance: a collection of Trusts driving forward an evidenced approach to enable reuse of medical equipment.

Emissions associated with digital services may also need to be considered separately, given they span multiple emissions categories [57]. As discussed elsewhere in this review, digital interventions can support carbon mitigation but must also be subject to energy efficiency interventions. With the increasing digitisation of NHS services in the UK and rising use of artificial intelligence software, this area requires more evidence.

2.2.3 Food and Catering

Whereas food contributes a low amount to overall NHS carbon footprint, in hospitals it could contribute up to 30% of scope 3 emissions due to high consumption [58]. Mitigation activities include low-carbon menus (the Healthier Planetary Health Diet [59]), reduction of food waste, considering local food suppliers to reduce transport and storage emissions (but context dependent, as this may not always produce carbon mitigation [60]), and reducing single-use catering plastics [61]. The NYC Health + Hospitals [62] program in a US hospital is premised on nudging patients and staff to choose more sustainable, healthier food options, and achieved a 36% reduction in food emissions with a satisfaction rate of over 90%. However, with interventions in this area mainly supported by small-scale case-studies, more work is needed to understand how lower carbon food provision could be delivered at scale across NHS sites in the UK.

2.3 Buildings and Energy

Hospitals are intensive sites of energy use compared to other healthcare facilities [6]. Decarbonisation of the UK national grid contributed to a 64% reduction in emissions from energy use between 1999 and 2019 [6], but gas as an energy source makes up the majority of energy emissions in the NHS estate [57]. Existing guidance outlines an approach to decarbonise the NHS estate [63], which includes four main aspects:

(1) Reduce energy use and improve energy efficiency. Measures include adopting Building Management Systems, digital optimisation of electrical equipment use, maximising building use, and installing energy-efficient lighting. For example, operating theatres may use six times the energy of other hospital estate [45] with heating, ventilation and air conditioning (HVAC) systems contributing over 90% of this. HVAC can be safely switched off in elective theatres out of hours [64]. Similarly, Roletto et al. [65] identified 40–91% of energy used by radiological devices as "nonproductive" and estimated savings of 14,180–171,000 kWh per annum using workflow informatics tools to switch off 'idle' devices.

(2) Preparing buildings for electricity-driven heating: e.g., improving insulation, replacing windows with high-performance alternatives, green/cool roofing, and reducing thermal bridging.

(3) Switching to non-fossil fuel heating: removal of coal/oil boilers, electrically-led heating, use of heat pumps and links to district heat networks.

(4) Investing in on-site generation: Solar generation has tripled in the NHS since 2019 [57]. The compact layout of some hospital buildings may make on-site generation challenging, so alternatives such as solar farming (where energy is connected directly to a hospital's electrical system) should also be considered. Uptake could however be limited by restrictions enforced through power purchase agreements [66].

2.4 Waste Management

Waste, particularly recycling, are often evocative topics in discussions around sustainability. However, the primary mechanism of reducing emissions from waste ought to be waste reduction through mechanisms outlined elsewhere in this review (see 2.2.2). Low carbon waste management should only be explored where realistic opportunities for reduced use or reuse/repair of equipment have been exhausted. Effective waste management is through maximising material recovery for recycling (associated with lower carbon emissions than current forms of disposal) and choosing the lowest carbon options for waste disposal [67]. This requires effective waste segregation at source, supported by education programs for clinical staff [26]. Where disposal is necessary, waste should be treated cognisant of environmental impacts: for example, coupling incineration to electricity generation or completing autoclave decontamination to enable infectious waste to be managed with lower temperature incineration [67]. NHS Clinical Waste Strategy aims for a 30% reduction in carbon emissions and savings of £11 million through implementing such waste segregation and disposal principles [68].

In reality, the ideals of waste management are difficult to achieve. Waste segregation in UK hospitals is poor, with one audit showing half of waste in clinical bins was inappropriate and poorly resolved by educational interventions [69]. This sector requires significant innovation and research [26].

2.5 Water Usage

Calculations of water-related emissions primarily derive from supply and treatment. To reduce emissions, hospitals should therefore reduce water utilisation and increase recovery, ideally using a comprehensive water management programme [6,70]. In an Australian context, it was estimated that water consumption could be reduced by 10 to 25% [71]. Renal dialysis is a hotspot: a patient receiving intermittent haemodialysis may utilise over 18,500 litres of water per annum [47] and there are over 25,000 patients receiving haemodialysis in the UK [72]. Options to reduce consumption include guidelines for reduced activity via delayed dialysis, optimising dialysis flow rates and reverse osmosis systems, water recycling for other hospital activities (which could save millions of litres), and zero liquid discharge water treatment processes [50]. Other opportunities include switching off idle equipment such as steam sterilizers [70,73].

2.6 Travel and Transport

Successful strategies to mitigate travel and transport footprints are relatively well-evidenced, with the highest impact approach being to avoid unnecessary journeys [74].

Staff and patient travel contribute similarly to healthcare emissions [57]. The carbon footprint of most outpatient consultations is however dominated by the patient journey to the hospital (ranging 0.70 to 372 kilograms of carbon dioxide equivalence per consultation depending on distance and mode of transport [75]). Remote/digital consultations and streamlined pathways should be used where clinically safe and appropriate.

Data from Getting it Right First Time (GIRFT) show large variation in patient pathways between hospitals, for example in the proportion of outpatients followed up after initial consultation, highlighting room for improvement [76]. A review of telemedicine found insufficient evidence on patient outcomes, acceptability and cost, but also no evidence of patient harm [77]. A targeted rather than blanket approach to remote consultation is needed: for example, our data from ear, nose and throat (ENT) consultations during the COVID-19 pandemic revealed patients having their first consultation remotely were more likely to have follow up or investigation than those seen face to face, whereas follow-up patients showed no difference [78]. We also found that patients consulting for symptoms of recurrent tonsillitis were satisfied with and accurately assessed remotely [79]. Another opportunity is to offer "one-stop" services, where investigations (such as radiology or blood tests) that aid diagnosis or prepare a patient for surgery are all performed at a single hospital visit, ideally the same day as a consultation.

Where transport is necessary, green transport can be supported or incentivised. This could include active travel schemes, infrastructure and schemes to support cycling, public transport and electric vehicles [80].

2.7 Clinical Gases

Owing to the potency of greenhouse gases released during their use, clinical gases (anaesthetic gases and metered dose inhalers) require special consideration.

In acute trusts anaesthetic gases contribute a larger portion of clinical gas emissions than inhalers. There has been a 98% reduction in emissions from desflurane since 2019/20 in England, owing to a drive to eliminate its use in favour of other anaesthetic gases with lower global warming potential [57]. To further drive emission reductions, there is also a need to eliminate nitrous oxide (N_2O) (including decommissioning N_2O manifolds), and where appropriate use total intravenous anaesthesia (TIVA) and regional anaesthesia in place of clinical gases [11].

There are several practices, following the principles of sustainable healthcare, by which reductions in emissions from inhalers could be achieved [81]—for example, the rate of inhaler use can be lowered by reducing incidence of respiratory diseases (e.g., smoking cessation interventions), and improving symptom control of respiratory conditions (poorly controlled asthma has 8-fold higher greenhouse gas emissions per capita in the UK compared to well controlled asthma, largely due to increased reliever inhaler usage [82]). Dry powder inhaler (DPI) and soft-mist inhaler (SMI) are low carbon options compared with currently available pressurised metered-dose inhalers (pMDI) and appropriate preferencing of DPI over pMDI could reduce the European carbon footprint from inhalers by an estimated 85% [83]. Smaller cannister pMDI should also be preferred where available and necessary (e.g., such practice led to a reported decrease in the average emissions from short-acting beta-2 agonist inhalers from 24.2 kgCO2e in 2020 to 16.1 kgCO2e in 2024 in England) [84]. However, while these methods have been outlined with a focus on primary care in mind (given the larger burden of inhaler-related emissions in that context), there has been relatively little attention on how acute trusts specifically can reduce their emissions from inhalers. Interventions may not necessarily translate across settings. For example, care is required to make clinically appropriate switches to inhalers with lower carbon emissions that preserve disease control, as not all patients are able to demonstrate effective technique for their use [83]. In-hospital populations contain disproportionate numbers of patients with frailty compared to the general population which can limit DPI/SMI use and disparity across acute services in the provision of specialist respiratory teams to support this may affect the ability to implement safe switching.

Table 1. Summary of decarbonisation interventions by carbon emissions sector for acute hospitals in the UK.

Aim	Examples of interventions	Potential Barriers	Maturity of Evidence
Supply Chain and Procurement			
Reduce overprescribing of pharmaceuticals	De-prescribing tools to reduce polypharmacy Standardised pathways to avoid suboptimal prescribing Antimicrobial stewardship behavioural interventions	- Human resource intensity required to implement behavioural interventions at scale - Lack of efficacious deprescribing tools identified - Regional variation in pathways, prescribing patterns and prescribing systems	- Limited evidence on scale of overprescribing in hospital contexts - Lack of prior large-scale, effective and sustainable interventions demonstrating reductions - Strong evidence associating patient harm with polypharmacy - Evidence largely based on proxy measures and plausibility
Lower carbon medicinal forms prioritised	Lower carbon alternatives prioritised, utilising carbon footprint estimations and LCA data	- Lack of guidance on how to integrate carbon footprint data into pharmaceutical governance - Limited numbers of drugs with LCA available	- LCAs available for different medicinal forms of isolated drugs and alternatives only, with direct evidence of carbon mitigation when alternatives used - Carbon footprint estimates available for range of pharmaceuticals via indirect measures
Reduce waste from unused pharmaceuticals	Exploration of opportunities to re-stock unused pharmaceuticals Improved stock management	- UK policy and regulation currently prevent re-stocking - Regional variability in stock management systems	- Limited exploration of safe and patient-friendly methods to implement re-stocking in UK setting - Few studies examining extended pharmaceutical stability and safety for reuse
Reducing consumption of medical and non-medical equipment	Patient selection for tests/treatment optimised Reducing number of unnecessary but opened products for surgeries Removal of unnecessary products from procedure packs Avoiding unnecessary paper and electronic documentation Prioritising reusable products instead of disposable ones	- Lack of availability of many reusable alternatives - Human and physical resources required for decontamination - Infection risk perception, policy and practice - Need for governance practices to support reuse	- Patient selection optimisation and reusable equipment are well-evidenced in literature - There is centralised government support (through Design for Life)
Addressing emissions from food and catering	Introducing low-carbon menus Food waste reduced Local food suppliers prioritised Single-use catering plastics reduced	- Evidence for environmental benefits of local suppliers is context dependent	- Case study evidence only, has demonstrated benefits of reduced carbon emissions, healthier food choices and higher patient satisfaction
Estates and Facilities			
Decarbonising NHS estate's building and energy consumption	Reduction in energy use and improved energy efficiency through addressing hotspots Buildings prepared for electricity-driven/non-fossil fuel heating Investment in on-site energy generation	- Existing power purchasing agreements - Upfront cost to estate improvements - Technical challenges in retrofit of some buildings	- Well-evidenced, existing guidance for hospitals based on successful case-studies and knowledge from other sectors

Table 1. Continued.

Aim	Examples of interventions	Potential Barriers	Maturity of Evidence
Optimising waste management	Waste segregation at source Education programs for clinical staff Incineration coupled with electricity generation	- Poor existing waste segregation practices - Education may not improve waste segregation - Regional variation in waste facilities and services	- Innovation and research needed to support improvement at national scale
Optimising water usage and efficiency	Improved efficiency in renal dialysis Water recycling for hospital activities Zero liquid discharge water treatment processes	- Financial investment to modify local water restructure - Possible disruption to clinical services during improvements	- Hospital water usage and efficiency has had limited exploration in a UK context - Guidance on UK hospital water management not recently updated - Limited linkage made between water usage and carbon mitigation in literature
Travel and Transport			
Reducing travel and transport emissions	Reduction in unnecessary journeys Telemedicine adaptation Green and active transport	- Adaptation and appropriate usage of remote novel clinical pathways - Funding opportunities to support green travel initiatives	- Well-evidenced regarding decreasing travel and impact on carbon mitigation with systematic review evidence - Further exploration and elaboration on optimal efficiency needed by different clinical pathways
Clinical Gases			
Reducing emissions from clinical gases	Desflurane and nitrous oxide removed from hospital practice Total intravenousanaesthesia and regional anaesthesia prioritised Smaller canister common propellant inhalers prioritised DPI/SMIs prioritised over pMDIs and suitable patients switched	- Further data on clinical outcomes from TIVA and regional anaesthesia may be required - Clinical complexity in inhaler choice - Variation in human and time resource for inhaler reviews and education of clinical staff	- Desflurane has been nearly eliminated from UK clinical practice - Demonstrable environmental and financial benefit to N_2O manifold decommissioning - In general practice setting, demonstrable benefits at scale to switching to inhalers smaller cannister sizes by default - Limited published evidence regarding switching inhalers in hospital setting

DPI, Dry powder inhaler; SMI, soft-mist inhaler; pMDI, pressurised metered-dose inhaler; LCA, life-cycle analysis; TIVA, total intravenous anaesthesia; N_2O, nitrous oxide.

2.8 Summary of Interventions

Whereas interventions for hospitals to mitigate their carbon emissions may need to be individualised, most strategies are likely to be in common. Table 1 summarises several interventions discussed through this review by each sector of emissions, alongside potential barriers and estimated maturity of evidence (based on the type and availability of evidence, and whether there has been successful implementation). We also highlight that several interventions are likely to have co-benefits to clinical and non-clinical outcomes. For example, addressing overprescription may reduce adverse effects including hospitalisations, antimicrobial resistance, and other forms of environmental pollution (which in turn can harm people), as well as potentially being cost saving through reduced prescription costs. Other interventions can improve patient quality of life, such as reducing unnecessary travel for appointments that could be undertaken remotely, improving access to active travel, and reducing numbers of unnecessary invasive investigations.

3. Implementation of Hospital Decarbonisation Strategies

Executive leadership is needed to deliver decarbonisation strategy [85], but our recent analysis indicates only 76% of English NHS trusts have an executive lead for sustainability and that most of the initial wave of Green Plans (92%) did not iterate specific, measurable, achievable, relevant and time-bound (SMART) objectives across areas of decarbonisation [7]. Even where an executive lead is appointed, that does not equate to sustainability being prioritised within that trust [86]. As Green Plans are now being refreshed, the ideas presented here could help drive their content but must also be supported by metrics and accountability. Most interventions do not have precise estimates of their expected carbon mitigation, but proxy measures can and should be used (or estimated) and monitored over time, for example, volumes of medication/equipment use, weight of waste (food, clinical and other), proportion of on-site energy production that is zero/low-carbon options [87].

Dedicated sustainability teams, resource and governance are also necessary, alongside coherent system-wide approaches (with leadership crossing organisational borders). Historically many changes in sustainable healthcare have relied on volunteerism, but this is no basis for large-scale change: for example, our evidence suggests that the move to reusable medical equipment is often led by committed individuals working against, rather than with, systems, which limits adoption and scale [88]. Instead, GIRFT exemplifies how evidence-based carbon savings can be identified and implemented at each stage of a clinical pathway [89]. Another example is the NHS Scotland National Green Theatres Programme, which through overseeing evidence-based actions by Health Boards is projected to save 21,973 tCO_2e and £7.9 million per annum [7]. Such approaches will become increasingly important: while we should commend the decrease of 14% in 5 years in the NHS carbon footprint [57], progress may not be sustained: the "low-hanging fruit" may be gone.

Sustainability should be integrated into decision-making wherever relevant [90]. This may seem difficult, even impossible, when facing financial difficulties, but green strategies frequently save money. There are several examples where hospitals have saved substantial sums through green strategy, year-on-year. For example, one trust is expected to save £75,000 over 10 years from nitrous oxide manifold decommissioning, another stated they will save over £225,000 per year in energy bills following solar panel installation [91]. But to realise this, we must also take a re-imagined approach to financing, such as strategic capital planning, allowing upfront financial investment to achieve long-term savings.

Patient outcomes, including safety, also need to be considered when making changes to health systems. There is potential for harm: for example, inappropriate switching of inhalers could increase risk of asthma exacerbation. However, as highlighted elsewhere in this review, many sustainability interventions have neutral effect or even contribute to improved clinical outcomes. What is important is that evidence drives decision-making: misconceptions of the impact of "going green" on patient outcomes does prevent uptake of impactful changes (e.g., operating theatre practitioners' refusal to use reusable drapes and gowns despite no evidence of infection risk [92]).

We should also recall that to date no single healthcare organisation has achieved net zero carbon emissions and the barriers to doing so are frequently outside the domain of a single trust [85,86,93,94]. Hence change also needs support from national institutions, to target these barriers (such as opening up funding opportunities), support development of evidence-based research on knowledge gaps to inform national guidance, and build accountability, commissioning and delivery structures that support low carbon models of care—for example for reusable products, through preferencing their purchase, developing regulations that support reuse, and building infrastructure to enable decontamination.

4. Conclusion

The challenge to decarbonise hospitals is not to be underestimated. Yet, despite urgency, the scale of contribution of acute care to carbon emissions, and statutory requirements for hospitals to develop decarbonisation strategy, there has been to date limited progress. We have outlined here evidence and possible strategic priorities for decarbonisation of acute hospitals by sector of emissions, which requires the necessary leadership, governance and monitoring structures to ensure timely implementation. Successful case studies of going green are frequently not transferred to other settings, reflecting a lack of system-wide learning, policy or funding mechanisms to support sustained reductions in hospital carbon emissions. Whereas sustainability may be seen as a sideline to other hospital commitments, the significant financial savings of "going green", alongside other possible co-benefits to patient and staff wellbeing, should be seen as important additional drivers of change.

Key Points

• Hospital emissions in England have been described according to emissions sector, with the largest contribution derived from procurement of medicines, medical equipment, food and other supplies.

• Hospitals in England are required by contract to have emission reduction strategies, but to date these have not been comprehensive, specific, measurable and action-focussed.

• Actions to decarbonize hospitals should be underpinned by the principles of low carbon care, but specific actions will vary by emissions sector. This review summarizes key actions that can be taken by emissions sector to mitigate carbon emissions in UK hospitals.

• Differences in the availability and maturity of evidence between emissions sectors may limit the possibility of implementation of successful emissions strategies, particularly for emissions from supply chain and procurement.

• To ensure large-scale implementation and avoid reliance on volunteerism, a comprehensive strategy needs to involve changes to supporting leadership, governance and financial structures within hospitals and nationally.

Availability of Data and Materials

Not applicable.

Author Contributions

MFB conceptualized the review structure. JA, PT, SV, FP and MFB conducted the literature search. JA completed the initial manuscript draft. All authors made substantial contributions to editing the manuscript and reviewed it critically for important intellectual content. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Romanello M, Walawender M, Hsu SC, Moskeland A, Palmeiro-Silva Y, Scamman D, et al. The 2025 report of the Lancet Countdown on health and climate change: climate change action offers a lifeline. Lancet (London, England). 2025; 406: 2804–2857. https://doi.org/10.1016/S0140-6736(25)01919-1

[2] Karliner J, Slotterback S, Boyd R, Ashby B, Steele K. Health care's climate footprint: How the health sector contributes to the global climate crisis and opportunities for action. 2019. Available at: https://global.noharm.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf (Accessed: 27 April 2026).

[3] NHS England, NHS Improvement. Delivering a 'Net Zero' National Health Service. 2022. Available at: https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2022/07/B1728-delivering-a-net-zero-nhs-july-2022.pdf (Accessed: 7 August 2023).

[4] The Scottish Government. NHS Scotland Climate Emergency and Sustainability Strategy: 2022–2026. 2022. Available at: https://www.gov.scot/publications/nhs-scotland-climate-emergency-sustainability-strategy-2022-2026/documents/ (Accessed: 30 July 2026).

[5] Welsh Government. NHS Wales decarbonisation strategic delivery plan 2025 to 2030. 2025. Available at: https://www.gov.wales/nhs-wales-decarbonisation-strategic-delivery-plan-2025-2030-0 (Accessed: 14 August 2026).

[6] Tennison I, Roschnik S, Ashby B, Boyd R, Hamilton I, Oreszczyn T, et al. Health care's response to climate change: a carbon footprint assessment of the NHS in England. The Lancet. Planetary Health. 2021; 5: e84–e92. https://doi.org/10.1016/S2542-5196(20)30271-0

[7] Tabakov P, Bhutta M. Policy Brief: A critical evaluation of Green Plans to support NHS Trusts in England. Brighton and Sussex Medical School: Brighton. 2025. https://doi.org/10.13140/RG.2.2.33204.56968

[8] Centre for Sustainable Healthcare. Case studies in sustainable healthcare. Available at: https://networks.sustainablehealthcare.org.uk/CaseStudies (Accessed: 28 November 2025).

[9] Abbott J, Rizan C, Smith JN, Loeken M, Trueba ML, Bhutta MF. Country of Origin of Medical Products and Risk of Labour Rights Abuse: A Cross-Sectional Analysis Using Four Procurement Datasets. Cureus. 2024; 16: e54258. https://doi.org/10.7759/cureus.54258

[10] Mortimer F. The sustainable physician. Clinical Medicine (London, England). 2010; 10: 110–111. https://doi.org/10.7861/clinmedicine.10-2-110

[11] Brighton & Sussex Medical School, Centre for Sustainable Healthcare, UK Health Alliance on Climate Change. Green Surgery: Reducing the Environmental Impact of Surgical Care. 2023. Available at: https://www.rcseng.ac.uk/-/media/Files/GreenSurgeryReport2023.pdf (Accessed: 27 January 2025).

[12] Royal College of Emergency Medicine. GreenED Handbook. 2023. Available at: https://rcem.ac.uk/wp-content/uploads/2023/03/GreenED-Toolkit-V1_6-March-2023-_-0603.pdf (Accessed: 27 January 2025).
[13] Sebastian S, Dhar A, Baddeley R, Donnelly L, Haddock R, Arasaradnam R, et al. Green endoscopy: British Society of Gastroenterology (BSG), Joint Accreditation Group (JAG) and Centre for Sustainable Health (CSH) joint consensus on practical measures for environmental sustainability in endoscopy. Gut. 2023; 72: 12–26. https://doi.org/10.1136/gutjnl-2022-328460
[14] Stigant CE, Barraclough KA, Harber M, Kanagasundaram NS, Malik C, Jha V, et al. Our shared responsibility: the urgent necessity of global environmentally sustainable kidney care. Kidney International. 2023; 104: 12–15. https://doi.org/10.1016/j.kint.2022.12.015
[15] Montero R, Mortimer F. How-to Guide: Improving Environmental Sustainability in New-Build Dialysis Units. 2023. Available at: https://networks.sustainablehealthcare.org.uk/sites/default/files/2024-02/Green%20Dialysis%20Unit%20checklist_0.pdf (Accessed: 11 April 2025).
[16] EFLM Task Force-Green Labs. EFLM Guidelines for Green and Sustainable Medical Laboratories. 2022. Available at: https://www.eflm.eu/upload/docs/EFLM-GREEN-LAB-BOOKLET.pdf (Accessed: 1 February 2025).
[17] Cohen ES, Kouwenberg LHJA, Moody KS, Sperna Weiland NH, Kringos DS, Timmermans A, et al. Environmental sustainability in obstetrics and gynaecology: A systematic review. BJOG: an International Journal of Obstetrics and Gynaecology. 2024; 131: 555–567. https://doi.org/10.1111/1471-0528.17637
[18] McGain F, Muret J, Lawson C, Sherman JD. Environmental sustainability in anaesthesia and critical care. British Journal of Anaesthesia. 2020; 125: 680–692. https://doi.org/10.1016/j.bja.2020.06.055
[19] O'Hare A, Lyons T. 47 Integrated care system (ICS) pharmacy medicines optimisation and sustainability checklist for NHS green plans. BMJ Leader. 2023; 7: A27–A28. https://doi.org/10.1136/leader-2023-fmlm.32
[20] Martin MF, Maturen KE. On Green Radiology. Academic Radiology. 2020; 27: 1601–1602. https://doi.org/10.1016/j.acra.2020.04.017
[21] Zurynski Y, Herkes-Deane J, Holt J, McPherson E, Lamprell G, Dammery G, et al. How can the healthcare system deliver sustainable performance? A scoping review. BMJ Open. 2022; 12: e059207. https://doi.org/10.1136/bmjopen-2021-059207
[22] Wolters A, Santos F, Lloyd T, Lilburne C, Steventon A. Emergency admissions to hospital from care homes: how often and what for? The Health Foundation: London. 2019.
[23] Begum H, Gray WK, Simpson RM, Ingleton R, Phull MK. Carbon emissions from clinical activities by speciality in secondary and tertiary care in England: an exploratory cross-sectional analysis of routine administrative data. The Lancet Regional Health. Europe. 2025; 54: 101333. https://doi.org/10.1016/j.lanepe.2025.101333
[24] Wright J, Franks A, Ayres P, Jones K, Roberts T, Whitty P. Public health in hospitals: the missing link in health improvement. Journal of Public Health Medicine. 2002; 24: 152–155. https://doi.org/10.1093/pubmed/24.3.152
[25] UK Government Department of Health and Social Care. Fit for the future: 10 Year Health Plan for England - Executive Summary. 2025. Available at: https://www.gov.uk/government/publications/10-year-health-plan-for-england-fit-for-the-future/fit-for-the-future-10-year-health-plan-for-england-executive-summary (Accessed: 14 April 2026).
[26] Ranjbari M, Shams Esfandabadi Z, Shevchenko T, Chassagnon-Haned N, Peng W, Tabatabaei M, et al. Mapping healthcare waste management research: Past evolution, current challenges, and future perspectives towards a circular economy transition. Journal of Hazardous Materials. 2022; 422: 126724. https://doi.org/10.1016/j.jhazmat.2021.126724
[27] Syms R, Taylor-Robinson SD, Trovato G. Circular Medicine - Being Mindful of Resources and Waste Recycling in Healthcare Systems. Risk Management and Healthcare Policy. 2023; 16: 267–270. https://doi.org/10.2147/RMHP.S396667
[28] World Health Organization, Unitaid Secretariat. Report of Climate Resilient and Environmentally Sustainable Supply Chains in the Health Sector Expert Consultation. Geneva. 2024. Available at: https://cdn.who.int/media/docs/default-source/climate-change/cres_supply_chains.pdf?sfvrsn=3b521e6e_3&download=true (Accessed: 30 July 2026).
[29] NHSBSA. Prescribing Costs in Hospitals and the Community England 24/25. 2025. Available at: https://nhsbsa-opendata.s3.eu-west-2.amazonaws.com/pchc/pchc-2024-2025-narrative-v001.html (Accessed: 14 April 2026).
[30] UK Government Department of Health and Social Care. Good for you, good for us, good for everybody: a plan to reduce overprescribing to make patient care better and safer, support the NHS, and reduce carbon emissions. 2021. Available at: https://www.gov.uk/government/publications/national-overprescribing-review-report (Accessed: 24 January 2024).
[31] Elliott RA, Camacho E, Campbell F, Jankovic D, Martyn-St James M, Kaltenthaler E, et al. Prevalence and economic burden of medication errors in the NHS in England: rapid evidence synthesis and economic analysis of the prevalence and burden of medication error in the UK. The University of Sheffield: Sheffield. 2024. https://doi.org/10.15131/shef.data.25218950.v1
[32] Alejandre JC, Stevenson EM, Fady PE, Bennett N. Eco-directed and Sustainable Prescribing of Pharmaceuticals in the United Kingdom. Policy Brief. 2023. Available at: https://bsac.org.uk/wp-content/uploads/2023/07/Fina-Digital_Policy-Brief-on-EDSP_18Jul23.pdf (Accessed: 12 January 2024).
[33] Bennett F, Ferner R, Sofat R. Overprescribing and rational therapeutics: Barriers to change and opportunities to improve. British Journal of Clinical Pharmacology. 2021; 87: 34–38. https://doi.org/10.1111/bcp.14291
[34] Pazan F, Wehling M. Polypharmacy in older adults: a narrative review of definitions, epidemiology and consequences. European Geriatric Medicine. 2021; 12: 443–452. https://doi.org/10.1007/s41999-021-00479-3
[35] Mejías-Trueba M, Fernández-Rubio B, Rodríguez-Pérez A, Bernabeu-Wittel M, Sánchez-FIdalgo S. Identification and characterisation of deprescribing tools for older patients: A scoping review. Research in Social & Administrative Pharmacy: RSAP. 2022; 18: 3484–3491. https://doi.org/10.1016/j.sapharm.2022.03.008
[36] O'Hara J, Stocken DD, Watson GC, Fouweather T, McGlashan J, MacKenzie K, et al. Use of proton pump inhibitors to treat persistent throat symptoms: multicentre, double blind, randomised, placebo controlled trial. BMJ (Clinical Research Ed.). 2021; 372: m4903. https://doi.org/10.1136/bmj.m4903
[37] Llewelyn MJ, Budgell EP, Laskawiec-Szkonter M, Cross ELA, Alexander R, Bond S, et al. Antibiotic review kit for hospitals (ARK-Hospital): a stepped-wedge cluster-randomised controlled trial. The Lancet. Infectious Diseases. 2023; 23: 207–221. https://doi.org/10.1016/S1473-3099(22)00508-4
[38] Smale EM, Ottenbros AB, van den Bemt BJF, Heerdink ER, Verploegen J, van Zelm R, et al. Environmental Outcomes of Reducing Medication Waste by Redispensing Unused Oral Anti-

cancer Drugs. JAMA Network Open. 2024; 7: e2438677. https://doi.org/10.1001/jamanetworkopen.2024.38677
[39] Donyai P, McCrindle R, Hui TKL, Sherratt RS. Stakeholder Views on the Idea of Medicines Reuse in the UK. Pharmacy (Basel, Switzerland). 2021; 9: 85. https://doi.org/10.3390/pharmacy9020085
[40] European Health Management Association. Digital medication management in healthcare settings: A key opportunity for the European Union. 2022. Available at: https://ehma.org/digital-medication-management-in-healthcare-settings/ (Accessed: 27 January 2025).
[41] Arioua A, Shaw D. Use of Expired Drugs: Patients Benefits versus Industry Interest. JMA Journal. 2024; 7: 1–4. https://doi.org/10.31662/jmaj.2022-0209
[42] Davies JF, McAlister S, Eckelman MJ, McGain F, Seglenieks R, Gutman EN, et al. Environmental and financial impacts of perioperative paracetamol use: a multicentre international life-cycle assessment. British Journal of Anaesthesia. 2024; 133: 1439–1448. https://doi.org/10.1016/j.bja.2023.11.053
[43] Taylor H, Mahamdallie S, Sawyer M, Rahman N. MCF classifier: Estimating, standardizing, and stratifying medicine carbon footprints, at scale. British Journal of Clinical Pharmacology. 2024; 90: 2713–2723. https://doi.org/10.1111/bcp.16229
[44] Piffoux M, Le Tellier A, Taillemite Z, Ducrot C, Taillemite S. Carbon footprint of oral medicines using hybrid life cycle assessment. Journal of Cleaner Production. 2024; 475: 143576. https://doi.org/10.1016/j.jclepro.2024.143576
[45] Choi BJJ, Chen CL. The Triple Bottom Line and Stabilization Wedges: A Framework for Perioperative Sustainability. Anesthesia and Analgesia. 2022; 134: 475–485. https://doi.org/10.1213/ANE.0000000000005890
[46] Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The Carbon Footprint of Surgical Operations: A Systematic Review. Annals of Surgery. 2020; 272: 986–995. https://doi.org/10.1097/SLA.0000000000003951
[47] Barraclough KA, Agar JWM. Green nephrology. Nature Reviews. Nephrology. 2020; 16: 257–268. https://doi.org/10.1038/s41581-019-0245-1
[48] Lopez JB, Jackson D, Gammie A, Badrick T. Reducing the Environmental Impact of Clinical Laboratories. The Clinical Biochemist. Reviews. 2017; 38: 3–11.
[49] Hunfeld N, Diehl JC, Timmermann M, van Exter P, Bouwens J, Browne-Wilkinson S, et al. Circular material flow in the intensive care unit-environmental effects and identification of hotspots. Intensive Care Medicine. 2023; 49: 65–74. https://doi.org/10.1007/s00134-022-06940-6
[50] Ben Hmida M, Mechichi T, Piccoli GB, Ksibi M. Water implications in dialysis therapy, threats and opportunities to reduce water consumption: a call for the planet. Kidney International. 2023; 104: 46–52. https://doi.org/10.1016/j.kint.2023.04.008
[51] Rizan C, Mortimer F, Stancliffe R, Bhutta MF. Plastics in healthcare: time for a re-evaluation. Journal of the Royal Society of Medicine. 2020; 113: 49–53. https://doi.org/10.1177/0141076819890554
[52] Zhi M, Ding EL, Theisen-Toupal J, Whelan J, Arnaout R. The landscape of inappropriate laboratory testing: a 15-year meta-analysis. PloS One. 2013; 8: e78962. https://doi.org/10.1371/journal.pone.0078962
[53] Bravo D, Thiel C, Bello R, Moses A, Paksima N, Melamed E. What a Waste! The Impact of Unused Surgical Supplies in Hand Surgery and How We Can Improve. Hand (New York, N.Y.). 2023; 18: 1215–1221. https://doi.org/10.1177/15589447221084011
[54] Robb HD, Pegna V. The Intercollegiate Green Theatre Checklist. The Bulletin of the Royal College of Surgeons of England. 2023; 105: 64–67. https://doi.org/10.1308/rcsbull.2023.25
[55] Rizan C, Lillywhite R, Reed M, Bhutta MF. The carbon footprint of products used in five common surgical operations: identifying contributing products and processes. Journal of the Royal Society of Medicine. 2023; 116: 199–213. https://doi.org/10.1177/01410768231166135
[56] Saravanos GL, Islam MS, Huang Y, Basseal JM, Seale H, Mitchell BG, et al. Infection prevention and control programme priorities for sustainable health and environmental systems. BMC Global and Public Health. 2024; 2: 6. https://doi.org/10.1186/s44263-023-00031-4
[57] NHS England. Five years of a greener NHS: progress and forward look. 2025. Available at: https://www.england.nhs.uk/long-read/five-years-greener-nhs-progress-forward-look/ (Accessed: 12 April 2026).
[58] Rodríguez-Jiménez L, Romero-Martín M, Spruell T, Steley Z, Gómez-Salgado J. The carbon footprint of healthcare settings: A systematic review. Journal of Advanced Nursing. 2023; 79: 2830–2844. https://doi.org/10.1111/jan.15671
[59] Moseley G, Spajic L, Behrens G. Hospital food environments: a human and planetary health opportunity. The Medical Journal of Australia. 2020; 212: 384–384.e1. https://doi.org/10.5694/mja2.50576
[60] Coley D, Howard M, Winter M. Local food, food miles and carbon emissions: A comparison of farm shop and mass distribution approaches. Food Policy. 2009; 34: 150–155. https://doi.org/10.1016/J.FOODPOL.2008.11.001
[61] NHS England. National standards for healthcare food and drink. 2022. Available at: https://www.england.nhs.uk/long-read/national-standards-for-healthcare-food-and-drink/#4-improving-sustainable-procurement-and-reducing-food-waste (Accessed: 14 February 2025).
[62] NYC Health + Hospitals. NYC Health + Hospitals Celebrates 1.2 Million Plant-Based Meals Served. 2024. Available at: https://www.nychealthandhospitals.org/pressrelease/nyc-health-hospitals-celebrates-1-2-million-plant-based-meals-served/ (Accessed: 14 April 2026).
[63] Greener NHS. Estates Net Zero Carbon Delivery Plan Technical Annex (version 1.0). 2022. Available at: https://future.nhs.uk/Estates_and_Facilities_Hub (Accessed: 13 January 2025).
[64] Bolten A, Kringos DS, Spijkerman IJB, Sperna Weiland NH. The carbon footprint of the operating room related to infection prevention measures: a scoping review. The Journal of Hospital Infection. 2022; 128: 64–73. https://doi.org/10.1016/j.jhin.2022.07.011
[65] Roletto A, Zanardo M, Bonfitto GR, Catania D, Sardanelli F, Zanoni S. The environmental impact of energy consumption and carbon emissions in radiology departments: a systematic review. European Radiology Experimental. 2024; 8: 35. https://doi.org/10.1186/s41747-024-00424-6
[66] Pascale F, Jones K. Existing hospitals' journey into a sustainable and climate-resilient future: barriers and opportunities for estates and facilities management. Facilities. 2025; 43: 777–802. https://doi.org/10.1108/F-01-2025-0002
[67] Rizan C, Bhutta MF, Reed M, Lillywhite R. The carbon footprint of waste streams in a UK hospital. Journal of Cleaner Production. 2021; 286: 125446. https://doi.org/10.1016/j.jclepro.2020.125446
[68] NHS England. NHS Clinical Waste Strategy. 2023. Available at: https://www.england.nhs.uk/publication/nhs-clinical-waste-strategy/ (Accessed: 14 April 2026)
[69] Runcie H. Sort your waste! An audit on the use of clinical waste bins and its implications. Future Healthcare Journal. 2018; 5: 203–206. https://doi.org/10.7861/futurehosp.5-3-203
[70] Department of Health. Environment and sustainability Health Technical Memorandum 07-04: Water management and water efficiency-best practice advice for the healthcare sector. 2013.

Available at: https://www.england.nhs.uk/wp-content/uploads/2021/05/HTM_07-04_Final.pdf (Accessed: 27 April 2025).

[71] McGain F, Naylor C. Environmental sustainability in hospitals - a systematic review and research agenda. Journal of Health Services Research & Policy. 2014; 19: 245–252. https://doi.org/10.1177/1355819614534836

[72] UK Renal Registry. UK Renal Registry: Summary of Annual Report - Analyses of adult data to the end of 2022. Available at: https://www.ukkidney.org/sites/renal.org/files/UK%20Renal%20Registry%20Annual%20Report%202022%20Patient%20Summary.pdf (Accessed: 28 January 2025).

[73] McGain F, Moore G, Black J. Hospital steam sterilizer usage: could we switch off to save electricity and water? Journal of Health Services Research & Policy. 2016; 21: 166–171. https://doi.org/10.1177/1355819615625698

[74] Braithwaite J, Smith CL, Leask E, Wijekulasuriya S, Brooke-Cowden K, Fisher G, et al. Strategies and tactics to reduce the impact of healthcare on climate change: systematic review. BMJ (Clinical Research Ed.). 2024; 387: e081284. https://doi.org/10.1136/bmj-2024-081284

[75] Purohit A, Smith J, Hibble A. Does telemedicine reduce the carbon footprint of healthcare? A systematic review. Future Healthcare Journal. 2021; 8: e85–e91. https://doi.org/10.7861/fhj.2020-0080

[76] NHS England. Outpatient services: a clinical and operational improvement guide. 2025. Available at: https://www.england.nhs.uk/long-read/outpatient-services-a-clinical-and-operational-improvement-guide/ (Accessed: 18 November 2025).

[77] Flodgren G, Rachas A, Farmer AJ, Inzitari M, Shepperd S. Interactive telemedicine: effects on professional practice and health care outcomes. The Cochrane Database of Systematic Reviews. 2015; 2015: CD002098. https://doi.org/10.1002/14651858.CD002098.pub2

[78] Gupta T, Bhutta MF. Outcomes of remote versus face-to-face ear, nose and throat outpatient consultation on patient pathways. Annals of the Royal College of Surgeons of England. 2023; 105: 561–567. https://doi.org/10.1308/rcsann.2022.0144

[79] Gupta T, Bowles P, Bhutta MF. Effectiveness, perceptions and environmental benefits of remote consultation for adults referred with recurrent tonsillitis. Annals of the Royal College of Surgeons of England. 2024; 106: 173–177. https://doi.org/10.1308/rcsann.2022.0098

[80] NHS England. NHS Net Zero Travel and Transport Strategy. 2023. Available at: https://www.england.nhs.uk/wp-content/uploads/2023/10/PRN00712_NHS-Net-Zero-Travel-and-Transport-Strategy.pdf (Accessed: 28 January 2025).

[81] Smith LJ, Marshall H, Medvecsky T, Nixon J, Phillips G, Saggu R, et al. Position Statement Sustainability and the Environment: Climate Change and Lung Health 2024 version 1.2. London. 2024. Available at: https://www.brit-thoracic.org.uk/about-us/position-statements/ (Accessed: 10 July 2024).

[82] Wilkinson AJK, Maslova E, Janson C, Radhakrishnan V, Quint JK, Budgen N, et al. Greenhouse gas emissions associated with suboptimal asthma care in the UK: the SABINA healthCARe-Based envirONmental cost of treatment (CARBON) study. Thorax. 2024; 79: 412–421. https://doi.org/10.1136/thorax-2023-220259 (online ahead of print)

[83] Vartiainen V, Woodcock AA, Wilkinson A, Janson C, Björnsdóttir U, Haahtela T, et al. Thoughtful prescription of inhaled medication has the potential to reduce inhaler-related greenhouse gas emissions by 85%. BMJ Open Respiratory Research. 2024; 11: e001782. https://doi.org/10.1136/bmjresp-2023-001782

[84] Wilkinson E. Net zero: progress on reducing the environmental impact of medicines. The Pharmaceutical Journal. 2025: 314. https://doi.org/10.1211/PJ.2025.1.356486

[85] Callan C, Cameron G, Hardie T. Policy levers for a net zero NHS: four priorities for the future [Internet]. 2024. Available at: https://www.health.org.uk/reports-and-analysis/briefings/policy-levers-for-a-net-zero-nhs-four-priorities-for-the-future (Accessed: 28 January 2025).

[86] Naylor C, Wills E, Hillson R. Environmental sustainability in the NHS. 2026. Available at: https://www.kingsfund.org.uk/insight-and-analysis/reports/environmental-sustainability-nhs (Accessed: 29 April 2026).

[87] Mortimer F, Isherwood J, Wilkinson A, Vaux E. Sustainability in quality improvement: redefining value. Future Healthcare Journal. 2018; 5: 88–93. https://doi.org/10.7861/futurehosp.5-2-88

[88] Mortimer F, Cameron D, Hillson R, McLean R, Bhutta MF, Llewellyn C, et al. Policy Brief: Transition to reusable medical products in NHS hospitals: Current practice and challenges. 2025. Available at: https://doi.org/10.13140/RG.2.2.28635.22567 (Accessed: 17 November 2025).

[89] John J, McGrath J, Gray K, O'Flynn K, Briggs T. A practical guide to decarbonising the bladder cancer care pathway. 2024. Available at: https://gettingitrightfirsttime.co.uk/wp-content/uploads/2024/12/FINAL-A-practical-guide-to-decarbonising-the-bladder-cancer-care-pathway-FINAL-December-2024.pdf (Accessed: 2 April 2026).

[90] Sherman JD, Thiel C, MacNeill A, Eckelman MJ, Dubrow R, Hopf H, et al. The Green Print: Advancement of Environmental Sustainability in Healthcare. Resources, Conservation and Recycling. 2020; 161: 104882. https://doi.org/10.1016/j.resconrec.2020.104882

[91] NHS England. Greener NHS - System progress and Case Studies. Available at: https://www.england.nhs.uk/greenernhs/whats-already-happening/ (Accessed: 14 April 2026).

[92] van der Klink M, Demirel P. Implementing reusable medical textiles in NHS operating theatres: Barriers and enablers. Journal of Cleaner Production. 2025; 491: 144852. https://doi.org/10.1016/j.jclepro.2025.144852

[93] Naylor C, Appleby J. Environmentally sustainable health and social care: Scoping review and implications for the English NHS. Journal of Health Services Research & Policy. 2013; 18: 114–121. https://doi.org/10.1177/1355819613485672

[94] McGeoch L, Hardie T, Coxon C, Cameron G. Net Zero Care: What Will It Take? 2023. Available at: https://www.health.org.uk/reports-and-analysis/briefings/net-zero-care-what-will-it-take (Accessed: 27 January 2025).