Clean Air, Waste Segregation, and a Decarbonised Supply Chain.

> There is an unmistakable link between the impact of healthcare's waste on the environment, and the respiratory health of the patients they care for.

The NHS has set the goal of becoming Net Zero by 2045.

The supply chain and waste contribute to 67% of the greenhouse gas emissions of the NHS, which directly leads to poor air quality. [1] Action is necessary to improve air quality both outside and within our homes, ensure waste is properly managed, and the supply chains are systematically decarbonised. This white paper aims to draw a correlation between cleaner air, efficient waste management and decarbonising the supply chain, within healthcare.

The purpose being to show that improving one area will lead to positive changes in the others. In this paper we describe the 'Integrated Clean Air & Environmental Management Model' and how it can be utilised to take a holistic approach to simultaneously decarbonising the supply chain, improving waste segregation, and increasing air quality. We will also explain how strategically targeting key impact areas, where more than one sector benefits, will create an easier and more efficient pathway to Net Zero.

Introduction

We believe in taking a holistic view on decarbonising the healthcare sector by seeing everything as interconnected, rather than isolated problems to be tackled in silos.

While the need for specific data to enable effective data-driven decisions cannot be ignored, as it drives agenda forward, long lasting change is more likely to be sustained if clean air data is also considered in the context of decarbonising the supply chain and waste management.

One can address national and global issues, which are negatively affecting healthcare, through focussing on these three symbiotic areas. By improving one area, it will create a positive knock-on effect onto the other two. In doing so, stopping healthcare contributing to its own financial, environmental, and health related burdens and difficulties.

Carbon neutrality cannot be achieved in one area without driving sustainable change in the other two; not doing so would be counterproductive to the end goal - achieving the Net Zero targets across the NHS.

Outlining the Problem

Waste

To give the reader an idea of the scale of each of these problems, in 2021, the UK sent 6.8 million tonnes of biodegradable municipal waste to landfill [2]. In the same year, the NHS generated 538,000 tonnes of waste [3], costing £115 million to dispose of and equivalent to around 30,000 tonnes of CO_2e [4]. Although waste and water is only equivalent to 5% the total carbon footprint of healthcare, these numbers are still worth tackling [1]; all emitting factors of the NHS must be addressed to achieve Net Zero. The disposal of medical waste can also lead to soil and water pollution [5].

Air Pollution

Moving on to air pollution, it is estimated that 28,000-36,000 people in the UK die each year from health issues such as lung cancer, strokes and heart disease caused by poor air quality [6]. The government website has declared 'air pollution is the largest environmental risk to public health' [7]. According to the World Health Organization (WHO), each year air pollution is responsible for nearly 7 million deaths around the globe [8]. 9 out of 10 people currently breathe air that exceeds the WHO's guideline limits for pollutants, with those living in low and middle-income countries suffering the most. [9].

Supply Chain

In 2021, the NHS Supply Chain was found to contribute 62% of all the organisation's emissions, procuring products from 80,000 suppliers [1]. This is equivalent to approximately 19.22Mt CO_2e a year [1]. A study by CPD, a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts, found that supply chain emissions are typically 11.4 times higher than operational emissions [10]. Given the supply chain represents such a higher percentage of the total emissions, it has the biggest opportunity for carbon savings.

Outlining the Problem

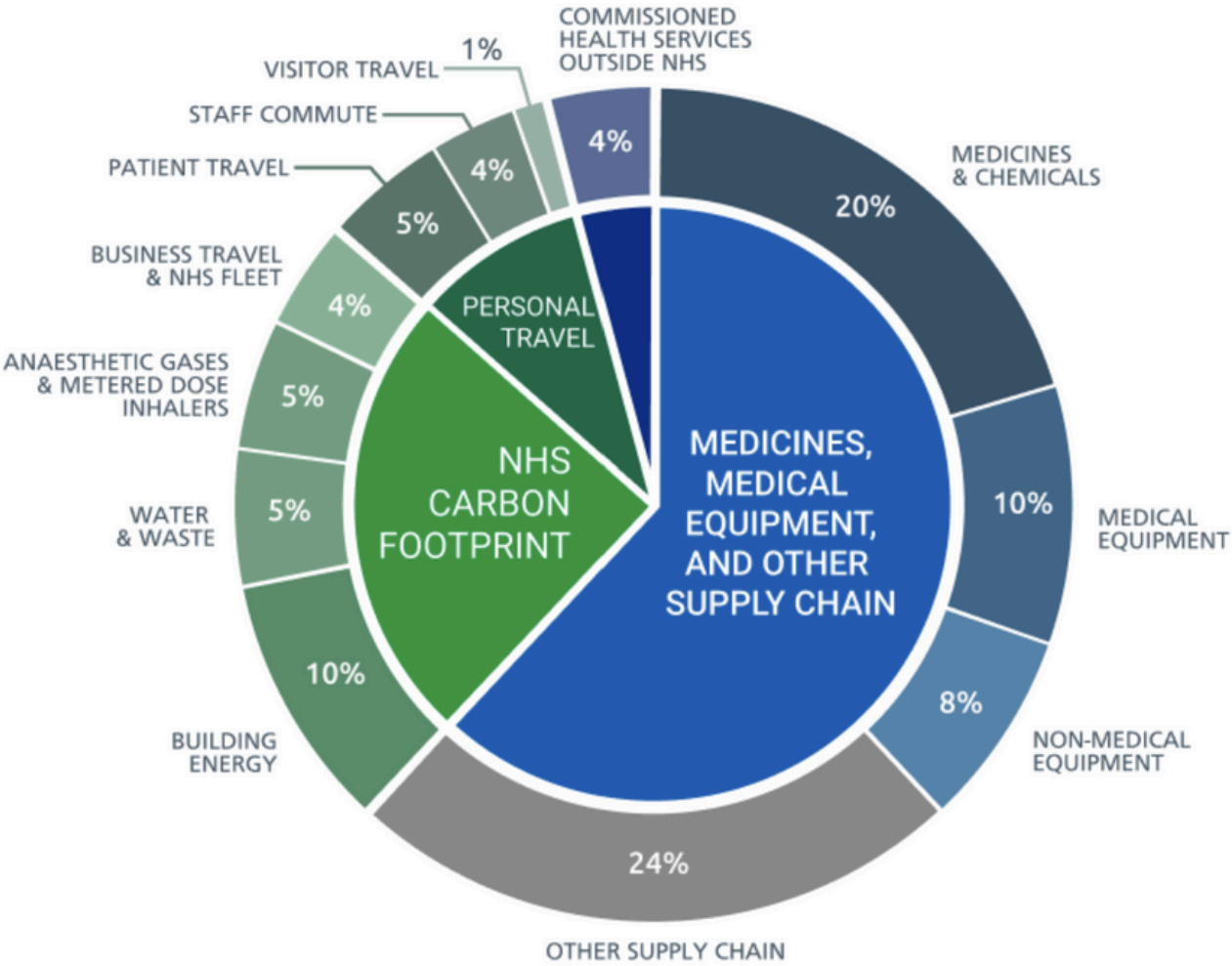
NHS Targets and Benefits

The NHS has set itself the target to reach Net Zero for all its direct emissions by 2040, and all indirect emissions by 2045 [1]. The targets are made not just to mitigate the negative effects of global warming, but also to reduce the impact of climate change on healthcare. Pollutants caused by the climate crisis generates more ill health, and natural disasters results in human injuries. The NHS represents 5% of the United Kingdom's carbon footprint, thereby directly escalating their own pressures on a health system already under strain [11]. Thus, it is in the best interest of the NHS to reach net zero from an operational standpoint beyond safeguarding the population's wellbeing it serves. By working towards Net Zero, 31 Mt CO_2e will no longer enter the atmosphere, resulting in cleaner air and a reduced volume of patients with respiratory issues, thereby reducing the strain on the NHS [1]. In 'Delivering a Net Zero NHS', the organisation outlined its intentions to improve each of the three aforementioned areas as it will: increase reclaimed materials and circularity,

improve resource efficiencies, greatly reduce their carbon footprint and costs, and increase prevention of disease, illness, and premature deaths [1]. The improved quality of life from a decarbonised NHS will also see a boosted economy from less financial strain on the NHS and healthier, longer living members of the public. There are great and obvious benefits from tackling all three areas in the Integrated Clean Air and Environmental Management (ICAEM) Model, but some are more subtle, which will be highlighted in this paper. By enacting up on all three, it makes efforts more efficient and beneficial due to the knock-on effect caused by their symbiotic relationship. This should result in a more efficient route to Net Zero.

Outlining the Problem

NHS Targets and Benefits



[1]

Clean Air

Air pollution is the presence of harmful substances in our air, often an intricate combination of different particles and gases [12]. Indoor and outdoor environments can be contaminated by chemical, physical or biological agents that alter the natural properties of the atmosphere and cause damage to the climate as well as human health [8]. The principal pollutants, which have national emission reduction commitments as part of the Clean Air Strategy and legislation, are fine particulate matter (PM2.5), ammonia (NH_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and non-methane volatile organic compounds (NMVOCs) [13]. Further ambient air pollutants comprise carbon monoxide (CO) and ozone [14]. Although natural phenomena like volcanic eruptions can contribute to air pollution, human activities are the main culprit [15].

Historically, the primary concern revolved around elevated levels of smoke and sulphur dioxide resulting from the combustion of sulphur-containing fossil fuels like coal, which were commonly used for domestic and industrial purposes. However, these days the predominant threat to clean air stems from traffic emissions. Petrol and diesel-powered vehicles release a diverse array of pollutants, including carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs), and particulate matter (PM10) [13]. While the concentration of pollutants does vary both temporally and spatially, these pollutants increasingly impact urban air quality where there are typically more road users and congestion leading to concentrations of particulate matter and NO_2 being markedly high [7].

Clean Air

When considering air pollution, most people picture smoggy streets in cities, heavy traffic and big industrial chimneys emitting clouds of smoke into the atmosphere. Not all pollutants are obvious given that the particulate matter isn't visible to the human eye. Furthermore, indoor air quality is just as important to devote attention to, given the average person spends 80% of their time indoors, the effect it could have on human health must be considered [7]. Sources include CO_2 & NO_2 from combustion appliances like a boiler, heaters, fires, stoves, and ovens. These appliances burn carbon containing fuels (coal, gas, kerosene, and wood). Housing conditions are also an important factor: poor ventilation, lack of maintenance, damp and poorly maintained fuel-burning appliances can all reduce the quality of the indoor air [16].

Pollutants found in the air can have harmful impacts on everybody's health, especially for people with existing respiratory or cardiovascular conditions, who are some of the most vulnerable populations in our society [17]. Air pollution can affect the eyes [18], nose and throat [19,20], the heart and associated blood vessels [21] and the lungs and respiratory system [22]. The particles can penetrate deep into the lungs and even the bloodstream, causing inflammation, irritation, and damage [22].

Short-term exposure (hours/days) increases in levels of air pollution can also cause a range of health impacts, including effects on lung function; coughing, wheezing and shortness of breath, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality [14]. Long term exposure (years/lifetimes) can increase the risk of asthma attacks, bronchitis, pneumonia, heart attacks, strokes, lung cancer and chronic obstructive pulmonary disease [23]. All of which can reduce the quality of life and life expectancy of affected individuals.

Clean Air

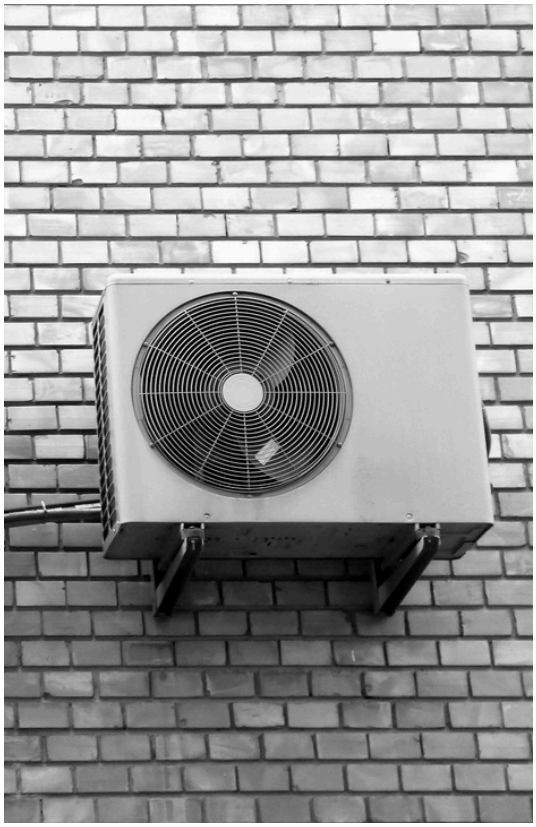
Beyond physical health ailments, recent research outlines the impact of air quality on mental health. Poor air quality is associated with impaired cognitive function as well as an increased risk for psychological disorders including depression, dementia, and a decline in perinatal health [24]. Moreover, air pollution can have adverse effects on the development of the foetus and the child, as exposure to high levels of pollution during pregnancy can increase the likelihood of asthma and other respiratory infections on the unborn child [25].

The impact air pollution has on someone's health may depend on the type of pollutant the person is exposed to, how long the exposure lasts as well as the dose intensity, how the person came into contact with the pollutant, the individual's current health status, genetics, age, and sex [7]. Therefore, reducing pollutants is vital for protecting public health and well-being.

According to the World Health Organization (WHO), the combined effects of ambient and household air pollution is associated with 7 million premature deaths worldwide every year [8]. In the context of the UK, the annual mortality of human-made air pollution is roughly equivalent to between 28,000 and 36,000 deaths every year [1].

A landmark case in 2021 saw a coroner list air pollution as one of the causes of death of Ella Kissi Debrah; a 9-year-old girl who had severe asthma [26]. Due to these high mortality rates, poor air quality is considered by the UK government to be "the largest environmental risk to public health in the UK" [7]. It's estimated that 94% of land in the country is affected by air pollution above background levels, despite roads occupying less than 1% of the country [27]. The vast contrast in these percentages highlights the scale of the problem.

Clean Air



Air pollution isn't just problematic for built urban areas and given this paper is discussing air pollution in the context of the NHS, it requires actions from all estates, not just inner-city hospitals.

Air pollution also has huge implications for the UK and global economy. According to the Royal College of Physicians, air pollution costs £20 billion to the UK economy annually [28]. Another report by the Confederation of British Industry showed that the UK could benefit by £1.6 billion annually if it met the WHO guidelines for air pollution [29]. Air pollution can have an impact on the economy in many forms such as higher rates of asthma, diabetes or chronic respiratory diseases leading to reduced ability to work and lower participation rates in the labour force. [30]. Children susceptible to asthma attacks also miss school days, impacting their learning while healthcare requirements can result in their parents/guardians taking extra time off work [30]. This ultimately puts a financial strain on the public health care related costs. In 2017, the costs of air pollution to the NHS and social care in England were estimated to be £157 million [31].

The drivers of climate change are also the drivers of ill health and health inequalities. The combustion of fossil fuels is the primary contributor to deaths in the UK from air pollution, disproportionately affecting deprived and vulnerable communities [32]. As a key priority, the NHS are working to reduce air pollution and improve local environments, thereby supporting the development of local economies in geographical areas of deprivation [7].

Clean Air

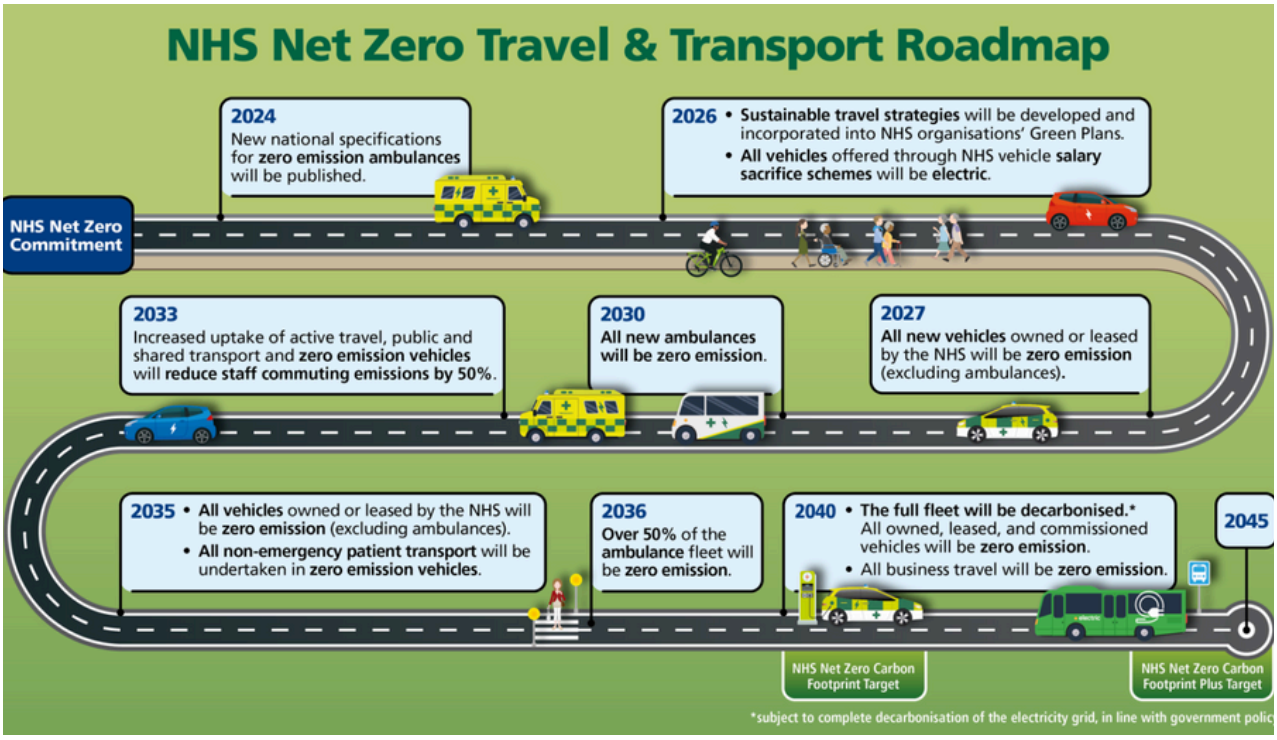
Examples of the links between climate change, sustainable development and health inequalities are seen across the country, such as access to green spaces having positive mental and physical health impacts, and these beneficial effects are greatest for those from socioeconomically disadvantaged groups [1]. However, these groups also have the least access to green spaces.

Action must not only cut NHS emissions but also build adaptive capacity and resilience into the way care is provided. This action will lead to direct benefits for patients, with research suggesting that up to one-third of new asthma cases might be avoided as a result of efforts to cut emissions [1]. It is in the NHS' best interest to tackle air pollution where it can. Its estimated more than 2,000 GP practices and 200 hospitals are in areas affected by toxic air [33].

As a significant contributor to the country's overall emissions (5%) the NHS has a duty to reduce the pollutants they emit [1]. While wider strategies on tackling air pollution and the subsequent targets and action are being led by the government, the NHS is still working to reduce the air pollution associated with their activities where possible.

The NHS fleet, suppliers and visitors account for approximately 9.5 billion road miles a year (3.5% all UK road miles) [1]. This is equivalent to 4.34Mt CO_2e a year and around 14% of the system's total emissions [1]. This includes approximately 4% for business travel and fleet transport, 5% for patient travel, 4% for staff commutes and 1% for visitor travel [1]. Thus, the NHS has a responsibility to reduce the amount of traffic it puts on the road and the air pollution associated with it.

Clean Air



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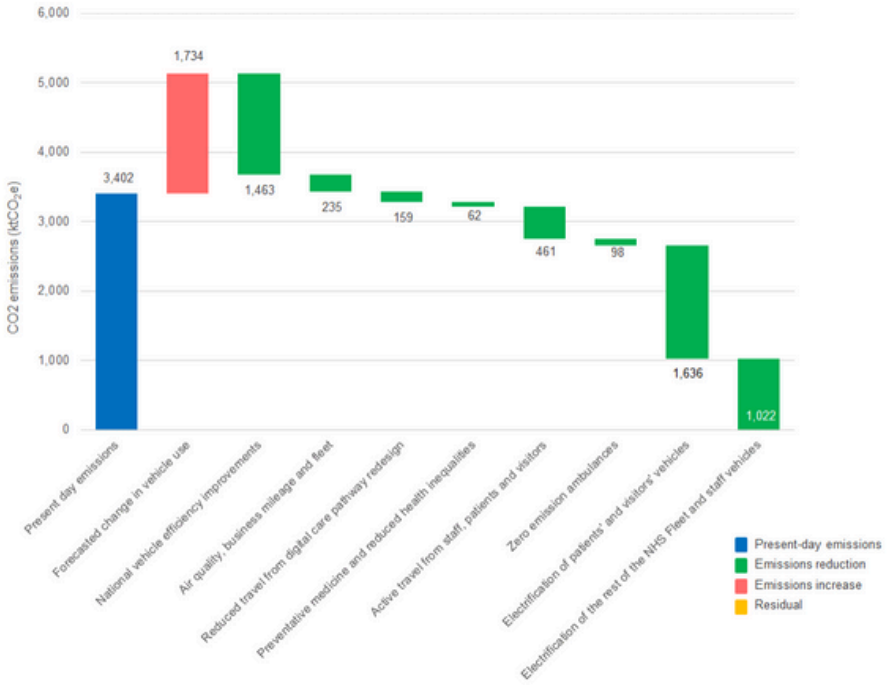
Emissions from vehicles used for NHS duties, that are directly owned and leased by the NHS and its staff, totals approximately 1,000kt CO_2e per year [1]. The NHS has published a 'Net Zero Travel and Transport Roadmap' [34]. The end goal is to have the full ambulance fleet decarbonised and all owned, leased, and commissioned vehicles will be zero emissions by 2040 [34].

They are also encouraging staff to shift modes of transport with cycle and walk to work schemes. Manchester University NHS Foundation Trust provide 200 additional cycle parking spaces and two cycle hubs that feature storage, lockers and showers. Alternative transport to work could mean potential transport emission savings of 456kt CO_2e per year [1]. Changes can be made even if the influence is less direct. Emissions can be reduced through dedicated programmes to tackle air pollution and prevent unnecessary journeys through improved preventative medicine and enhanced digital care also.

Clean Air

Significant pollutants from personal vehicles could be saved if appropriate appointments were to be moved online. Early estimates suggest that moving outpatient appointments online could have avoided 58,000,000 miles over three months period [1]. Furthermore, primary heating from coal and oil fuel in NHS sites will be fully phased out. A wide range of interventions focused on air conditioning and cooling, building fabric, space heating, ventilation and hot water will be rolled out throughout the secondary care estate over the next 5 to 10 years, saving some £250 million per year (once all interventions are implemented by 2034) [1].



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Clean Air

Implementations have been introduced at some London Hospitals which allows them to measure their own impact and implement measures to reduce air pollution [1]. Having this kind of insight on a more granular level may incentivise change given these figures are far more personalised than national NHS statistics.

The drivers for change, mitigating the damage to our environment, improving human wellbeing, and avoiding detrimental effects to the health of the economy are all interlinked. The NHS has set ambitious targets to reduce emissions, and with more than 1.3 million people employed by the NHS in England, much can be done to limit the impact on the environment and make a difference to public health [26]. This white paper focuses on the NHS, but they aren't the only actors in the improving how we tackle air pollution, proper waste management, and a decarbonised supply chain.

By tackling air pollution there can be equal focus on both preventing diseases as well as seizing an opportunity to address unacceptable health inequalities [26]. The government must adhere to set targets on air quality, including for fine particulate matter, and mandates closer collaboration between public bodies to tackle local air quality issues.

Waste Segregation

A two-week waste audit, carried out across 6 operating theatres at the Royal Sussex County Hospital in Brighton, found 40% of the waste was potentially recyclable paper, card, plastic, and glass [35]. Further misclassification was found on a 30-day waste audit, which was across 3 acute hospitals in the Northwest of England, it identified 59% (by item count) of offensive and infectious waste was incorrectly disposed of and should have been downgraded to either domestic or recycling [36]. These audits highlight a great issue facing waste management in the NHS, and one that largely hinders their Net Zero efforts.

The HTM-07-01 [37] and the NHS Clinical Waste strategy [38] instruct that NHS hospitals and trusts must align their clinical, infectious, and offensive waste to the ratio of 20:20:60 (clinical:infectious:offensive). Based on the 2021/22 ERIC data [39], the NHS produced 176,139t of waste between the 3 waste streams, with a ratio of 28:49:23. It is worth mentioning that the COVID pandemic would have affected these figures due to increased waste going into the infectious waste stream.

Out of the 3 waste streams included in the 20:20:60 ratio, clinical waste is the most cost and carbon intensive, with infectious second and offensive third. The average cost for clinical waste is £626/t, infectious is £385/t, and offensive is £337/t. Based on the average figures from the 2021/22 ERIC data, the NHS could save just over £6.3m annually through aligning. The NHS will not only yield great cost savings by aligning, but large carbon savings too.

Waste Segregation

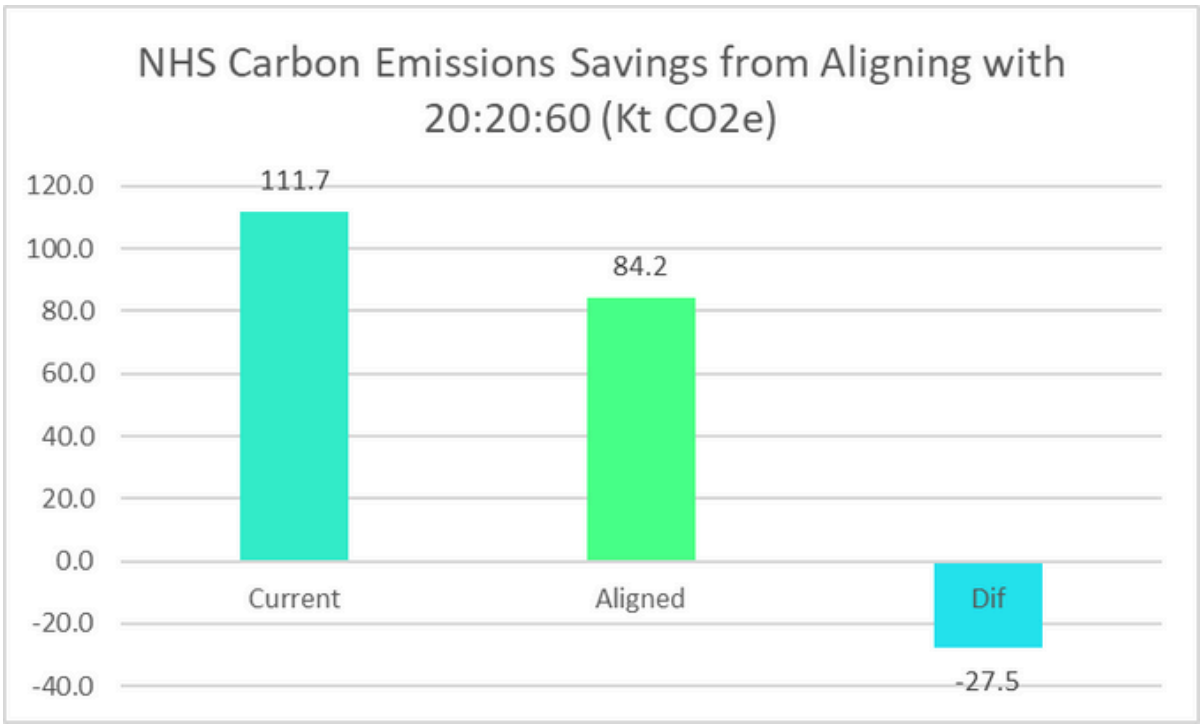
A study was completed to calculate the carbon footprints of various waste streams from UK hospitals. It calculated that per tonne on average; clinical waste emits 1074kg CO_2e, infectious emits waste 569kg CO_2e, and offensive waste emits 249kg CO_2e [40]. In the UK, clinical waste is treated with high temperature incineration, infectious is autoclaved before being sent to low temperature incineration, and offensive waste is either landfilled or sent to low temperature incineration. Although, waste is sent to incineration more often than not due to the zero-landfill policy from the NHS. Often when infectious and offensive waste is incinerated, it is done so to generate energy from waste (EfW). The carbon offsetting from EfW is included within the study's calculations. EfW offsets the incineration carbon footprint through the production of energy, which leads to EfW being considered a sustainable option, despite the large amount of greenhouse gas emissions emitted and a reduction in air quality. Transportation of waste is also included in the calculations, based on average haulage.

Using the ERIC data again and the above carbon footprints for each waste stream, we have calculated that the NHS could save 27.5kt of CO_2e annually.

From improving their waste stream ratios to align with 20:20:60, the NHS could save £6.3m and 27.5kt of CO_2e annually. If they were to also improve their waste segregation accuracy, even further savings will be made.

Waste Segregation

The waste segregation accuracy figures (by weight) from the waste audit of 3 acute hospitals in the Northwest of England [9], showed an accuracy of 71.17% for infectious waste and 62.54% for offensive waste. Unfortunately, there is no available data for the segregation accuracy for clinical waste, so it is omitted from our calculations on the savings of improved waste segregation. If all the incorrectly segregated waste across the infectious and offensive waste streams was instead disposed of into the domestic waste stream (average £120/t [39] and 172kg CO_2e/t [4]), the NHS would see annual savings of £8.9m and 13kt CO_2e for infectious waste, and £3.3m and 1.2kt CO_2e. for offensive waste. From solely increasing segregation accuracy, there are potential total annual savings of £12.2m and 14.2kt CO_2e, and that is not including the potential savings from the clinical waste stream. Obviously, these figures are just potentials as they assume segregation is 100% correct, which is unlikely to be achieved.



If the NHS were to segregate correctly and then align with the 20:20:60 ratio, they would see potential savings of £20.3m and 42kt CO_2e annually. Equivalent to 16,342 flights from London to Sydney in CO_2e (based on average 2.57t CO_2e) and 580 nurse salaries (based on average of £35k pa).

Waste Segregation

It is clear to see that accurate segregation is vital to reduce costs and the carbon footprint, but it is also important to improve circularity and reduce the dependencies on virgin materials. Easily recycled materials are being found in waste streams destined for incineration, which causes needless poisonous emissions being emitted into the atmosphere, and so are materials with the potential to be recycled less conventionally through sterilisation and shredding.

From a non-material-based perspective, accurate segregation is also important for hospitals and the NHS to remain compliant. There are strict guidelines and laws around legislation [10] to avoid the aforementioned negative impacts. The UK government and the NHS are aware segregation is important, hence why guidelines and plans have been produced. The 'HTM-07-01 Management and disposal of healthcare waste' [10] is an NHS publication on 'best practice for waste management and ways to improve the environment and carbon impacts of managing waste.'

The 'NHS Clinical Waste Strategy' [11] sets out NHS England's ambition to transform the management of clinical waste by eliminating unnecessary waste, finding innovative ways to reuse, and ensure waste is processed in the most cost effective, efficient, and sustainable way. As well as those two publications, there is also the NHS Green Plan which is a holistic strategy outlining the need to move towards a circular economy [41].

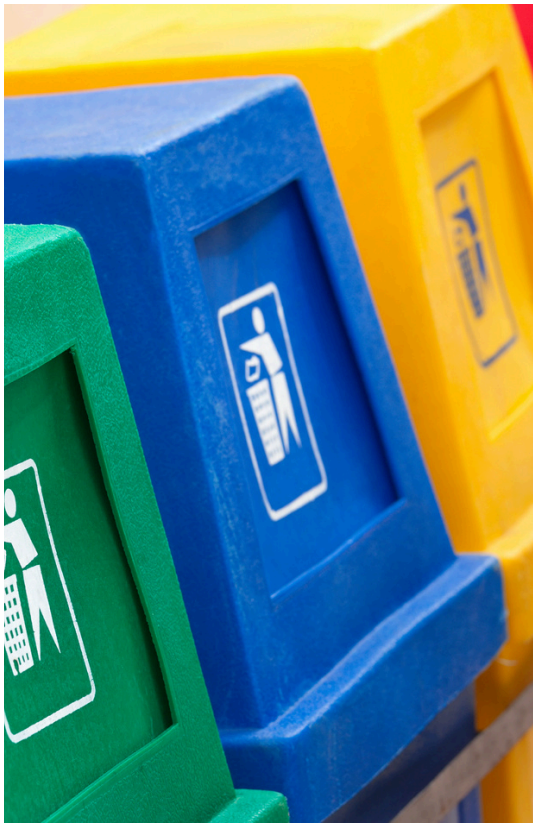
Waste Segregation

Each NHS Trust has their own green plan, or are working towards one, allowing for a localised approach as well as a national view from the NHS Green Plan and HTM-07-01. This shows that there is an understanding and desire to improve segregation and reduce waste, as well as having a plan in place. Although action has been taken, perhaps it has not been quick or ambitious enough.

The NHS is not alone in poor segregation, it happens across the UK, and most commonly within our curb-side collections where many of us 'wish-cycle' [42]. This piece is not meant to solely blame and lambast the NHS, as accurate segregation is no mean feat. There are a plethora of reasons why poor segregation occurs: overworked and understaffed hospital workers do not have the time; patients and visitors are not trained to segregate or are not in the right state of mind to consider it; the available bins are not convenient or clear; the COVID pandemic has left a distinct 'just in case' mentality; there is a lack of understanding on the impacts of poor segregation, and guidelines are confusing.

It is incredibly difficult to address all the issues at once. Doing so takes time and investment, which the NHS is short on. That is not to say that there are not successful sustainability teams working on such projects within the NHS right now, there are just not enough of them, and they often lack the funding and support to excel in what they set out to achieve.

Waste Segregation



So how does the NHS achieve this?

There are solutions out there, and they are accessible. Firstly however, it is important to fully understand where you stand with your waste. Completing waste audits creates invaluable baseline data, which can be used to highlight key impact areas as well as the consumption and the flow of materials. Acting blindly, without knowing your position, can potentially do more harm than good. Using the data to build science-based targets, enables the user to make well-informed data-driven decisions. Once areas for intervention have been identified, positive sustainable change can be actioned.

Education is also key in driving sustainable waste management. Education empowers people to take sustainability into account with each decision. Fully understanding the potential impacts of segregation will lead to more responsible action taking place.

Promoting accurate segregation with members of the public however, is more challenging than with staff as they do not go through the hospitals' onboarding process or training programmes. If the public are in hospital, they are often there for unpleasant reasons, and putting their used drink can in the correct bin is understandably not at the forefront of their minds.

Waste Segregation

To overcome this without causing further distress, making it as difficult as possible to segregate incorrectly or as easy as possible to segregate correctly, is a useful tool [43]. Not having clinical bins beside patient beds as an example. Combing bin placement with visual aids, which both explain how to act correctly and why, makes the strategy even more effective [43].

Visual aids, which are greatly effective with staff as well third parties, should be aligned with what behavioural science says about effective messaging techniques.

The aim should be to embed a sustainable culture within healthcare, and by enacting upon all of the above will greatly help this. Embedding a sustainable culture ensures all stakeholders buy in to the same ethos. With stakeholder buy in, sustainable decisions and initiatives will become more frequent and smoother to enact upon, becoming the default rather than a 'nice to have'. The benefits of a sustainable culture are not only advantageous for waste management, but it also drives positive sustainable behaviour and actions throughout the whole NHS, helping them on their way to reaching Net Zero by 2045.

Decarbonising the Supply Chain

A supply chain, regardless of its industry or sector, is going to represent a large proportion of emissions given it encompasses all the procurement necessary to run the business or organisation. Supply chain emissions come from the upstream and downstream activities of the reporting company's Scope 3. They are carbon intensive as the production and transportation of finished products produce a lot of emissions in the sourcing of raw materials, the manufacturing and packaging processes as well as the road miles that connects the various destinations of the product before it's in sellable condition for the customer.

The NHS is always going to require live-in equipment so the production and subsequent transportation of goods cannot just be stopped. Instead, we need to look at the inefficiencies that are happening in the supply chain so they can be amended, and cost and carbon can be saved.

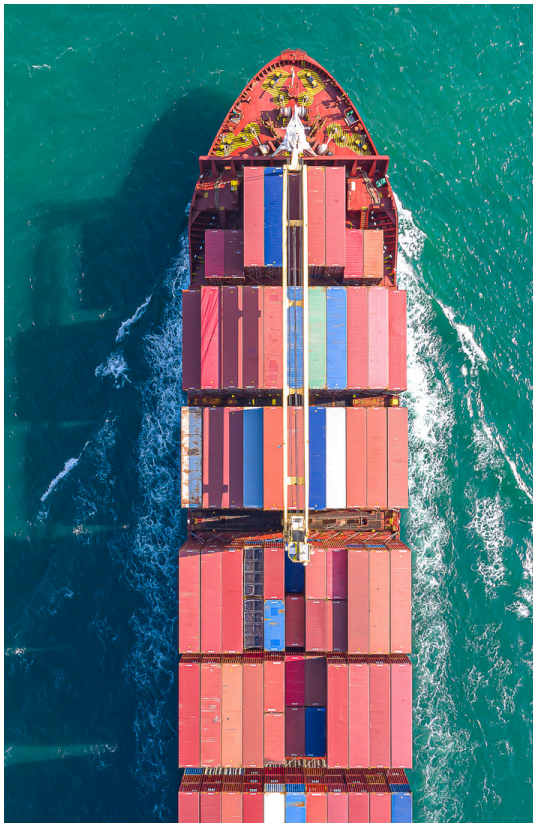
One of the biggest problems in successfully operating

supply chains is poor communication. Not only does this create delays in deliveries, but it also exposes the company to a higher risk of issues with little warning or context and thus maintains a weak position to incite innovative solutions due to little effective collaboration. It also leads to little shared insight into inefficiencies, including carbon intensive 'hot spots'. For example, a particular procurement item may be carbon intense because it's been manufactured, packaged and shipped from abroad.

Decarbonising the Supply Chain

Yet, a near identical supplier is available in the UK at a slightly higher cost. In the long run this will be a more sustainable solution as the money spent on the localised product will be saved on the carbon permits and public health issues caused by transportation miles. Inefficiencies like this happen because of the sheer number of involved parties across each supply chain. The NHS has approximately 80,000 suppliers, which makes it hard to convey or demand changes to all suppliers given each contract has its own stipulations [1].

Furthermore, supply chain teams are rarely trained or guided in communications and as a result take a 'laissez-faire approach' towards the process. These challenges need to be overcome if the supply chain is going to become more sustainable; this includes establishing clear communication protocols and informing all parties of what is expected of them. This can include regular meetings, timely updates, and effective use of technology. By doing so, companies can improve their supply chain efficiency and reduce the risk of disruptions.



The perpetual restructuring of the NHS is another blocker in full transparency as historical knowledge and relationships are being lost, making it hard to maintain key processes in operating with the greatest efficiency [44].

Another issue in creating a sustainable supply chain is that sustainability priorities may slip off the requirements from the customer as the function and quality of the device are the main priorities. Suppliers may be left to infer just how important it is for them to fulfil a green agenda.

Decarbonising the Supply Chain

In the context of the NHS, the organisation now has a well-defined supplier road map when it comes to effective carbon reporting [45].

The NHS has set out a roadmap to help suppliers align with their net zero ambition between now and 2030 [45]. One of the first key milestones was set for earlier last year. From April 2023, for all new contracts above £5 million per annum, the NHS requires suppliers to publish a Carbon Reduction Plan for their UK Scope 1 and 2 emissions and a subset of Scope 3 emissions as a minimum [46]. In six years' time, by 2030, its expected that suppliers will only be able to qualify for NHS contracts if they can demonstrate their progress through published progress reports and continued carbon emissions reporting [47]. The NHS strongly encourages all suppliers to prepare for these roadmap milestones, but will also account for the specific barriers that some may face. Thus, support will be available for Small & Medium Enterprises (SMEs) and Voluntary, Community & Social Enterprises (VCSEs) at each stage of the roadmap [47].

The Evergreen Sustainable Supplier Assessment, launched by the NHS in June 2023, is a pivotal tool in the NHS's sustainability strategy and compliments the Carbon Reduction Plan. It provides a platform for suppliers to engage with the NHS on their sustainability journey and align with the NHS's net zero and sustainability ambitions [48].

Decarbonising the Supply Chain

This self-assessment and reporting tool allows suppliers to share sustainability information with the NHS, providing a single route for information and data sharing. Upon completion, suppliers receive a sustainability maturity score against NHS priorities, which signposts their current position and pathway to progress. The Evergreen Assessment is not designed to be included as a scored or evaluated requirement in procurement, but it is required for suppliers on existing NHS Supply Chain Frameworks and for those bidding to be on any future NHS Supply Chain Frameworks [48]. The benefits of using Evergreen for suppliers include benchmarking against current and future NHS priorities, having a standardised way of communicating their sustainability information to all NHS buyers, and using the assessment to help inform internal planning and decision-making [48].

The supply chain is responsible for 62% of the NHS carbon footprint, this could be brought down if over purchasing was curbed [1].

Over purchasing in a healthcare setting may come from a 'better to be safe than sorry' attitude, the desire to be equipped with too much than not enough when patient health is at risk. This attitude may be more prominent as a hangover from the COVID-19 pandemic, when there was a surge in demand for PPE equipment such as gloves, surgical marks, protective gowns etc. This led to supply chain disruptions and over purchasing of these items. However on the other side of the pandemic, the volume of supplies should be given greater thought.

Decarbonising the Supply Chain

Outside of a pandemic, overconsumption may happen because the forecasted demand is calculated incorrectly and there is inadequate inventory management. The consequences are poor for the budget and carbon alike, as well as increased waste and reduced efficiency. To mitigate over purchasing, the NHS could implement better demand forecasting techniques, establish clear communication channels with both their suppliers and buyers, and optimise their inventory management systems. The discovery of out-of-date stock would be less of a frequent occurrence with optimised management systems and again, prevent over ordering by utilising what is already available and using the stock with the earliest expiry date first. By doing so, the NHS can reduce the risk of over purchasing and improve their supply chain efficiency.

Procedure packs within the NHS are also a cause for concern sustainability wise, as they often prioritise convenience over efficiency, leading to overconsumption.

Procedure packs are used throughout the NHS in both clinical and non-clinical environments, they are a collection of components used to complete a specific task or treatment. While these packs generate both cost savings to the end user and efficiency benefits in comparison to picking all of the individual components off the shelf, some components often go straight into the bin and thus resources aren't being effectively utilised.

Decarbonising the Supply Chain

For example, these packs can include plastic scissors, as most nurses/doctors have metal scissors on their person, this is a wasted resource. As it's in a sterile pack, once the pack been opened the sterility has been compromised and it cannot be kept so gets thrown away.

The NHS supply chain use both single-use and reusable medical devices, dependant on the application. The choice of using single-use or reusable devices depends on the specific medical procedure and the device's intended use. Single-use devices are preferred in some cases because they are sterile, convenient, and reduce the risk of infection. However, single-use devices can generate more waste and greenhouse gas emissions, contributing to the growing disposable culture in the healthcare sector.

On the other hand, reusable devices are more sustainable as they can be used multiple times, reducing the amount of waste generated.

They also consume less energy than single-use devices when considering the cost and energy needed for stock storage. This may not always be the case which is why you should always look at the data.

While single-use devices have their advantages, they can have a negative impact on the environment. The NHS supply chain is working with suppliers to provide a range of sustainable surgical instruments that can be recycled, reused, or repaired, decreasing the amount of waste going to landfill.

Decarbonising the Supply Chain

The healthcare supply chain has a significant impact on the environment and requires systematic decarbonisation in order to operate in a more sustainable way.

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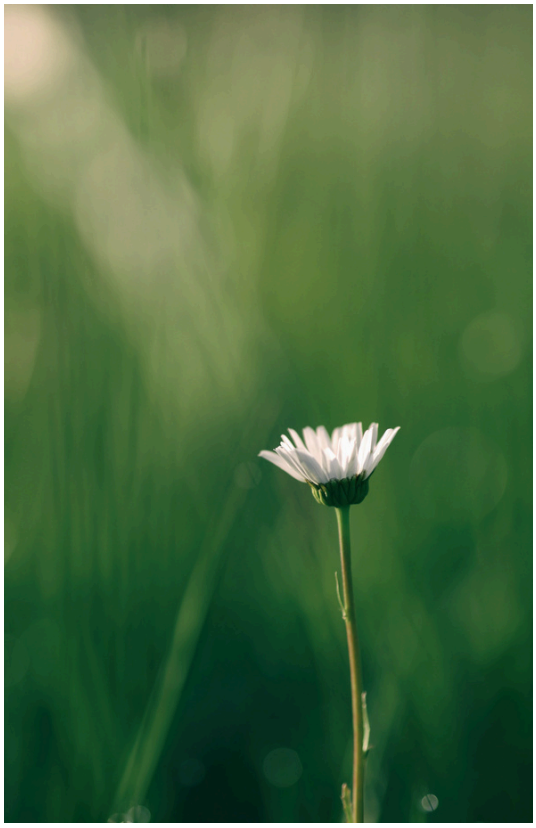
The healthcare supply chain has a significant impact on the environment and requires systematic decarbonisation in order to operate in a more sustainable way.

Decarbonising the supply chain is one of the biggest challenges the healthcare sector faces, as most of their emissions sit within scope 3, outside of its direct control and thus requires inciting suppliers to their own change; the problem here is that they may fail to meet the time frame and targets that the NHS supplier reduction plan demands, and thus will be unable to



deliver on net zero ambition for its Carbon Footprint Plus by 2045. Suppliers may lack the will to make change, seeing it as too much work for the value of the contract.

The NHS have set deadlines for its suppliers for various levels of decarbonisation, showing they are taking it seriously and won't partner with any supplier that does not hold up the right sustainable standard though the net zero supplier road map. Contracts with the NHS are relatively competitive, so if one supplier it too slow at updating its operations or is unwilling to

Decarbonising the Supply Chain

change, another supplier offering a near identical product/service can be found in the procurement process to take their place.

The production of medical equipment and pharmaceuticals is a significant source of emissions in the healthcare supply chain. For example, the production of inhalers used to treat respiratory conditions are a significant contributor to greenhouse gas emissions due to the use of hydrofluoroalkane (HFA) propellants [49]. However, there are alternatives such as dry powder inhalers that do not these harmful HFA propellants and have a lower carbon footprint [48].

Transportation is another significant source of emissions in the healthcare supply chain. However, there are efforts to reduce these emissions through the use of electric vehicles and other low-carbon transportation options [50]. This shows how tackling clean air can have positive impact on decarbonising the supply chain and vice versa with stipulations for uncontrolled suppliers' vehicles.

How are they Connected?

The connections between clean air, waste segregation, and a decarbonised supply chain may not be obvious at first sight, but by viewing them holistically we can see that they are interlinked. It is important to use a holistic lens when approaching the sustainability of the three areas. By viewing the full picture, it is possible to see how one area impacts the other, both positively and negatively. Focussing on just one area can create tunnel vision, thereby missing key impact areas where greater change can be produced. That being said, it is still important to zoom in on specific areas to build an understanding of the data and behaviours from the 'ground level'. Solely viewing holistically can cause everyday actions to be missed. Therefore, it is best to address sustainability with a balanced approach of both holistic and atomistic focusses..

The NuGreen ICAEM Model depicts how each area is connected, in not just a linear way, but in a circular way also.

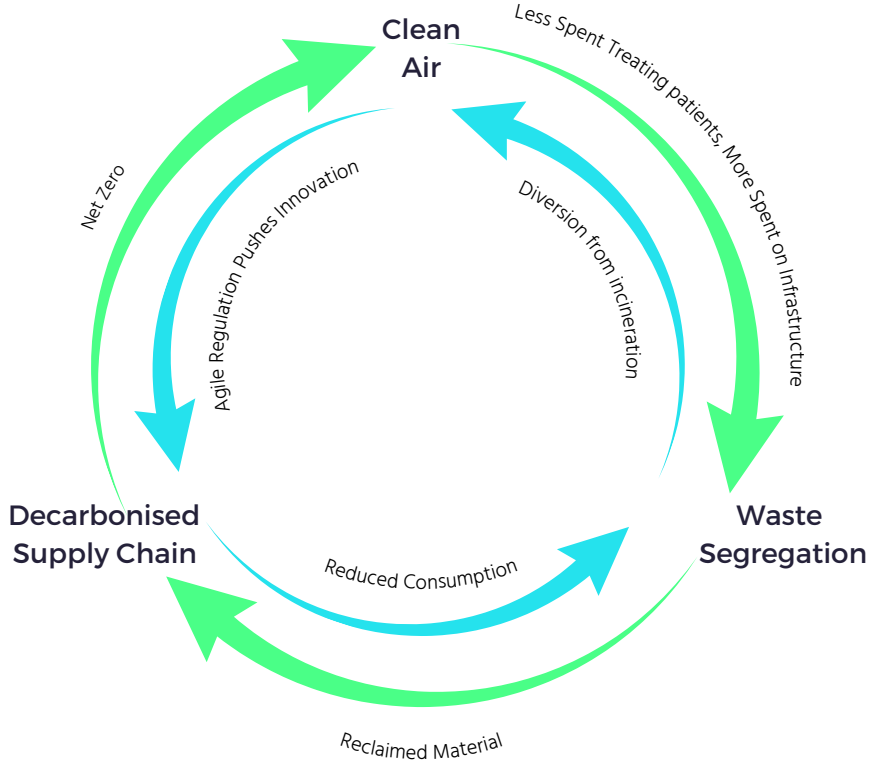
The link between improved waste segregation and clean air, is a more obvious one than the link in the opposite direction. We know that within healthcare waste there is a vast amount of incorrectly segregated waste, which should be downgraded into less carbon and cost intensive waste streams. By correctly segregating recyclable or domestic waste, the user is diverting waste from incineration. Although domestic waste is commonly used for EfW, the treatment of domestic waste does not require autoclaving or high temperature incineration like other healthcare waste streams. This diversion and reduction of waste from incineration, or a more carbon

How are they Connected?

intensive treatment, will reduce the volume of greenhouse gasses being emitted from incineration, thus improving the air quality.

In the opposite direction, cleaner air benefits waste segregation in a more subtle manner. Earlier in this paper we outlined the effects of air pollution on public health. By achieving the WHO-10 target across the UK, we will see a reduction of patients requiring treatment due to air pollution, as well as nationwide economic benefits [51]. Through the reduction of costs for treatment, combined with economic growth, there is an increased budget for sustainable waste management and its infrastructure. The increased budget will allow for investment into waste audits to build baseline data; more in-depth sustainable waste management training for staff; on or off-site sterilisation solutions for healthcare waste, infrastructure for the flow of materials; and more efficient recycling solutions. All this investment, allowed for by cleaner air, will improve waste segregation and reduce waste going to incineration, thereby creating clear air.

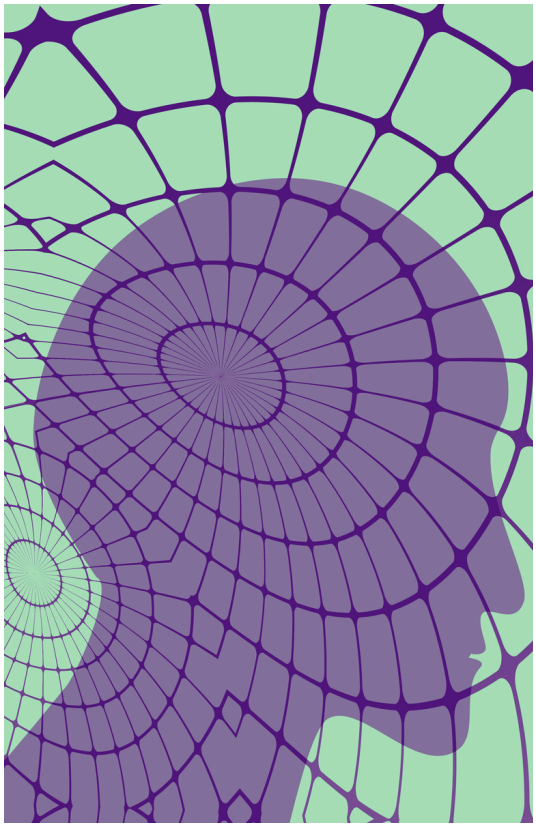
The Integrated Clean Air & Environmental Management Model



How are they Connected?

Analysing day-to-day operations and procedures, within hospitals, highlights the consumption of items and into which bin they are disposed. Analysing further into the consumption and focussing on if the items were used or unused, creates an important picture for the supply chain on which and how many items are actually required. Reducing unnecessary consumption on a supply chain level minimises the risk of unused medical grade materials being disposed of, ultimately ending up in landfill or incineration. By acting upon consumption at a supply chain level, it reduces the volume of materials being managed through healthcare waste streams, thus improving segregation and its sustainability [1].

Enhancing the segregation occurring throughout wards and departments, will increase the volume of reclaimed materials for recycling, repurposing, or rehoming. For example, keeping hold of unused items from procedure packs, when possible, allows for the opportunity to either store them for later use, or donate them to charities such as the Red Cross.



Another example would be to dispose of instruction booklets, for items such as medical applicators, in the recycling bin rather than the offensive waste stream with the contaminated waste.

Although solutions for the recycling of medical waste and sterilisation devices are not abundant in the UK, technology and research are progressing quickly. Should the legislation allow it, the recycling and diversion from incineration of healthcare waste is nearly ready to go.

How are they Connected?

There will always be hazardous healthcare waste that must be incinerated, but through sterilisation solutions, and improved waste segregation and management, greater responsibility could be afforded to waste, enabling the ability to reclaim as many materials as possible. Increasing reclaimed materials and the solutions for them, with improved waste segregation, creates a domino effect ending with a further decarbonised supply chain. Reclaimed materials increases the feed stock for recycling solutions, recycling solutions leads to a move towards a more circular economy, a circular economy leads to a reduced reliance on virgin materials for the supply chain, and that in-turn will help the supply chain on their way to decarbonisation. It is worth mentioning however, that recycling is still an energy intensive process and research should be done to ascertain whether recycling is a more sustainable option for each individual item. An increased use of renewable energy will also further decarbonise recycling as well as the supply chain.

Decarbonising the supply chain will ultimately reduce the number of pollutants being emitted into the

atmosphere, with the obvious result of cleaner air. Reaching Net Zero will play a vital role in improving our air quality in line with WHO-10 [17]. Although there will still be particulate matter from other sources, the air quality will be greatly improved from the reduction in greenhouse gasses emitted from the cradle to gate of supply chain products.

The Mayor of London's office stated they have 'committed to bring levels of fine particulate matter (PM2.5) in London down to 10ug/m3 by 2030 – a decade before the new UK legal deadline – which current data reveals is also achievable' [53].

How are they Connected?

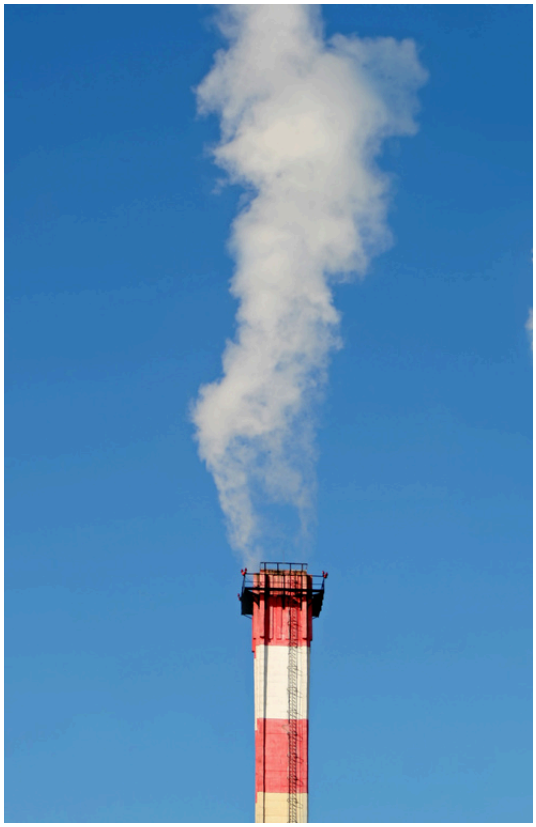
Achieving both the United Kingdom's target of 2040 and London's target of 2030 requires regulation, innovation, and infrastructure. Specifically, regarding the connection between clean air and a decarbonised supply chain, regulation and infrastructure are the link. Agile regulation pushes innovation. By taking a dynamic approach to regulation, legislators can create directives that are relevant to the modern day, present challenges, and national or global targets. Through the need to meet regulatory standards and fit into frameworks, innovators will have to design solutions for the current challenges and targets. Innovators create inventions and solutions for gaps in the market where there is a need for positive change. If regulators create the gaps, innovation will soon follow (e.g. the rise of electric scooters with the increasing ultra low emission zones in UK cities). The NHS Net zero supplier roadmap will hopefully achieve just that, for clean air, by helping to decarbonise the supply chain through regulation [54].

How are they Connected?

The 2023 report of the Lancet countdown on health and climate change validates the ICAEM model, through its findings on the links between public health and climate change.

The report states that healthcare can significantly contribute to environmental well-being by implementing public health interventions. These include reducing air pollution, promoting active travel, encouraging healthier diets, and advocating for better environmental conditions. The shift towards a net zero healthcare system would have cascading effects, ultimately impacting the broader economy.

Encouraging signs indicate the potential benefits of health-related action. Deaths attributed to fossil-fuel-derived air pollution have declined by 15.7% since 2005, with a significant reduction in coal-derived pollution. Scientific understanding of the links between health and climate change is rapidly advancing too. Despite gaps in data in some affected regions, over 3000 scientific articles covered this topic in 2022.



Furthermore, public discussion increasingly acknowledges the health factors of climate change. Approximately 24% of climate change newspaper articles in 2022 referenced health. International organisations are also becoming more engaged in addressing health-related climate challenges. These developments underscore the critical role of health in achieving environmental sustainability and global well-being, hence why healthcare's relationship with the climate should be considered globally as well as locally [61].

How are they Connected?

The NHS' role in reducing its carbon footprint is also a question of moral duty and responsibility on the global political stage, through upholding environmental standards and taking action to combat environmental degradation. The global north and south represent distinct regions, with differing levels of economic development and industrialisation, and by consequence have had varying levels of environmental impact from their economic models and attitudes towards consumption.

Countries in the global north, which include industrialised nations in Europe, North America, and parts of Asia, are major contributors to GHG emissions. Their high rates of consumption and industrial activities significantly impact the environment, as well as often exporting waste to the global south, thereby exacerbating the problem. As Europe's biggest employer and a healthcare provider principled on free care at the point of delivery, which is a service which many people in the global south do not have access too, the NHS has an opportunity to lead by example and expand the role of the global

north by alleviating climate change on what they have control over. While having a smaller carbon footprint overall, countries in the global south bear the brunt of climate change effects. They experience extreme weather events, loss of biodiversity, and threats to agriculture and livelihoods. Despite contributing less to emissions, they suffer disproportionately from the consequences. The impacts of environmental degradation are multi-dimensional. Vulnerability to climate change disproportionately affects the poorer south and threatens their livelihoods.

How are they Connected?

For example, their reliance on agriculture as part of the economy and a way of life is severely threatened by flooding and drought, caused by climate change. Uddini emphasises the need for equitable solutions that bridge this divide, where weight of responsibility rests heavier on the biggest polluters [62].

Furthermore, Climate Matters has pointed out that the global north tends to receive more extensive media coverage on climate change. Their news outlets frequently and politically discuss climate change in reference to climate science, policy, and international negotiations. Climate change is spoken in an almost theoretical way, discussions revolve around how it is described apposed to how it affects human livelihood. This is partly due to much of the global north being separated from the worst of climate change. By contrast, the media in countries in the global south focus more on the human impact of climate change. They highlight rising sea levels threatening homes, the spread of diseases, and disruptions to daily life.

These tangible consequences are emphasised more, as it is where the most severe effects of climate change occur.

In summary, the global north's focus on climate science and policy contrasts with the global south's emphasis on human impacts. Bridging this divide is crucial for effective climate action, as both regions face interconnected challenges in addressing this global crisis.

Ultimately clean air, waste segregation, and the supply chain are all connected. Enacting upon one, benefits the other two. This is shown in the ICAEM Model.

How to Improve?

For example, diverting waste from incineration reduces costs and carbon, which improves air quality, which then reduces consumption of resources from reduced volume of patients, and the cycle goes on. Achieving sustainability and net zero targets requires regulation, innovation, and infrastructure. Just as the ICAEM Model shows how the three are linked, regulation, innovation, and infrastructure are similarly interconnected. Regulation guides innovation, and infrastructure is needed to scale up the innovation.

Sustainable innovation has the potential to solve our net zero problems, but without the ability to scale up or efficiently do so, it becomes impractical. A hypothetical example would be a process being invented to capture particulates produced from car tyres, but it is expensive and energy intensive to produce; the process would then be unfeasible to roll out nationwide and potentially have a negative environmental impact that outweighs the benefits. Innovations must be practical and accessible to all stakeholders.

When planning to improve clean air, waste segregation, and the supply chain, we must consider the required infrastructure, and if it adheres to regulation. If the regulation is preventing necessary sustainable change however, it is worth considering if it is the legislation that needs to change, and not the innovation. This highlights the pre-mentioned need for agile regulation.

How to Improve?

Collaboration, local networks, and stakeholder buy in are also key to solving infrastructure for the ICAEM Model. Infrastructure can be a complicated puzzle to put together and made even harder with siloed working. Cooperating to solve problems, whilst sharing knowledge, capabilities, and skills, is vital in breaking down the siloes and building the required infrastructure. For example, a possible way to divert NHS waste from incineration would be to install a sterilisation machine local to the hospital, have the community feed into it as well as the hospital, have waste management organisations handle the movement of materials from source to sterilisation, and then to the buyer. This would not only reduce emissions for the hospital, but for the local community too, which would then improve air quality and reduce volume of patients admitted to the hospital with air quality related health issues.

Arguably the most important tool to drive sustainable change, is to consider sustainability in every decision. Sustainability does not necessarily have to be the most dominant factor in every decision but should always be considered. By building that process into the culture, it will enable sustainable action in every choice, from which bin to place waste into, to writing legislation.

On a daily basis, the NHS see hundreds of thousands of patients walk through their doors, many of whom will have existing health conditions that will deteriorate with increased exposure to air pollution.

Given the serious health consequences relating to air population, improper waste management, a carbon intensive supply chain, and being a professional body

How to Improve?

individuals look towards for health and wellbeing guidance, the NHS have duty to educate and support communities, families, and individuals on how to act to reduce air pollution as well as the associated health impacts. As a result, there could be mandatory training delivered to health care professionals on how to support and advise their patients on preventing exposure to avoidable sources of air pollution. Healthcare professionals can have an impact on an individual level by communicating important messages and giving general advice to raise awareness of how to reduce exposure to those most vulnerable during high pollution episodes. Advice could include limiting or avoiding any strenuous activity in high pollution episodes or reducing exposure to highly polluted outdoor air by closing external doors and windows facing a busy street during congested periods.

Patients could also be pointed to information sources like DEFRA's UK Air Website [55], air pollution helpline (0800 55 66 77) or text service that alerts people who are signed up of the air pollution forecast in their area [56]. Advising that individual contributions such as

walking and cycling improve an individual's health as well as improving air quality is another option. However, this advice may be primarily focused on addressing the symptoms rather than the solutions which is not a sustainable and practical solution looking forward.

As well as dispersing this information, if staff have been given sufficient training, they can educate themselves and comprehend which specific activities in their day-to-day role can prevent, protect, and promote public health.

How to Improve?

With education on the dangers of air pollution, poor waste management and carbon in the supply chain, staff will understand why it's crucial that they engage with system wide initiatives to cut the emissions linked to NHS operations, and consider the resources available in health and wellbeing systems and the potential impact of earlier diagnosis and better management.

On a more managerial level, team leaders, managers, community health professionals and providers of specialist services can have an impact by advising local plans and other primary strategies on how they will address air pollution, including promoting active travel, enabling zero and low emission travel; and how to design buildings and spaces to improve air quality using a government mandated review on how to improve outdoor air quality and public health [57].

Senior and strategic leaders should be aware of the requirements and interventions at population level, which include raising awareness of the health issues associated with air pollution.

This should be in line with the 6 identified principles for communicating with the public about air pollution from DEFRA's Air Quality: a briefing for Directors of Public Health report [58].

In terms of strategising against emissions emitted by the healthcare sector, a holistic approach is essential. Healthcare professionals need to think beyond the healthcare setting to more community-based thinking. By working in tandem with a network of relevant individuals, groups, and organisations, initiatives can be more efficiently promoted.

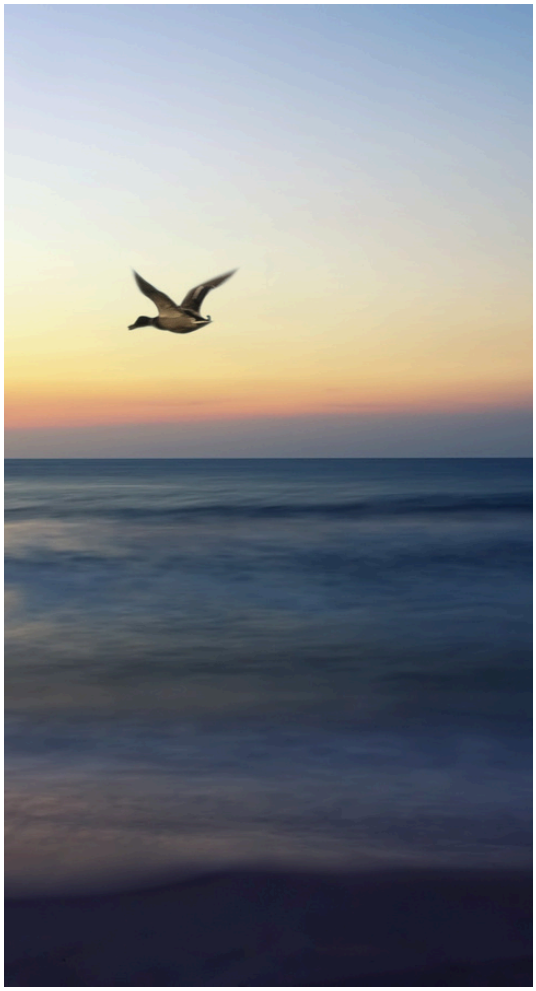
How to Improve?

For example, assisting in the facilitation of active travel such as healthy schools programmes, school travel plans, and cycle to work schemes. Another example is networks within estates and hospital settings like green champions, who spread awareness as a champion amongst professional and personal colleagues. As a health professional, there is a range of reasons why it makes sense to measure your impact and demonstrate the value of your contribution. This could be about sharing what has worked well in order to benefit your colleagues and local people or to support your professional development. Share best practice through regular communication. A systematic approach is necessary if the general population is going to be sufficiently influenced. Healthcare professionals are not stuck for educational resources and tools including the PHE free online e-learning resource 'All our Health' [7]. There is also the WHO Global Air Quality Guidelines [59], which provide clear evidence of the damage air pollution inflicts on human health and recommends new air quality levels to protect the health of populations by reducing levels of key air pollutants as well as DEFRA's website that has a Daily Air Quality Index [53]. Appendix A shows a full list of the resources.

By enhancing knowledge of air pollution, it increases staff confidence in discussing it. This could look like

an increased understanding of health inequalities relating to air pollution and what actions can be taken to address this in one's setting. Armed with this knowledge staff are able to understand the data, resources, and services available in their area which can help address or manage air pollution. Healthcare professionals are invaluable as a trusted source in helping to provide advice for the public about how air pollution can affect their health, and how to help reduce their exposure.

Conclusion

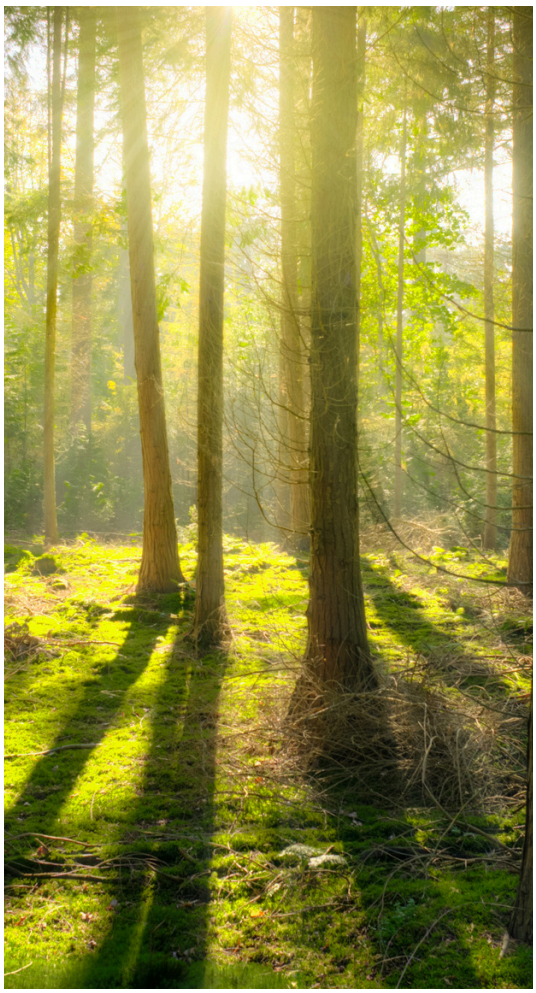


The sustainability of material management within healthcare is in a precarious position. If current practice continues, within the supply chain and waste segregation, then the NHS will ultimately fail to achieve net zero and reverse its own negative impacts on air quality. With the supply chain and waste and water contributing to 67% of the total carbon footprint of the NHS (5% waste and water, 62% supply chain), it is imperative that positive action is taken swiftly. There are already frameworks in place to reduce the footprint of the supply chain (NHS Net Zero Supplier Road Map, Evergreen), but legislative change is still required to build on a circular economy as well as a reduced carbon footprint (e.g. allowing on-site sterilisation machines to process healthcare waste into a useable material is a modern approach to divert waste from incineration, and value textiles and materials for longer). As well as legislation, worthwhile stakeholder engagement is required at every level to successfully steer the change. Change is not always widely accepted, but sustainable change is necessary.

Taking a top-down and bottom-up approach to stakeholder engagement, will enable collaboration and engagement at every rung in the hierarchy [33].

Although waste and water only equates to 5% of the NHS carbon footprint, it is important to understand that greenhouse gas emissions are not the only area of focus when considering sustainability. Through reclaimed materials and efficient resource management, healthcare can enhance their circularity, waste management, and help decarbonise the supply chain. From a cost perspective, a 1% increase in CO_2e emissions increased healthcare expenditure by 2.5% [60]. Positive and sustainable change within the supply chain and waste segregation, drives improved air quality, which then in turn circulates benefits straight back to the two areas.

Conclusion



All three areas from the ICAEM Model, must be tackled together in order to decarbonise the NHS and healthcare. This is why it is vital to take a holistic approach to simultaneously improving their sustainability. As described in this paper, clean air, waste segregation, and a decarbonised supply chain are unmistakably linked and hold a symbiotic relationship. Strategically targeting key impact areas, where more than one sector benefits, will create an easier and more efficient pathway to Net Zero [33].

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Appendix A

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