

# CAN SURGERY EVER BECOME ENVIRONMENTALLY SUSTAINABLE?

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## ABSTRACT

Climate change represents the ‘biggest health threat facing humanity’ (WHO, 2021) and every sector must do its part to reduce their greenhouse gas emissions and become more environmentally sustainable. A large proportion of healthcare greenhouse gas emissions and clinical waste come from surgery but making sustainability changes in this area without putting patients at risk of harm can be very difficult.

This article investigates sustainability initiatives which could be introduced across the NHS to reduce the environmental impact of surgery without compromising patient safety or negatively impacting patient care. This literature review reveals multiple sustainability initiatives which could be introduced, including reducing anaesthetic gas use, more efficient waste management, water conservation, and the development of programmes prioritising sustainability amongst surgeons.

## INTRODUCTION

Surgery is highly resource-intensive, requiring the use of environmentally damaging anaesthetic gases and sterile single-use equipment, and consuming huge quantities of energy and water. The carbon footprint of the average operation is 173 kg CO<sub>2</sub>e (Macneill et al., 2017): this is the equivalent of a car run on petrol traveling from Glasgow to London and back (UK Government, 2021). From a waste perspective, a hip operation produces almost 11kg of waste, with only 1-2kg of waste currently being recycled (Pegg et al., 2022). Over 25,000 operations are carried out in Scotland each month, the equivalent to over 830 operations each day (Public Health Scotland, 2020), and so it is easy to see the impact that surgery can have on the environment.

The World Health Organisation (WHO) has identified climate change as the ‘biggest health threat facing humanity’, stating that the global temperature rise must be limited to 1.5°C to limit climate change-related health impacts and deaths (WHO, 2021). The health impacts of climate change have been extensively studied and include increased rates of asthma, heart disease, stroke, and dementia (Oliver, 2021). The Glasgow Climate Pact saw over 120 world leaders pledge to reduce CO<sub>2</sub> emissions to prevent the global temperature from breaching this 1.5°C threshold (UN, 2022), to reduce the risk of these health impacts occurring.

The Scottish Government has ambitious goals relating to environmental sustainability, with a target to reach net-zero greenhouse gas emissions by 2045, without the use of carbon offsetting (Scottish Parliament, 2019). The National Health Service (NHS) is the biggest public sector greenhouse gas emitter in the UK as it is responsible for 4% of the country’s total greenhouse gas emissions (NHS England, 2020) and producing large amounts of plastic waste, much considered to be ‘clinical’ and therefore non-recyclable. The Scottish Government is conscious of the impact of healthcare on climate change and so has committed to NHS Scotland becoming a net-zero emissions organisation by 2040 (Scottish Government, 2021a).

This article examines the different ways that surgery could become more environmentally sustainable, without compromising on patient safety or negatively impacting on patient care. This literature review explores some of the sustainability initiatives trialled by various UK hospitals, focusing on initiatives which improve waste management,

reduce water and energy consumption, and reduce the use of environmentally damaging anaesthetic gases. These focuses emerged from my research as areas in which surgery had the most environmental impact, so any recommendations need to reduce the impact of these areas.

The findings of the literature review I have conducted have been used to create recommendations for actions that NHS Scotland could implement to make surgery more environmentally sustainable and ensure that the net-zero emissions target of 2040 is achieved.

## FINDINGS

### Waste

The largest sustainability area to emerge from my literature review was waste management. Operating theatres produce high volumes of waste; reducing this waste volume can appear near impossible due to the need for single-use disposable objects for infection control purposes. Research into waste in operating theatres found that up to 40% was potentially recyclable, being made of materials such as paper, card and plastics (Hutchins and White, 2009). The difficulties with recycling this waste comes from the potential contamination of these materials with blood or other ‘clinical’ material. Waste from surgery is segregated into 3 main areas: clinical waste, sharps, and recyclable waste (Department of Health, 2013a). Clinical waste includes items which have been in contact with patients’ body fluids, such as swabs, gloves, masks, urine bags and tissues (Department of Health, 2013). Clinical waste is usually incinerated, producing an estimated additional 2135kg CO<sub>2</sub>e emitted and costing the NHS an extra £317 per tonne compared to recycled waste (Oxford University Hospitals, 2012). Many operating theatres do not have recycling bins, making recycling more difficult for staff, and resulting in all non-sharps waste from operating theatres being disposed of as clinical waste. The Oxford University Hospitals Trust installed recycling bins in operating theatres and anaesthetic rooms, increasing recycling of theatre waste from 0% to 22% (Oxford University Hospitals, 2012). This led to reduced waste and a reduction in carbon emissions as less waste was being incinerated. A survey of 524 operating theatre staff showed that most staff recycled at home and supported the idea of increasing recycling in operating theatres but felt limited by lack of knowledge of recyclable materials and inconvenient bin locations (Azouz et al., 2019). This article recommends the

introduction of educational training focused on recycling in operating theatres, ensuring that recycling bins are available, and the addition of informative posters showing examples of recyclable items to improve recycling rates and so reduce the waste produced from surgery.

Surgery produces a huge amount of ‘sharps’ such as scalpels and needles for stitching. Each operating theatre can produce up to 230kg of sharps waste each year (Scottish Government, 2021) and these must be disposed of in a separate sharps bin. These bins are made of plastic and have a special lid mechanism that stops anyone from reaching into the bin and can be locked when full, to prevent injury (Department of Health, 2013). Most hospitals currently use single-use sharps bins which, when full, are incinerated along with their contents. Reusable sharps bins have an average lifetime of 28 years and an 84% lower carbon footprint (Grimmond et al., 2021). Studies show that if all 227 NHS trusts in England were to change to reusable sharps bins, they would reduce their total carbon emissions by over 3% (Grimmond et al., 2021). This article recommends that all health boards change from using single-use to reusable sharps bins as an easy change which would allow surgery to become more environmentally sustainable without affecting patient care or infection control measures.

Many surgical instruments are single use, as an infection control measure to protect patients. If instruments are reusable, they must be able to be sterilised with steam between patients for infection control. One common instrument that can be either disposable or reusable is metal surgical scissors. Reusable scissors have a lifetime environmental carbon footprint 80% lower than disposable scissors and will reduce non-recyclable hospital waste. This financial and environmental benefit was found with reusable surgical gowns, which are washed between use, when compared with disposable surgical gowns (Centre for Sustainable Healthcare, 2021a). This article recommends that all disposable surgical instruments and equipment should be evaluated for whether a reusable form would be more environmentally sustainable while still maintaining patient safety.

### Energy

This literature review highlighted that surgery is an energy-intensive process requiring the use of near-constant heating, ventilation, and air conditioning, with surgical theatres found to be up to six times more energy-intensive than the rest of the hospital (Macneill et al., 2017). To tackle energy consumption in surgical departments, energy use outside of operating times should be carefully monitored. Barts Health NHS Trust launched a behavioural change programme called ‘Operation TLC – Turn off equipment, Lights Out, Control temperatures’ (Sawin et al, 2018). This was found to be highly successful in reducing energy consumption and carbon emissions, it has since been implemented in 12 other NHS trusts and has reduced carbon emissions by 2200 tonnes and saved the NHS £500,000 in energy bills over five years (Sawin et al, 2018). This article recommends the introduction of this initiative across all NHS Scotland health boards to increase staff awareness of simple behavioural changes and their impact on the environment.

Carbon emissions from surgery can be reduced through the modernisation of old, energy-inefficient buildings and equipment with newer ‘greener’ versions. Research comparing energy consumption and carbon emissions found that a UK surgical department consumed significantly higher levels of energy, and so had higher energy-related carbon emissions, due to having older hospital buildings and therefore less energy efficient infrastructure (Macneill et al., 2017). This will likely have been cost-efficient, with one American hospital estimating annual energy bill savings of £1.5 million by replacing older

lighting and air conditioning units with newer, more energy-efficient models (Kwakye et al., 2011). NHS Scotland has a modernising sustainability plan for all its buildings which consists of replacing all standard light bulbs with LED bulbs, installing roof and wall insulation, and replacing windows and doors with highly insulated units (Scottish Government, 2021a). These changes will help mitigate the energy intensive nature of surgery by reducing energy consumption and carbon emissions. The Scottish Government is dedicated to creating new hospitals with a net zero status in mind. It achieved this goal with the careful design and creation of Balfour hospital in Orkney, which runs entirely on energy generated from solar panels (BBC, 2021). This article recommends that all surgical theatres should be modernised with the latest energy efficiency measures to reduce the energy-related carbon emissions associated with surgery.

### Water

Surgery requires the use of large volumes of water, due to the need for hygiene and infection control in surgical staff, so water consumption emerged from my literature review as a potential target for sustainability initiatives. Surgical staff, who have direct contact with the patient or surgical instruments, are required to ‘scrub’ before any surgical procedure. Completing a scrub involves meticulously washing the hands with antiseptic solution for a period of 3 minutes to remove harmful bacteria and reduce infection risk (Leeds Teaching Hospitals NHS Trust, 2020). Each 3-minute full antiseptic scrub uses approximately 18.5L of water (Jehle et al., 2008) and each operation involves a minimum of 2 ‘scrubbed’ staff members. Whilst maintaining patient safety is essential, national guidelines now state that a full water scrub only needs to be performed before the 1st operation of the session, for example morning or afternoon surgical sessions (NICE, 2019). This recommendation would not negatively impact patient safety, with evidence that using alcohol-based gel between surgeries did not lead to more post-operative infections or worse patient outcomes (NICE, 2019). One English district general hospital estimated saving over 800,000L of water a year by using these recommendations (Jehle et al., 2008). This is the equivalent of 10,000 baths full of water (South Staffs Water, 2010). An Australian trial reduced the water consumed during scrub procedures to 4.5L of water by simply turning taps off when hands were not being actively rinsed (Petterwood and Shridhar, 2009). The use of lever or foot-operated taps should be considered to ensure that staff members can efficiently perform the scrub procedure without re-contaminating their hands by turning taps on and off. These two initiatives represent very easy behavioural changes which would reduce water consumption during the scrubbing procedure from 18.5L per staff member for each surgical procedure to only 4.5L for each staff member for the entire surgical session. This water consumption could also be reduced by ensuring that water facilities are not faulty. Leaking taps are responsible for up to 30% of a hospital’s water consumption, with a dripping tap consuming approximately 15L of water each day (Department of Health, 2013b). This article recommends the evaluation of all surgical taps to remove leaks, the use of alcohol-based gel scrubbing between surgeries and the implementation of lever or foot-pedal taps as measures to reduce the water consumption of surgical procedures.

### Anaesthetic Gases

A somewhat surprising source of greenhouse gas emissions in healthcare found by my literature review was from anaesthetic gases. Anaesthesia is use of medications to reduce pain, sensation or to induce unconsciousness. Anaesthetic agents are required for surgery and can range from local anaesthesia which

blocks pain and sensation from a specific area of the body to general anaesthesia which results in unconsciousness. Anaesthetic agents can be intravenous medications which are injected into a vein or gas agents which are inhaled into the lungs. Anaesthetic gases are recognised as greenhouse gases and are considerably more environmentally damaging than CO<sub>2</sub>, contributing 5% of the NHS carbon footprint (Aldoori, Hartley and MacFie, 2021). Desflurane and Nitric Oxide (NO) are two anaesthetic gases which are considered particularly harmful to the environment, and so their use must be evaluated when considering how to make surgery more environmentally sustainable. Desflurane is used to render patients unconscious prior to surgery and is particularly useful for patients who cannot tolerate the use of injected agent, such as children or individuals with needle phobias. Desflurane, however, is an incredibly damaging greenhouse gas which has a global warming potential estimated at 1620 times higher than that of CO<sub>2</sub> (Andersen et al., 2010). Sevoflurane is another commonly used anaesthetic gas; it is still a harmful greenhouse gas, but has 8 times less global warming potential than Desflurane (Andersen et al., 2010). Raigmore hospital, in Inverness, has started a 'Green Surgery' initiative which aims to make surgery more environmentally sustainable. One of its projects has been to stop the use of Desflurane entirely, replacing it with less environmentally damaging anaesthetic gases such as Sevoflurane. This has resulted in a 4.5% reduction in carbon emissions and an annual saving of £70,000 (Scottish Government, 2021b). This article recommends NHS Scotland ban the use of Desflurane and initiate a switch to less environmentally damaging anaesthetic gases to reduce the greenhouse gas emissions cause by anaesthesia in surgery.

Nitrous oxide (NO) is used for pain relief as a carrier gas for other inhaled anaesthetics; it has the highest carbon footprint of the inhaled anaesthetic gases. It accounts for 75% of total anaesthetic gas emissions and 2% of the total carbon footprint for NHS England (Chakera, Fennell-Wells and Allen, 2020). When NO is used for a patient, some is released into the environment, creating a source of NO waste. NHS Scotland has a target to achieve zero NO emissions by 2027 (Scottish Government, 2021b), by reducing the use of NO use and NO waste. A sustainability initiative called 'The Nitrous Oxide Project' discovered that 98% of NO emissions in NHS Lothian were due to NO leaking from the pipe systems into the environment, rather than from clinical use in patients (Chakera, Fennell-Wells and Allen, 2020). Leakage from pipe systems has been found to be the cause of most NO emissions in multiple hospitals across the UK, confirming that this is a common problem. It can therefore be recommended that all hospitals check their NO pipe systems and fix any leakages.

### **Promoting Sustainability in Surgery**

This article discusses how surgery can be made more environmentally sustainable through the development of national and local initiatives which actively promote the importance of sustainability amongst surgeons. This could potentially be achieved by collaborating or partnering with The Centre for Sustainable Healthcare, a charitable organisation that runs educational courses and quality improvement challenges to raise awareness of and promote sustainability in all areas of healthcare. They host a Green Surgery Challenge, in which 5 teams of surgeons from around the UK receive mentoring from sustainable healthcare specialists, design a sustainability project and measure the outcomes (Centre for Sustainable Healthcare, 2021b). These projects have explored concepts such as reducing anaesthetic gas use and reusable surgical instruments and gowns. These projects can lead to long-term carbon emission reductions in their hospitals and increase awareness of environmental sustainability in those competing. It could therefore be recommended that NHS Scotland creates

partnerships with organisations such as The Centre for Sustainable Healthcare, to create a Scottish Green Surgery Challenge, allowing multiple Scottish teams to compete and creating sustainability awareness and specialist knowledge amongst Scottish surgeons.

My literature review revealed that there is a lack of leadership on sustainability in surgery; this is confirmed by a study which found that 82% of surgeons were willing to make sustainability changes in their practice but felt they required increased leadership for these changes to succeed (Harris et al., 2021). The Centre for Sustainable Healthcare created a partnership with NHS Kidney Care, to implement a 'Green Nephrology' Programme. This programme has been a hugely successful, producing a sustainability network of local representatives covering 80% of the UK's kidney care (Nephrology) units (Centre for Sustainable Healthcare, 2010). Additionally, this programme created Green Fellowships, where a trainee doctor in Nephrology is selected to receive additional training in sustainable healthcare with the aim of creating a new leadership role in the specialty. With the success of programmes like these, it would be beneficial for all surgical specialties to have the aim of becoming 'Green'. A recommendation of this article would be the establishment of a fellowship programme for each specialty to create the leadership roles which surgeons have stated is currently lacking and the development of local networks would increase awareness in sustainable healthcare. Implementing these sustainability programmes and promoting the importance of sustainability in surgery would require additional funds specifically allocated to sustainability to be introduced, therefore it is this recommendation of this article to make this funding available. Although this would be an additional expense, this article has shown that many sustainability initiatives led to not only reduced carbon emissions but long-term cost savings.

### **Remote Conferences**

Professional groups of surgeons often hold yearly conferences to share research updates and network. These are usually held in-person, with surgeons travelling from around the world to attend and thus creating high levels of carbon emissions. These conferences often provide catering and printed materials to attendees, increasing their environmental impact.

During the lockdown phases of the COVID pandemic, these events moved online, reducing the associated carbon emissions from each event. The American Urology Association and European Association of Urology held virtual conferences throughout the pandemic, saving approximately 27,000 tonnes of CO<sub>2</sub> of travel-related carbon emissions (Patel et al., 2021). This is the equivalent of the annual carbon emissions for approximately 2000 Scottish individuals (Zero Waste Scotland, 2021), showing just how environmentally damaging these conferences are. One conclusion that can be drawn from this literature review is that surgical conferences should be held virtually when possible to reduce the environmental impact of these events.

### **Remote Appointments**

When thinking of the word 'surgery', we tend to think of the operating theatre. However, surgery usually involves pre- and post-operative appointments with a surgeon. These appointments normally occur in-person; however, the COVID-19 pandemic forced many patient appointments to occur remotely, including some surgical appointments. Prior to COVID-19, surgery appointments would almost always be in-person and usually at a large hospital centre. This can lead to patients from rural communities being required to travel long distances to attend surgical appointments. Patients from NHS

Shetland are often required to travel by ferry or plane to mainland hospitals as far away as Aberdeen for surgical appointments (Promote Shetland, 2022). Remote appointments can save these patients time while also reducing travel-related carbon emissions in healthcare. Approximately 14% of NHS England's greenhouse gas emissions can be accounted for by travel of patients and staff (NHS England, 2020); therefore, the continued use of remote appointments would have environmental benefits as well as saving patients time on travelling to hospital. The limitations of remote appointments are the potential negative impact on patient and doctor satisfaction. A study evaluating the use of virtual consultations by Orthopaedic surgeons revealed that 93% of patients were satisfied with telephone consultations (Vusirikala et al., 2021); however, doctor satisfaction was significantly reduced, with only 72% of doctors being satisfied (Vusirikala et al., 2021). The main concerns from doctors were related to the lack of visual information available and the inability to physically examine patients (Vusirikala et al., 2021). While video consultations can provide visual information, doctors are still unable to perform physical examinations and so remote consultations are not suitable for all conditions or patients. The sudden lockdown caused by the COVID-19 pandemic demonstrated how major environmental initiatives such as remote appointments can be introduced quickly and effectively. By continuing the use of remote appointments, even in only specific patient groups, such as post-operative patients or patients from distant rural communities, the NHS could reduce the environmental impact of patient travel while still maintaining a high standard of patient care.

## CONCLUSION

The findings from this literature review have made me aware of the many environmental impacts of surgery and the various sustainability initiatives which could be implemented across NHS Scotland to reduce these impacts and make surgery more environmentally sustainable. While many of these initiatives

would be limited by the requirement for national involvement and funding, such as the creation of sustainability partnerships and the modernisation of energy-inefficient infrastructure, there is a role for hospitals and even individuals to play in limiting the environmental consequences of surgery. There are many potential changes which health boards in NHS Scotland could implement to reduce carbon emissions and lead to significant cost savings, such as the introduction of reusable sharps containers and the switch to Sevoflurane anaesthetic gas. These changes would not be noticed by patients but would significantly reduce the negative environmental effects of surgery. This article has shown how small projects in led by surgical staff, such as Operation TLC, can be successfully implemented across health boards and so projects such as this could be actively encouraged amongst staff. Individual members of surgical staff can reduce these environmental impacts by making behavioural changes such as turning taps off while scrubbing and being aware of recyclable surgical materials.

For Scotland to reach its net-zero greenhouse gas emissions target, sustainability must be prioritised for all levels of healthcare, from government to individuals. While it is unlikely that all the mentioned sustainability initiatives will be introduced due to financial and logistical issues, implementing these changes can contribute to reducing the health sector's impact on climate change.

As demonstrated in the above article, there is hope for the future of sustainability in healthcare. An example of a successful case study is the recent net zero operation carried out by surgeons in Solihull hospital, West Midlands. This was achieved using a range of sustainability initiatives (University of Birmingham, 2022), including many of those discussed in this literature review.

## REFERENCES

- Aldoori, J., Hartley, J., and Macfie, J. 2021. Sustainable surgery: in and out of the operating theatre. *British Journal of Surgery* 108, E219-E220.
- Andersen, M. P. S., Sander, S. P., Nielsen, O. J., Wagner, D. S., Sanford, T. J., and Wallington, T. J. 2010. Inhalation anaesthetics and climate change(dagger). *British Journal of Anaesthesia* 105, 760-766.
- Azouz, S., Boyll, P., Swanson, M., Castel, N., Maffi, T., and Rebecca, A. M. 2019. Managing barriers to recycling in the operating room. *American Journal of Surgery* 217, 634-638.
- BBC, 2021. Scotland's first net-zero hospital leads the way. BBC News [online]. Available from: <<https://www.bbc.co.uk/news/uk-scotland-58928932>> [Accessed 10th June 2022].
- Centre for Sustainable Healthcare, 2021a. News: Introducing team 5 of the Green Surgery Challenge [online]. Available from: <<https://sustainablehealthcare.org.uk/news/2021/10/introducing-team-5-green-surgery-challenge>> [Accessed 9th June 2022].
- Centre for Sustainable Healthcare, 2021b. Green Surgery Challenge [online]. Available from: <<https://sustainablehealthcare.org.uk/what-we-do/green-surgery-challenge>> [Accessed 10th June 2022].
- Centre for Sustainable Healthcare, 2010. Kidney Care: Sustainable Specialties. [online] Available from: <<https://sustainablehealthcare.org.uk/what-we-do/sustainable-specialties/kidney-care>> [Accessed 10th June 2022].
- Chakera, A., Fennell-Wells, A., Allen, C. 2021. The Nitrous Oxide Project. Centre for Sustainable Healthcare [online]. Available from: <<https://sustainablehealthcare.org.uk/what-we-do/sustainable-specialties/anaesthetics/nitrous-oxide-project>> [Accessed 10th June 2022].
- Department of Health, 2013a. Environment and sustainability: Health Technical Memorandum 07-01: Safe management of healthcare waste [online]. Available from: <[https://www.england.nhs.uk/wp-content/uploads/2021/05/HTM\\_07-01\\_Final.pdf](https://www.england.nhs.uk/wp-content/uploads/2021/05/HTM_07-01_Final.pdf)> [Accessed 9th June 2022].

- Department of Health, 2013b. Environment and sustainability: Health Technical Memorandum 07-04: Water management and water efficiency – best practice advice for the healthcare sector [online]. Available from: <[https://www.england.nhs.uk/wp-content/uploads/2021/05/HTM\\_07-04\\_Final.pdf](https://www.england.nhs.uk/wp-content/uploads/2021/05/HTM_07-04_Final.pdf)> [Accessed 9th June 2022].
- Grimmond, T. R., Bright, A., Cadman, J., Dixon, J., Ludditt, S., Robinson, C., and Topping, C. 2021. Before/after intervention study to determine impact on life-cycle carbon footprint of converting from single-use to reusable sharps containers in 40 UK NHS trusts. *BMJ Open* 11.
- Harris, H., Bhutta, M. F., and Rizan, C. 2021. A survey of UK and Irish surgeons' attitudes, behaviours and barriers to change for environmental sustainability. *Annals of the Royal College of Surgeons of England* 103, 725-729.
- Hutchins, D. C. J. and White, S. M. 2009. Coming round to recycling. *British Medical Journal* 338.
- Oliver, I. 2021. Understanding the health effects of climate change. UK Health Security Agency blog [online]. 9 November. Available from: <<https://ukhsa.blog.gov.uk/2021/11/09/understanding-the-health-effects-of-climate-change/>> [Accessed 9th June 2022].
- Jehle, K., Jarrett, N., and Matthews, S. 2008. Clean and green: saving water in the operating theatre. *Annals of the Royal College of Surgeons of England* 90, 22-24.
- Kwakye, G., Brat, G. A., and Makary, M. A. 2011. Green Surgical Practices for Health Care. *Archives of Surgery* 146, 131-136.
- Leeds Teaching Hospitals NHS Trust, 2020. Surgical Scrub, Gowning and Gloving: Standard Operating Procedure [online]. Available from: <<http://www.lhp.leedsth.nhs.uk/detail.aspx?id=3936>> [Accessed 9th June 2022].
- Macneill, A. J., Lillywhite, R., and Brown, C. J. 2017. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. *Lancet Planetary Health* 1, E381-E388.
- NICE, 2019. Surgical site infections: prevention and treatment [online]. Available from: <<https://www.nice.org.uk/guidance/ng125/chapter/recommendations>> [Accessed 9th June 2022].
- NHS England, 2020. Delivering a 'Net-Zero' National Health Service [online]. Available from: <<https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf>> [Accessed 9th June 2022].
- Oxford University Hospitals NHS Trust, 2012. Introducing recycling into the operating theatres. Sustainable Healthcare Case Studies [online]. Available from: <<https://map.sustainablehealthcare.org.uk/oxford-radcliffe-hospitals-nhs-trust/introducing-recycling-operating-theatres>> [Accessed 9th June 2022].
- Patel, S., Gallo, K., Becker, R., Borin, J., and Loeb, S. 2021. Climate Change Impact of Virtual Urology Meetings. *European Urology* 80, 121-122.
- Pegg, M., Rawson, R., and Okere, U. 2022. Operating room waste management: A case study of primary hip operations at a leading national health service hospital in the United Kingdom. *Journal of health services research & policy* 13558196221094488.
- Petterwood, J., and Shridhar, V. 2009. Water conservation in surgery: A comparison of two surgical scrub techniques demonstrating the amount of water saved using a 'taps on/taps off' technique. *Australian Journal of Rural Health* 17, 214-217.
- Promote Shetland, 2022. Healthcare in Shetland: some FAQs [online]. Available from: <<https://www.shetland.org/blog/healthcare-in-shetland>> [Accessed 10th June 2022].
- Public Health Scotland, 2020. Cancelled planned operations: Month ending 29 February 2020 [online]. Available from: <<https://publichealthscotland.scot/publications/cancelled-planned-operations/cancelled-planned-operations-month-ending-29-february-2020/>> [Accessed 9th June 2022].
- Sawin, E., McCauley, S., Edberg, S., Mwaura, G., and Gutierrez, M. 2018. Multisolving at the intersection of health and climate: lessons from success stories. Climate Interactive [online]. Available from: <<https://www.climateinteractive.org/wp-content/uploads/2018/01/Multisolving-at-the-Intersection-of-Health-and-Climate.pdf>> [Accessed 9th June 2022].
- Scottish Government, 2021a. Consultation Draft: NHS Scotland Climate Emergency & Sustainability Strategy 2022-2026 [online]. Available from: <<https://www.gov.scot/publications/nhs-scotland-draft-climate-emergency-sustainability-strategy/>> [Accessed 9th June 2022].
- Scottish Government, 2021b. Chief Medical Officer – annual report: 2020 to 2021 [online]. Available from: <<https://www.gov.scot/publications/cmo-annual-report-2020-21/pages/6/>> [Accessed 9th June 2022].
- Scottish Parliament, 2019. Climate Change (Emissions Reduction Targets) (Scotland) Bill. Available from: <<https://www.parliament.scot/bills-and-laws/bills/climate-change-emissions-reduction-target-scotland-bill>> [Accessed 9th June 2022].
- South Staffs Water, 2010. Water use in your home: Tips to save water [online]. Available from: <<https://www.south-staffs-water.co.uk/media/1539/waterusehome.pdf>> [Accessed 9th June 2022].
- UK Government, 2021. Official Statistics: Transport and environment statistics: Autumn 2021 [online]. Available from: <<https://www.gov.uk/government/statistics/transport-and-environment-statistics-autumn-2021/transport-and-environment-statistics-autumn-2021>> [Accessed 9th June 2022].

United Nations, 2022. United Nations Climate Change News: The Glasgow Climate Pact – Key Outcomes from COP26 [online]. Available from:

<<https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26>> [Accessed 9th June 2022].

University of Birmingham, 2022. Sustainable surgery: The first ‘net zero’ operation in the NHS [online]. Available from: <<https://www.birmingham.ac.uk/news/2022/first-net-zero-operation-in-the-nhs>> [Accessed 10th June 2022].

Vusirikala, A., Ensor, D., Asokan, A. K., Lee, A. J. X., Ray, R., Tsekos, D., and Edwin, J. 2021. Hello, can you hear me? Orthopaedic clinic telephone consultations in the COVID-19 era- a patient and clinician perspective. *World Journal of Orthopedics* 12, 24-34.

WHO, 2021. Climate change and health: Fact sheets. World Health Organisation [online]. Available from: <<https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>> [Accessed 9th June 2022].

Zero Waste Scotland, 2021. Everything we buy has a carbon cost [online]. Available from: <<https://www.zerowastescotland.org.uk/content/everything-we-buy-has-carbon-cost>> [Accessed 10th June 2022].