REPORT

On the CONFERENCE on RESEARCH OUTPUTS in ENVIRONMENTAL SUSTAINABILITY

Date: 06 September 2024

Authors:
Dr Fanny Burrows, Greener NHS programme, NHS England,
Dr Sophia Lentzos & Jennifer Ekelund, National Institute of Health and Care Research
Dr Susan Simon, Medical Research Council, UKRI

UKRI Medical Research Council
NHS England
NIHR | National Institute for Health and Care Research

Contents

Abstract

Environmental and human health are inextricably interconnected and interdependent. The UKRI Medical Research Council (MRC), the National Health Service (NHS) and the National Institute for Health and Care Research (NIHR) recognise the impacts of the climate crisis, the intersection between health and climate change and are committed to tackle climate change at source.

The inaugural conference at the Sir Francis Crick Institute on 29 April 2024 marked the start of a collaborative and mutually supportive approach to achieve greater impact on this agenda, given the shared priorities and mission of the three organisations.

Selected research projects, funded by each organisation relating to three key themes (*Research Systems*, *Circular Systems* and *Clinical Pathways)* presented findings, indicating significant problems in the wider health care and health research system, but also highlighted solutions.

Two in-depth panel discussions explored a couple of important subjects - The first one considered the role of funders in driving environmentally sustainable research systems and sustainable research and innovation practices. The second panel examined how knowledge (both theoretical and practical) can be disseminated more effectively to achieve implementation at scale and at pace and explored the barriers and enablers to achieving this.

This conference is the beginning of a concerted effort to align initiatives and support the medical community in addressing and implementing sustainable research practices.

The MRC, NHS and NIHR will work collectively with the wider health community to implement a set of actions that result from the conference and report on progress at the next conference in 2025.

Foreword

This conference marks a pivotal step in ongoing efforts to integrate environmental sustainability into the core of scientific and medical research. The diverse and innovative projects showcased at this event reflect our collective drive to not only understand the environmental impacts of our practices but also to implement tangible solutions that pave the way towards a net-zero future.

As we reflect on the outcomes of this conference, it is clear that our journey towards sustainability is only just beginning. This report serves not only as a record of our collective achievements but also as a roadmap for future initiatives. Together, we will continue to champion sustainability, ensuring that our research practices and healthcare systems are resilient, responsible, and ready to meet the challenges of the future.

Prof. Patrick Chinnery, Executive Chair, Medical Research Council

Climate change is a health emergency. If the NHS is to deliver on the ambition of the long-term-plan, improving health now and for future generations, it must tackle climate change at source. That is why the NHS became the world's first health system to commit to reaching net zero carbon; and that is why we are supporting important initiatives across the healthcare system to deliver high quality, low carbon, cost saving care.

Research plays a pivotal role in helping the NHS fulfil its commitment. Strong collaborations across the sector are required to understand and share research needs, disseminate research outputs and findings effectively and implement them into practice, at pace, to mitigate the impact of climate change and adapt the way we deliver care.

This report demonstrates the scale of the challenges and the breadth of opportunities that we can achieve as a collaborative, and I am delighted that this conference has cemented the joint approach towards findings solutions and enabling collective actions.

Chris Gormley, Acting Chief Sustainability Officer, NHS England

Climate change is a significant challenge to public health. In addition to the direct health impacts, it has consequences for future generations and deepens health inequalities. As the nation's largest funder of health and care research, the NIHR must play a key role to support the transition to low carbon, sustainable and resilient health and care systems.

We have developed our first set of NIHR public commitments on climate, health and sustainability. Working with others in the UK research, innovation and healthcare community is central to our approach and the MRC, NHS, and NIHR all share a common goal: to respond to the current health crises and anticipate and mitigate future challenges. This inaugural conference marks the beginning of a collaborative journey to harness our collective strengths to achieve greater impact, and its outcome will serve as a roadmap for joint future actions. These commitments matter for science and research but will crucially make a difference to patient and public health, as well as planetary health.

Prof. Lucy Chappell, Chief Executive Officer, National Institute for Health and Care Research

Introduction

Impacts of climate change are ever more apparent and extreme. The health of the planet and those who occupy it is inextricably linked and interdependent, with rising temperatures and extreme weather impacting the underlying determinants of health, including housing, food and water availability, wider spread of infectious diseases and healthcare provision. It is clear that the effect of this is felt unequally across the globe, with those contributing the least to the climate change bearing the most significant detriment[1].

The Director-General of the World Health Organisation (WHO), Dr Tedros Adhanom Ghebreyesus warns that the world itself is in "intensive care" with rapidly deteriorating conditions and significant implications for human health, such as a rising burden of cardiovascular disease, lung cancer, asthma, kidney disease and increased risks of zoonotic spillover[2].

Despite annual COP events and declaration, the move towards more environmentally sustainable actions is too slow to compete with the pace of global warming: a 1.5°C temperature increase is now predicted between 2030 and 2052 with a high level of certainty, causing not only a global warming of air and oceans, but also more frequent extreme weather events[3].

As organisations dedicated to human health, the three major patrons of this event, NHS, MRC and NIHR, must champion and lead on this agenda. All three organisations recognise the need to decarbonise and the benefits this transformation will bring, including reducing operating costs, reducing waste and, as some of the research demonstrates, improving efficiencies within the organisations. Each organisation faces similar challenges in achieving this, including related supply chain, complexities of buildings and estates, and certain practices, alongside challenges unique to each organisation. Such challenges include preparing for and ensuring business continuity in the face of the changing climate.

Each of the organisations have been leading in their field in progressing the protection of a world that is beneficial to human health. The NHS was the first national healthcare system in the world to commit to net zero with a clear ambition and specific targets. MRC was one of the first funders who produced a comprehensive transformation plan for its own organisation

[1] Royal Netherlands Academy of Arts and Sciences (June 2023), 'Planetary Health, An Emerging Field To Be Developed'

[2] Ghebreyesus, T. A. (18 March 2024) 'For centuries we have plundered our planet. Now we are paying the price', The Telegraph, 18.03.2024, available at : https://www.who.int/news-room/commentaries/detail/for-centuries-we-have-plundered-our-planet-now-we-are-paying-the-price

[3] IPCC (2018) Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming *of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24. https://doi.org/10.1017/9781009157940.001.

and funded initial research for improving practices. NIHR has published clear guidance to the research community of how to make research more sustainable and launched their commitment to environmental sustainability. Combined, these three organisations can effect meaningful change in the health sector and this conference is a start to this ambition.

The conference on research outputs in environmental sustainability is the result of this ambition and is the start of building a closer relationship between organisations in the health research and care sector. It is envisaged to become an annual event, where progress is reported, and knowledge is exchanged. It is for this reason that representatives from many different organisations, who can make a difference have joined this event: researchers, funders, healthcare professionals, publishers, regulators, and others from the UK, across Europe and beyond.

This report details the key findings and messages from the conference on research outputs and highlights the actions each of the three patron organisations, the NHS, MRC and NIHR, commit to take to accelerate progress towards environmental sustainability.

PRESENTATIONS OF RESEARCH OUTPUTS

Research Systems

Research systems are complex systems including institutions which undertake research, funders, funding mechanisms, regulatory frameworks, collaborative frameworks, training, education, dissemination channels and much more, including politics. Changing such systems is not without the peril of unintended consequences and so the transition towards environmentally sustainable research systems carries risks.

However, doing nothing poses a much bigger risk – including significant disruption of research activities or simply the inability to fund research, with governments fighting the impacts of climate change (floods, droughts, health impacts, etc.).

System change is possible, as historic examples show with the introduction of 'Health & Safety' or more recently the incorporation of Equality, Diversity, and Inclusion aspects across everything we do.

The world is witnessing catastrophic impacts of the change in climate in all continents with increased frequency and severity of droughts, floods, storms, loss of habitat and biodiversity, food shortages and so on. Yet, this has not sparked the same response as has been triggered in the aforementioned event.

Science needs to change perceptions, cultures, methods, and materials. It will require support for researchers, providing tools for making the right choices as well as for funders to prioritise and judge environmental impacts of proposals in an informed way.

There is a strong current of willingness to change; the "Concordat for Environmentally Sustainable Research and Innovation Practice[4], which colleagues at the Wellcome Trust published in April 2024, is a strong indicator for the UK R&I sector to move as a whole in this area. This is a signal that the *status quo* is no longer acceptable.

Research projects presented in this section of the conference were selected from a wide range of research activities that relate to challenges and solutions for environmentally sustainable research and medical practices. They demonstrate forward thinking by both funders and researchers in solving some of the problems that need to be overcome.

[4] Wellcome Trust website: https://wellcome.org/what-we-do/our-work/environmental-sustainability-concordat

Greener Trials (Appendix 1)

Prof Paula Williamson, Professor of Medical Statistics, University of Liverpool

One of the key priorities from an Academy of Medical Sciences FORUM workshop on the environmental impact of biomedical research held in 2023 was to focus more on green practice in clinical trials.
Prof Williamson described the work of the MRC-NIHR Trials Methodology Research Partnership Greener Trials group, including:

- the development and testing of a method and guidance to calculate the carbon footprint of clinical trials.
- the application to UK and international academically sponsored clinical trials to identify hotspots.
- and the opportunities for lower carbon trial design.

Environmental Impact Assessment of Biobanking Strategies: Creating a Sustainable Biobanking Roadmap for sample storage (Appendix 2)

Dr Gabrielle Samuel, Lecturer in Environmental Justice and Health, King's College London, Matthew Graham, Research Assistant, King's College London

Biobanks have become an integral part of health and bioscience research. However, the ultra-low temperature (ULT) storage methods that biobanks employ (ULT freezers and liquid nitrogen (LN2) are associated with carbon emissions. While some research about the carbon impacts of ULT storage methods exists, this is limited, and furthermore there has been minimal drive to connect this research to biobanks in practice. To address this, a life-cycle assessment of ULT storage methods was conducted along with two qualitative stakeholder workshops. The research drew on the findings to develop a 'Roadmap' for reducing carbon emissions associated with ULT storage, which considers social and political factors associated with biobanking in practice. This roadmap contains recommendations for nine key areas relevant to mitigating the carbon emissions associated with ULT storage.

Action 1:

Tools that allow measurement and better-informed decision-making in relation to the environmental impact of clinical trials (and wider) will benefit both the health & research sector. The MRC will fund the development of such tools for clinical trials through a partnership with NHS Wales.

Action 2:

NHS England, together with NIHR and MRC, will support the development of Greener Clinical Trials' tool through (i) collaboration with the Getting It Right First Time (GIRFT), (ii) support from the Greener NHS programme to contribute to the database with activity-level carbon emissions data and (iii) support the programme of work to reduce barriers with relevant stakeholders.

Action 3:

Biobanks and freezer storage form a large part of the operations both in the healthcare and in research activities. Whilst there is good practice guidance available, more data is required, in particular from ULT freezer manufacturers. The MRC will organise engagement with main users of biobanks and ULT freezers together with manufacturers to address this issue and agree on firm actions and will share learnings that can be translated to NHS facilities and storage.

Circular Systems

The healthcare system in the UK produces a significant volume of waste, which is not only damaging to the environment, but also results in financial waste. The NHS produces 12,000 tonnes of medical waste per annum of which 23% are plastics. Over £10bn are spent annually on waste disposal. This is a challenge, which is recognised in the NHS and the Department of Health and Social Care, evidenced by the Medical Technology Strategy and the Design for Life programme. The NHS is not alone in this; not only is there much overlap with the Life sciences, but high-resource healthcare services across the world will have similar issues.

Research presented in this section highlights both the barriers to moving to reusable textiles and equipment and some of the solutions and enablers that can unlock a more circular approach to healthcare delivery, supported by evidence and good clinical outcomes.

Moving to a reuse economy for surgical drapes and gowns (Appendix 3)

Prof Mahmood Bhutta, Inaugural Chair in ENT Surgery, Professor of Sustainable Healthcare, Brighton, and Sussex Medical School

Surgical drapes and gowns can be single use or reusable. The NHS in England currently purchases around 80% of such supplies as single use, comprising 93 million items per annum. Yet reusable versions have one third of the carbon footprint of disposable. This research has included qualitative interviews to explore the perceived barriers of moving to reusable, and a review of the evidence on infection risk and environmental impact of the two options. The research output creates education and guidance to support local, regional, or national policy on this issue.

Circling back to move forwards (Appendix 4)

Dr Tom Dawson, Founder of Revolution-ZERO and visiting research fellow in circular health economics at the University of Exeter

Revolution-ZERO was founded to tackle the issues, exposed during the coronavirus pandemic, relating to supply chain resilience and the generation of waste from single-use medical textiles with a focus on PPE, surgical gowns, and operating theatre drapes. Dr Tom Dawson presents the problem set and the journey that Revolution-ZERO has been on from founding through to 29 April 2024.

Action 4:

NHS England will develop case studies to demonstrate the impact of reusing surgical textiles and PPE, from financial and environmental perspectives, whilst also demonstrating positive clinical outcomes and patient satisfaction.

Clinical Pathways

Transforming the way care is delivered is a critical component of a net zero journey, and requires huge efforts, underpinned by research and the translation of evidence into practice. It requires collaboration and engagement across communities.

Whilst ensuring efficient and safe care for better patient outcomes and experience, economic considerations of medical interventions and care, we also need to integrate the environmental impact of care delivery. This requires consideration of:

- The optimisation of the location of care, through low carbon care settings.
- Low carbon care treatments and interventions to reduce the carbon emissions from treatments and delivery of high-quality care.
- Care efficiency
- Prevention and earlier detection, diagnosis, and treatment to improve health, reduce care needs and reduce disease burden.
- System support underpinned by clinical leadership, systems, and workforce.

CrossCover (Appendix 5)

Dr Nathan Moore, Managing Director and founder of Primum Digital Ltd, Ex T+O Specialty Training Registrar, Web Software Engineer, NHS Clinical Entrepreneur.

CrossCover is a multi-award-winning platform designed by clinicians to optimise workflows for Clinical Pathways across Primary and Secondary Care: a system wide solution to getting the right care for the right patient at the right place at the right time utilising cost and carbon efficient pathways.

Towards reducing environmental pollution from healthcare practices (Appendix 6)

Professor Sharon Pledger, Consultant in Pharmaceutical Public Health, dual registered as a pharmacist and a public health specialist, NHS Highland (Scotland)

The use of a medicine is the most common intervention in healthcare. Prescribers are normally concerned with what effect the medicine is going to have on a patient's

condition, weighed up against any side effects to their health or wellbeing. They have not been taught what happens to the medicine when it is excreted into the environment, nor do they have the tools to help them make eco-directed prescribing choices. Research has shown that excreted medicines and metabolites can have deleterious effects on birds, aquatic and soil life including reproduction, physiology, behaviour, contamination of our food chain and driving antimicrobial resistance- all important aspects of a One Health where the health of humans, animals and the environment are intrinsically linked.

This study, for the first time in the UK, aimed to develop a framework for making formulary (medicine choice) decisions which includes environmental considerations as well as clinical and cost effectiveness, so that prescribing choices are good for patients and the planet. It used a mixed methods approach with nominal group technique to prioritise the environmental criteria and medicines to be studied, Bayesian Modelling to better understand environmental risk and focus groups with the public and prescribers to hear their views on pharmaceutical pollution, eco-directed prescribing and how they would prefer information on the subject to be presented. It is the first step in moving to eco-directed prescribing across the world.

Action 5:

NHS England will aim to expand the outputs of some clinical pathways redesign projects by developing 1-2 case studies demonstrating the environmental and financial impact.

DISCUSSION PANELS

PANEL 1 - Research & Innovation – Funder's perspective and responsibilities

The first Panel focused on the role of the funders in driving environmental sustainability in medical research and healthcare and brought together the perspectives from organisations of varied sizes and roles - including the Wellcome Trust, the NHS and Medical Research Foundation (MRF). Through an open and frank discussion, the panel explored different opportunities and concerns in relation to the incorporation of environmental sustainability in funder's activities, an issue highlighted by the engagement as part of the development of the Concordat for the Environmental Sustainability of Research and Innovation Practice.

The panel also discussed what the future looks like from a health research system and a healthcare perspective. Panel members shared their insights around the pivotal role research and innovation activities play in supporting the wider R&I sector and healthcare services to operate in an environmentally sustainable way. Funders and the healthcare service discussed the competing challenges they face and emphasised the need for a collaborative approach to overcome some of their challenges.

Sustainability criteria in assessment of research proposals

The discussion explored how environmental sustainability criteria could be integrated into research and innovation funding calls and opportunities. The audience explored some of the challenges and opportunities associated with the integration of sustainability criteria and requirements within the funding processes, with some strong support from larger funders such as UKRI, NIHR and the Wellcome Trust, but also some caution and nervousness from smaller fundings bodies such as charities.

However, some concerns arose regarding making environmental sustainability a condition for a grant, thus placing the responsibility on researchers and research consortium, rather than at the institution level. Research funders should perhaps work with the research sector to develop a framework, accreditation or shared approach to make the environmental sustainability criteria a reality, supplemented by strong guidance.

Some challenges and concerns were highlighted during the discussions:

- Small funders do not have the expertise and capacity and would require support (framework, or accreditation), to enable them to align with the sector. The additional challenge is that small funders, such as charities, receive funding from their members and must carefully manage their expectations with the outcomes from the funding they allocate.
- The Association of Medical Research Charities (AMRC) may find the sustainability criteria a challenge and would require education and training support to help them

on their sustainability journey and face the challenges associated with the size of their organisations and sources of funding.

- Methodologies which enable the evaluation of health benefits with financial savings and environmental impact are not readily available and consistent. Further guidance and support are required to undertake research sustainably whilst considering all outcomes (clinical, financial, social and environmental).

Some recommendations and opportunities were also discussed:

- Researchers can pivot and adapt quickly to new criteria and demands to seek funding. However, new requirements and expectations from researchers would require guidance, tools and support, all of which are considered and being investigated by the research and innovation sector.
- The Concordat for Environmentally Sustainable Research and Innovation Practices is enabling discussion at national and international level to introduce new requirements and practices in research and innovation.
- In order to reduce the environmental impact of research and innovation practice, there would be opportunities to reduce the inefficiencies associated with clinical or biomedical research and actions should be considered to minimise research waste and inefficiencies. Maximising the dissemination and implementation of research outputs and enabling negative research outcomes to be disseminated could be critical steps to prevent further inefficient research spend.
- A question about the level of reproducibility of research was raised by the audience. Reproducibility is now a key principle for the consideration of research proposals however, the rate of reproducibility must be improved.

Funding availability

Discussions also explored how the research funding can have a pivotal role in enabling more sustainable research:

- Firstly, additional tools and funds would be required for researchers to integrate sustainability assessment, quantification and strategies to reduce their environmental impact.
- Secondly, research funding should be required to enable changes in practices, whether related to research practices or healthcare practices.

There are additional challenges associated with research funding in relation to climate change. These are a) the speed of research needed in the light of the link between climate change and the health crisis we are facing and b) the scale of funding and opportunities necessary to enable these required changes, within a pressing timeframe.

The understanding of research infrastructure's carbon hotspots has gaps, and this forms a critical part of the guidance and framework that needs to be provided to researchers to lower their environmental impact.

Research gaps and needs for health research systems, for healthcare systems and for biomedical and clinical research must be clarified and appropriately signalled.

Supply chain

Reduction in the environmental impact of research and healthcare supply chain and scope 3 emissions present enormous challenges for all research and innovation stakeholders. This accounts for a sizeable proportion of carbon emissions and so requires coherent systems to enable greater impact.

The NHS has shown strong leadership with the publication of its net zero Supplier Roadmap, placing requirements on its suppliers which support the NHS's ambition to be net zero by 2045. There was agreement that a much more powerful message could be sent to the supply chain through a joint approach by research and healthcare organisations.

Some funders, such as the Wellcome Trust and UKRI, expressed an acceptance that the cost of research may initially increase by implementing sustainable methods. A similar view was noted on selecting more sustainable modes of transportation for performing research.

Network

Research needs to be trans-disciplinary, requiring efficiency and coordination to achieve the best outputs and outcomes. Concerns were raised about potential duplication of research – particularly through lack of coordination of institution-led research and NHS-led research, as dissemination is rarely consistent.

One of the suggestions was to consider and implement networks to reduce research duplication or wasted research. Some networks already exist and are acknowledged to be a critical component of research in the health and climate space. Developing and maintaining these networks is challenging within the limited funding and relevant infrastructure and resources available to support them.

Current funding opportunities, such as the recent UKRI/NIHR joint funding programme to 'realise the health co-benefits of a transition to net zero', will be a contribution to this solution and connect research in their area of focus, around the key challenges they are addressing: (i) urban transportation, (ii) sustainable diets, (iii) extreme weather, (iv) indoor air pollution and (v) decarbonising patient pathways.

Recent funding rounds discovered a buoyant community of researchers with whom a continued engagement and connection will be important to drive the changes in the sector and share knowledge.

Needs and pledge for change

The Panel discussed the role of innovative technologies and tools to support a shift towards more environmentally sustainable research, innovation and medical practices. Discussions with the audience pointed to the role of regulations to support more environmentally sustainable research to enable faster and adaptative changes.

Importantly, the need for cultural and behaviour change to shift towards sustainable research, innovation and medical practices was highlighted as critical.

Drivers

- The recently published Concordat on Environmentally Sustainable Research & Innovation Practice is a clear signal from the R&I sector that change is required and in progress. With some funders already showing their leadership by implementing environmental sustainability aspects in the criteria for funding awards, the drive for more sustainable research will be reinforced across the sector.
- Universities are increasingly reporting that future students are selecting their preferred University based on environmental credentials. This is further evident from the demand for more sustainable practice in research institutions by the young generation, such as PhD students.
- There is a growing interest from stakeholders, including the research sector, the healthcare and health regulators towards environmental sustainability – This was demonstrated by the Concordat as a strong initiative to bring consensus across research and innovation practices.

Conclusion

The Panel consented on the need to work collaboratively to advance some of the challenges that funders and the healthcare sector are facing.
Many opportunities exist to consolidate these learnings, share knowledge and good practices and use our combined power to advance the research field that support environmentally sustainable health research systems as well as healthcare systems.

Some key actions will be taken forward by the organisers to make progress against some of the topics discussed during this conference.

Action 6:

UKRI will convene collaborative networks bringing representatives from different research and innovation funding perspective (small versus large entities and different funding stakeholders) to agree an aligned approach to sustainability criteria in research.

Action 7:

UKRI will drive the collaborative development of guidance, tools and supporting information for researchers to interact with environmentally sustainable research whilst ensuring the responsibility is placed on institutions rather than researchers.

Action 8:

MRC, NHS and NIHR will work with stakeholders to identify opportunities and enablers to build capacity and capability in order to reduce our environmental impact and expand sustainable research practises.

PANEL 2 – Dissemination and Implementation

The Panel discussed effective dissemination of knowledge, such as findings from the presented research activities, and implementation of the knowledge and research outputs in practice. The panel explored how best to collaboratively implement research outputs and evidence at speed, with a focus on addressing barriers, discussing what the future could look like for the way we perform, access and disseminate research.

Best practice was explored to disseminate research outputs, from reaching the relevant audience, to considering the wide range of individuals and organisations involved in the efforts towards environmentally sustainable research and health and care services. Sharing research outcomes and good practice with scientists, technicians, doctors, nurses, estates professionals, policy makers, purchasers, etc. may require a different or tailored approach.

The panel emphasised the need for rapid coordinated action, contextualising the discussion around the health emergency posed by climate change, the direct and immediate effects on people's wellbeing and the increasing pressure on health services.

Implementation – The limitation and opportunities

The panel agreed that funding and time are key barriers to further implementation. It was clear that the field did not lack in enthusiasm towards sustainable practices in research or in the way we deliver care, however challenges exist around capacity and capability to implement.

The subject of environmental sustainability can be present in some departments but lacks full regulation and integration around entire organisations to ensure net zero is built into everything consistently.

Changes will require capital investment, but the cost benefits need to be clearly articulated, as the panels strongly expressed the cost-benefit payoff of the capital investment.

However, it was clear that the right community exists, whether in parliament, through civil society and through community engagement groups. From a policy perspective, the panel thought we currently hold a lot of knowledge and evidence, however, the challenge rests in the articulation of this evidence into the needs and requirements of existing and engaged groups.

It was clear that good case studies exist to demonstrate impact, however it was also found that such initiatives are often led by self-driven individuals and that the approach to scale and spread of these learnings was still challenging. One of the suggestions was to perform systematic research to understand how these case studies have succeeded in their implementation and what learnings we could extract from this research.

Funding, particularly access to grants and small pots of funding, was brought up as a barrier. It was clear that some of the clinical workforce was very enthused about collaboration and progressing the net zero agenda through actions and research and innovation. Linking up clinicians, health, and social care workforce with academics to enable further collaboration and access to funding was agreed to be a vital step towards advancing research, innovation and implementation. A clear example of enabling collaboration is the Connecting for Change programme, led by UCL Partners and funded by the Greener NHS programme, which brought together academics with healthcare professionals, to work on specific environmental projects.

Finally, the panel shared the view that the UK was strong at doing onsite 'pilots', but the real difficulties were around scaling and spreading the knowledge. Thus, avoiding the 'pilotitis' approach was a key implementation consideration to shift the focus on real opportunities and enablers for large scale implementation and spread. It was agreed that bringing users in the design and delivery of research was pivotal for change.

Dissemination – Opportunities to drive change

Dissemination is often considered a route to influence decision-makers and policy. The subject of climate change and health is recognised, although highly politicised, making it a challenging environment. More strategic thinking to leverage good existing relationships between scientists, policy makers and other key stakeholders is crucial to influence changes. A robust platform for engagement with clear identification of key stakeholders would support the dissemination of information relevant to policy development.

Another thought shared by the panel was whether our approach to dissemination is too broad and may not land appropriately to relevant individuals and groups. More specificity and strategy need to be built into:

- The evidence we require for policy or practice change.
- The stakeholders and decision-makers we intend to interact with to build the evidence for their purpose and requirements.
- Our approach to influencing and leveraging the funding required.

Finally, the panel members discussed that some of the knowledge and 'know-how' in the field is often held by more junior staff members and technicians, those that do not often have access to publication, or themselves, do not typically disseminate their findings in journals.

Therefore, knowledge mobilisation and sharing through networks and collaborations is crucial to share learnings that will enable large scale changes, at pace.

Conclusion

The panel agreed that dissemination of research outputs needs to be reconsidered more strategically to be specific to policy and practice change and supported by stronger stakeholder mapping and engagement to maximise the evidence needed.

Some key messages:

- Research should be accessible, and research dissemination in relation to climate change and environmental sustainability should be designed with the aim of influencing policy.
- Stronger stakeholder engagement needs to be strategically considered to influence funding, policy and regulation changes.
- Moving research outputs into research or clinical practice requires unmistakable evidence, but also time and resources from individuals involved. This needs to become integrated across organisations and become ‘business as usual’.
- Learning from implementation need to be evaluated and validated – the research could focus on systematic review of implementation successes and failures.
- Networks are an essential part of dissemination and implementation – stronger collaboration between researchers, academics and healthcare workforce need to be establish with forum for connecting and sharing knowledge.

Action 9:

MRC, NHS and NIHR will consider the translation of research outputs and solutions towards practical implementation (for medical & biomedical research) to enable more environmentally sustainable practises across the research, health and social care systems, with a view to draw key enablers, including relevant stakeholders and good practises.

Action 10:

Dissemination and implementation require the power of networks – The organisers will jointly consider how these networks and sharing forums can be established to advance dissemination of knowledge and promote knowledge mobilisation and sharing.

Conclusion

This conference marked the first step in a close collaboration between MRC, NHS and NIHR, centred on driving environmental sustainability in healthcare and health research. The rich and candid discussions throughout the day with key actors and decision makers emphasised the critical immediacy for action on this agenda, the necessity of collaboration and the need to both drive forward and advocate for change.

There is a clear need to understand and address the challenges, hurdles and barriers to more environmentally sustainable ways of working, as well as to identify solutions and opportunities. Presentation of research funded by MRC, NHS and NIHR alongside the diverse perspectives shared at panel discussions provided clarity on specific actions, which are highlighted in this report, and identified three clear priorities:

1. The research and healthcare community are challenged by environmental sustainability. It is less of a concern of accepting the need to change ways of working but more of an ability to assess impacts and seek support in adjusting existing practice. There are tools available, but they are not comprehensive and – more importantly - not always free at point of use.
2. The community (both research and healthcare) are already producing significant body of knowledge about best practice, which is dispersed in many different places, including websites and journals. Events, such as this conference, offer an invaluable platform for the exchange of knowledge, experience and opportunity for networking.

3. Whilst the activities on closing the gaps of understanding of viable practical interventions is critical, there must be more focus on wide-spread implementation to drive the environmental sustainability more effectively.

The importance of collective action cannot be overstated. As a community of change makers, we must be coherent and consistent in addressing these priorities to achieve sector and system wide impact. We must continue to challenge ourselves, aim high, and work smartly and effectively to drive positive change.

On a final note - Our passion must remain undimmed.

Acknowledgments

We would like to thank the MRC, NIHR and the Greener NHS for organising and hosting this inaugural conference on research outputs in environmental sustainability. In particular, thank you to Susan, Fanny and Sophia for organising and to Elena, Eleanor and Ellie for supporting the event and making it a reality.

A special thank you must go to the MRC whose generous support has made this important event possible.

A huge thank you to Professor John Iredale for chairing the day, keeping it live and engaging.

Thank you to all our knowledgeable presenters and panel members for making the presentations interesting and the discussions enriching and energetic.

Finally, we would like to thank the Francis Crick Institute for supporting this event and to all our online and in-person attendees for engaging and making it a memorable and impactful event.

Appendices

Appendix 1 – Presentation Greener Trials

ICR The Institute of Cancer Research

LIVERPOOL CLINICAL TRIALS CENTRE LCTC

FUNDED BY NIHR | National Institute for Health and Care Research

Greener Trials

Jess Griffiths, Institute of Cancer Research, Carbon in Clinical Trials Research Assistant
Lisa Fox, Institute of Cancer Research, NIHR MRC TMRP Greener Trials Group Lead
Paula Williamson, University of Liverpool and MRC-NIHR TMRP Lead

Trials Methodology TMRP Research Partnership

Academy of Medical Sciences FORUM, March 2023: Enabling environmentally sustainable biomedical research

- Accelerating **greener practices** in clinical research: A need to…

- Learn from progress made in greener laboratory research practice and in industry
- Ensure and demonstrate acceptability to regulators and research participants
- Create capacity in clinical research workforce
- Involve patients
- Provide support and continue the conversation

The Academy of Medical Sciences

UKRI Medical Research Council

NIHR | National Institute for Health and Care Research

FORUM Linking life science sectors

Clinical Trials

Subaiya *et al. Trials* 2011, **12**:31
http://www.trialsjournal.com/content/12/1/31

TRIALS

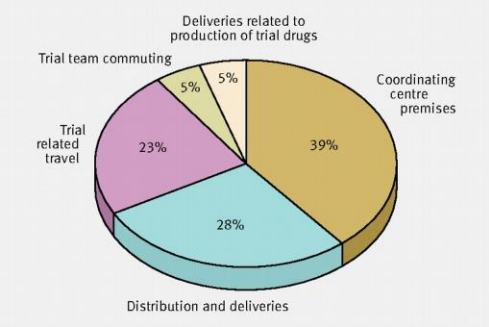
RESEARCH Open Access

Reducing the environmental impact of trials: a comparison of the carbon footprint of the CRASH-1 and CRASH-2 clinical trials

Saleena Subaiya[1*], Euan Hogg[2], Ian Roberts[3]

Take home message:

- Average carbon emissions generated by the 12 UK based academic trials appraised was 78.4 tonnes (42.1-112.7)
- ~Annual footprint of 6.3 UK citizens
- 40,000 new trials in ClinicalTrials.gov in 2023
- Faster recruitment, lighter trial materials, web-based data entry



Proportions of greenhouse gas emissions in CRASH Trial Case study *BMJ* 2007;334:671

BMJ

Cite this as: *BMJ* 2009;339:b4187
doi:10.1136/bmj.b4187

Carbon cost of pragmatic randomised controlled trials: retrospective analysis of sample of trials

Katy Lyle, research fellow,[1] Louise Dent, acting principal research fellow,[1] Sally Bailey, senior programme manager,[1] Lynn Kerridge, chief executive officer,[1] Ian Roberts, professor of epidemiology and public health,[2] Ruairidh Milne, director of strategy and development[1]

Project aims

FUNDED BY
NIHR | National Institute for Health and Care Research

“Development and prototype testing of a method to quantify the carbon footprint of current clinical trials to inform future lower carbon clinical trial design”

NIHR Clinical Trials Unit Support Funding Opportunity – Supporting efficient / innovative delivery of NIHR research

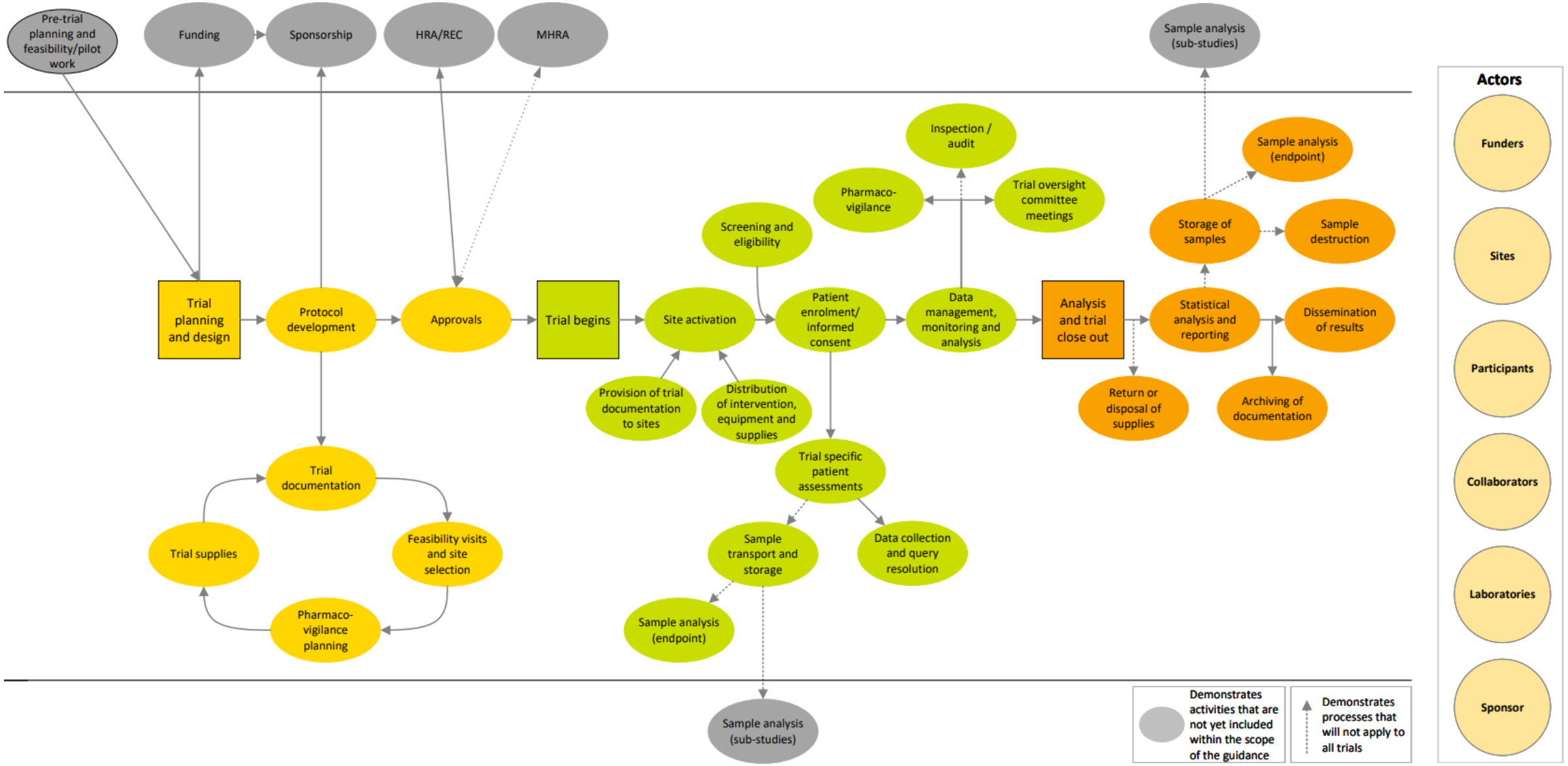
1. Develop a process map
A tool to capture all possible clinical trial processes which have a carbon footprint

2. Develop methodology to calculate carbon footprint of each process Processes grouped into modules, emission factor library built

3. Test process map and methodology
Calculate footprint of trials from UK CRC registered CTUs

4. Analyse and report on findings
Including PPIE input on patient attitudes to carbon trade off decisions

Clinical trial process mapping



Phase 1: Guidance and pilot study

FUNDED BY
NIHR | National Institute for Health and Care Research

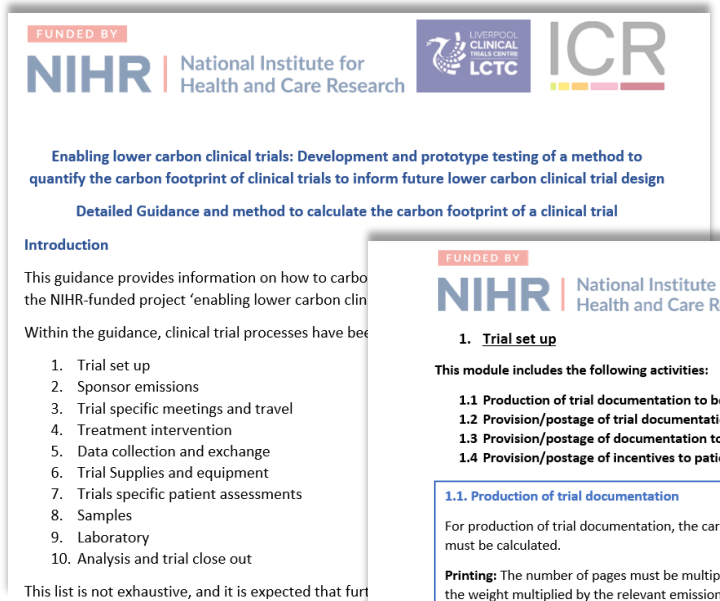
Open access Communication

BMJ Open

Quantifying the carbon footprint of clinical trials: guidance development and case studies

Jessica Griffiths ,[1] Lisa Fox,[1] Paula R Williamson,[2] on behalf of the Low Carbon Clinical Trials Group

doi:10.1136/ bmjopen-2023-075755



FUNDED BY
NIHR | National Institute for Health and Care Research
LCTC ICR

Enabling lower carbon clinical trials: Development and prototype testing of a method to quantify the carbon footprint of clinical trials to inform future lower carbon clinical trial design

Detailed Guidance and method to calculate the carbon footprint of a clinical trial

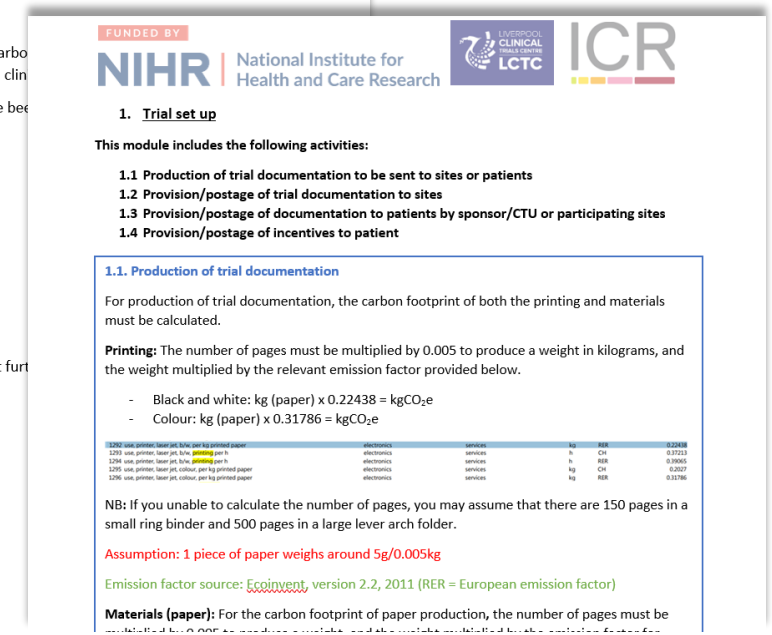
Introduction

This guidance provides information on how to carbo
the NIHR-funded project 'enabling lower carbon clin

Within the guidance, clinical trial processes have bee

1. Trial set up
2. Sponsor emissions
3. Trial specific meetings and travel
4. Treatment intervention
5. Data collection and exchange
6. Trial Supplies and equipment
7. Trials specific patient assessments
8. Samples
9. Laboratory
10. Analysis and trial close out

This list is not exhaustive, and it is expected that furt



FUNDED BY
NIHR | National Institute for Health and Care Research
LCTC ICR

1. Trial set up

This module includes the following activities:

1.1 Production of trial documentation to be sent to sites or patients
1.2 Provision/postage of trial documentation to sites
1.3 Provision/postage of documentation to patients by sponsor/CTU or participating sites
1.4 Provision/postage of incentives to patient

1.1. Production of trial documentation

For production of trial documentation, the carbon footprint of both the printing and materials must be calculated.

Printing: The number of pages must be multiplied by 0.005 to produce a weight in kilograms, and the weight multiplied by the relevant emission factor provided below.

- Black and white: kg (paper) x 0.22438 = $kgCO_2e$
- Colour: kg (paper) x 0.31786 = $kgCO_2e$

1292 use, printer, laser jet, b/w, per kg printed paper	electronics	services	kg	RER	0.22438
1293 use, printer, laser jet, b/w, printing per h	electronics	services	h	CH	0.37213
1294 use, printer, laser jet, b/w, printing per h	electronics	services	h	RER	0.39065
1295 use, printer, laser jet, colour, per kg printed paper	electronics	services	kg	CH	0.2027
1296 use, printer, laser jet, colour, per kg printed paper	electronics	services	kg	RER	0.31786

NB: If you unable to calculate the number of pages, you may assume that there are 150 pages in a small ring binder and 500 pages in a large lever arch folder.

Assumption: 1 piece of paper weighs around 5g/0.005kg

Emission factor source: Ecoinvent, version 2.2, 2011 (RER = European emission factor)

Materials (paper): For the carbon footprint of paper production, the number of pages must be

ICR | LIVERPOOL CLINICAL TRIALS CENTRE LCTC | Sustainable Healthcare Coalition | Trials Methodology TMRP Research Partnership | UK Clinical Research Collaboration | ERM

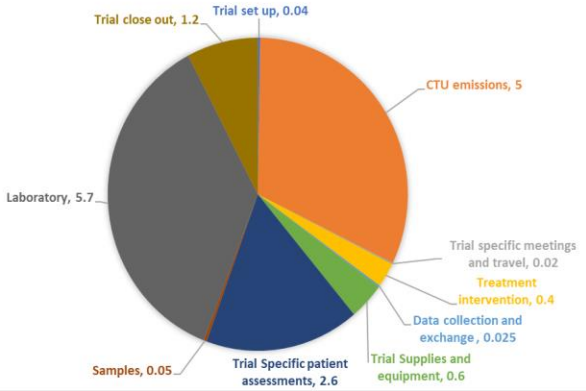
Phase 2: Working with Clinical Trials Units

- Trials footprinted by a variety of people: Clinical Trial Managers, PhD students, MSc students, CiCT Research Assistant
- Time taken ranged from 5 hours to 60 hours

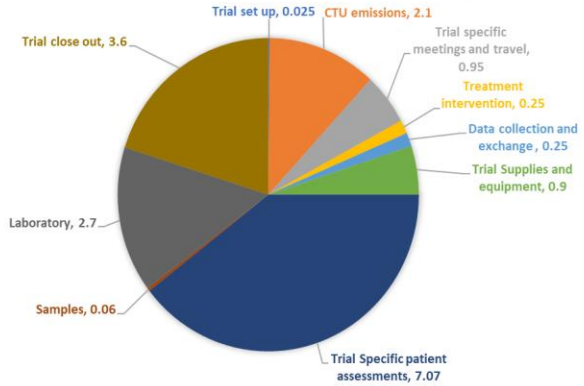
Interventions	
IMP	Breast cancer, COVID, Gestational diabetes, HIV, Stroke, Nutritional, COPD
Surgical	Prostate cancer
Educational	Anti-bullying
Surveillance	Dental health
Reach	National, International

CHaRT Centre for Healthcare Randomised Trials
GAILLIMH 18 45 GALWAY
The George Institute for Global Health UK Better treatments. Better care. Healthier societies.
cancer trials ireland
Newcastle University
Imperial Clinical Trials Unit
CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD
LIVERPOOL CLINICAL TRIALS CENTRE LCTC
ECTU Edinburgh Clinical Trials Unit
MRC Clinical Trials Unit
UCL

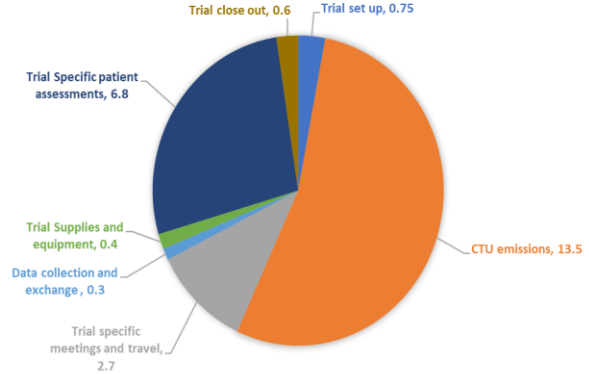
ON-PACE CARBON FOOTPRINT (16 tonnes CO_2e)



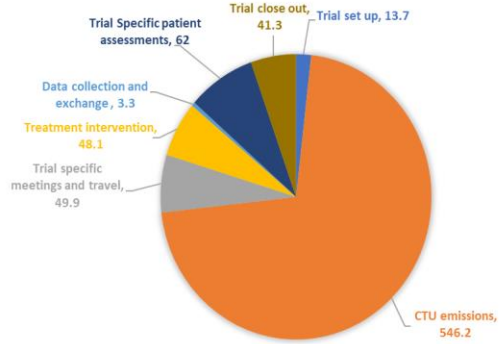
MAVMET CARBON FOOTPRINT (18 tonnes CO_2e)



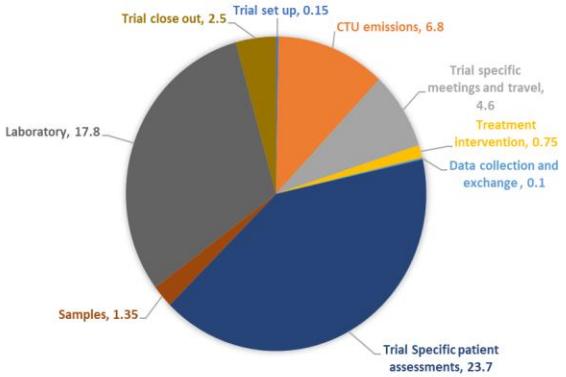
PREMISE CARBON FOOTPRINT (25 tonnes CO_2e)



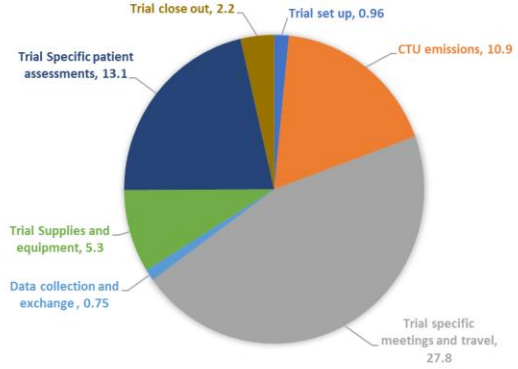
INTERACT-3 CARBON FOOTPRINT (765 tonnes CO_2e)



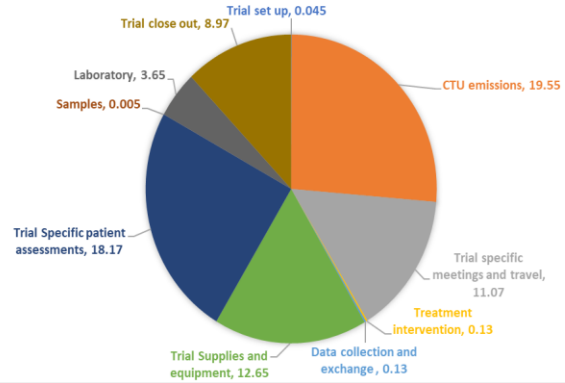
SHAMROCK CARBON FOOTPRINT (58 tonnes CO_2e)



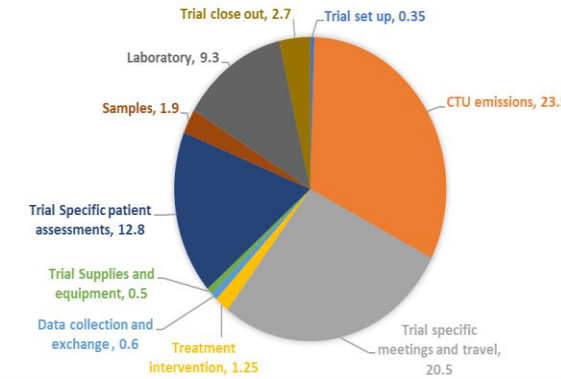
INTERVAL CARBON FOOTPRINT (61 tonnes CO_2e)



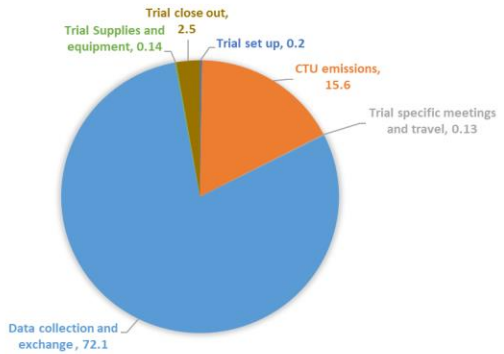
EMERGE CARBON FOOTPRINT (74 tonnes CO_2e)



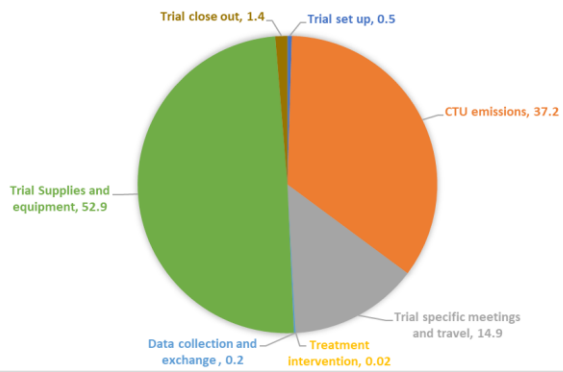
CASPS CARBON FOOTPRINT (73 tonnes CO_2e)



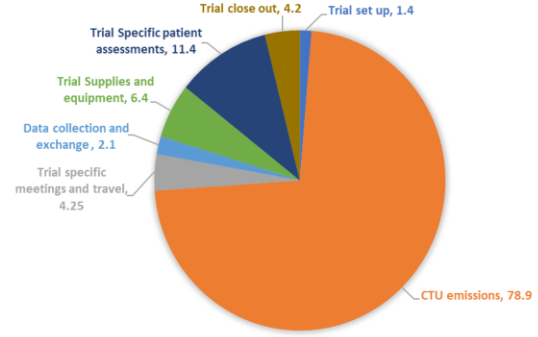
HEAL-COVID CARBON FOOTPRINT (91 tonnes CO_2e)



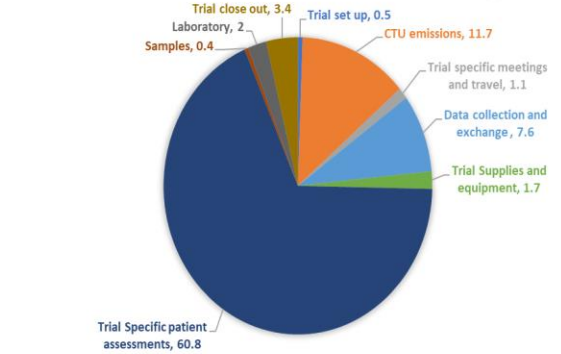
UK STAND TOGETHER CARBON FOOTPRINT (107 tonnes CO_2e)



RESTART CARBON FOOTPRINT (109 tonnes CO_2e)

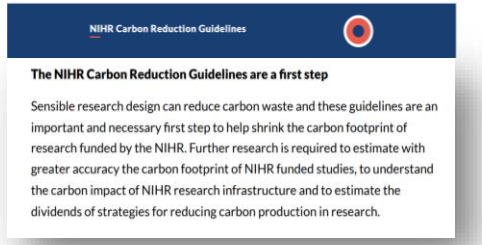


PRIMETIME CARBON FOOTPRINT (89 tonnes CO_2e)



What can researchers do to reduce carbon emissions?

- Follow existing guidance



my green lab.

LEAF – The Laboratory Efficiency Assessment Framework

- Common hotspots to date
- CTU emissions
- Trial-specific patient assessments
- Trial meetings and monitoring
- Sample collection, IMP shipments

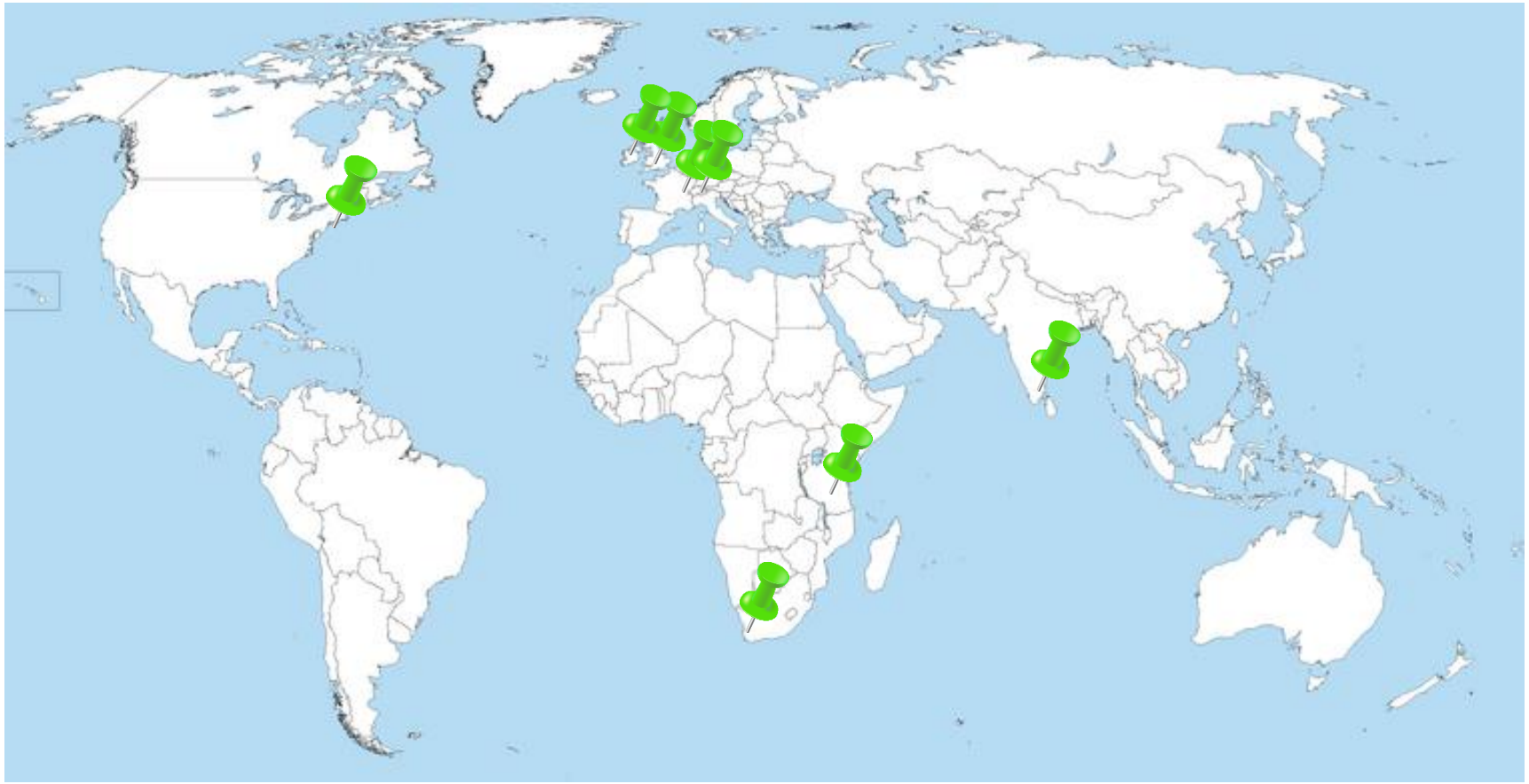
COMET Initiative

- Check for environmental sustainability practice of suppliers, vendors and third parties

Greener Trials

- Email lisa.fox@icr.ac.uk to get involved

Trials Methodology TMRP Research Partnership

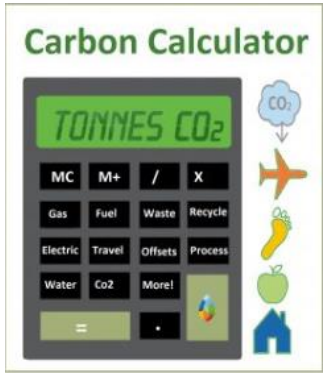


Future plans

- Continue to refine, expand, enhance method, source data
- Training - drop-in clinics, recorded webinars
- Dissemination - ICTMC 2024
- An online eco-design tool compatible with NHS, industry, initiatives in other countries

ICTMC 2024

- Continued identification and reduction of hotspots
- Design change efficiency, acceptability – co-produced video
- Behavioural aspects
- Innovate UK Regulatory Science Discovery Award - what data is needed, who should review it, how to assess it?



With thanks to our many partners and collaborators

Appendix 2 – Presentation Biobanking Strategies

Roadmap for Low-carbon Ultra-low Temperature Storage in Biobanking

MRC– Francis Crick Institute

29th April, 2024

Matthew Graham, Gabrielle Samuel, Martin Farley, Lee Stanyer

Medical Research Council

Format of Talk

1. Importance of the topic
2. Methodological approach
3. Findings
4. Dissemination activities
5. Challenges and successes

1. Importance of the topic

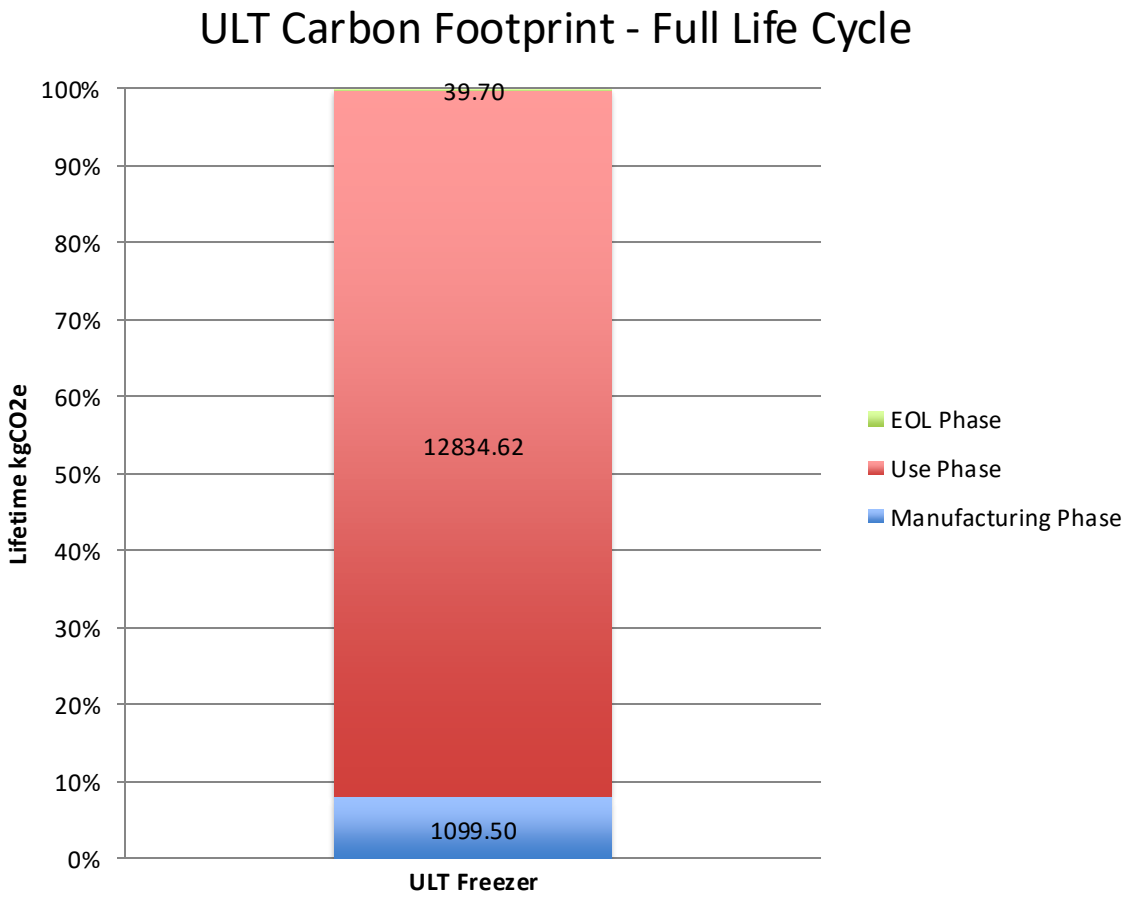
- Carbon footprint of ULT storage:
  - ULT freezers reports: electricity = eq to a UK household
  - Evidence of 70% embodied carbon in other products
  - Lack of evidence surrounding LN2 footprint

- Evidence needed: where best to reduce carbon footprint
  - When to buy new freezers? [given marketing promises of increased efficiencies]
  - LN2 or freezer sample storage?
  - Centralising or de-centralized biobank configurations?

2. Methodological approach

- One year, UK-based, multidisciplinary research project
- Quantitative Carbon Footprint for 1 year ULT storage (ULT freezer & LN2): 4 case study sites
- Two stakeholder workshops: UK based biobank stakeholders: discuss how findings could be incorporated into practice (constraints/opportunities)
- Results: development of ‘Roadmap’.

3. Findings
Phase 1: ULT Carbon Footprint Assessment



Carbon Footprinting Assessment of four case study sites

Case Study Site	Assessment Categories & Units of Assessment	Configuration
School of Neuroscience, Wolfson Centre, King's College London	• ULT freezer storage ($kgCO_2e$ L-y^{-1}) • LN2 storage ($kgCO_2e$ L-y^{-1}) • Costing (£)	Devolved configuration in which in which samples are managed by researchers and technical staff.
Institute of Neurology (IoN), Queen's Square House, University College London	• ULT freezer storage ($kgCO_2e$ L-y^{-1}) • LN2 storage ($kgCO_2e$ L-y^{-1}) • Costing (£)	Devolved system, but contained in a single site, with central guidance on tracking samples.
Department for Twin Research and Genetic Epidemiology (Twins), St. Thomas' Hospital, King's College London	• ULT freezer storage ($kgCO_2e$ L-y^{-1}) • LN2 storage ($kgCO_2e$ L-y^{-1}) • Costing (£)	Centralised biobanking system, overseen by an executive committee and managed by technical staff.
University of Nottingham (UoN) Cell Bank	• LN2 storage ($kgCO_2e$ L-y^{-1}) • Costing (£)	Solely LN2 storage systems, but uses an automated-refill LN2 storage system, allowing a comparison with manual fill dewars.

3. Findings
Phase 2: Roadmap

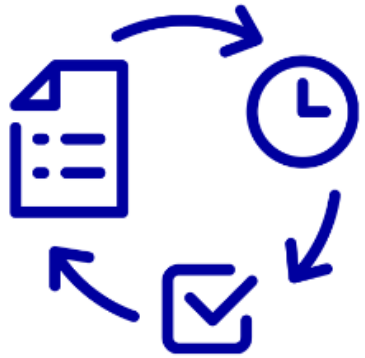
Areas of Practice

ULT Freezers

- 'Warming Up'
- Best Management Practices
- Replacement Strategies
- End of Life Practices

LN2 Storage

- Delivery & Manual Refill
- Auto-Refill Systems
- On-Site Generation



Sample Management & Centralisation

- Sample Management & Security
- Centralisation of samples

ULT Freezers

1. 'Warming Up' ULT Freezers

Using a ULT freezer accounts for over 90% of lifecycle carbon emissions

Temperature increases from -80°C to -70°C can reduce electricity consumption up to 28%

'Warming up' a ULT freezer from its -80°C 'default' will reduce carbon emissions. However, several barriers make this change difficult to implement.

Barriers:

- Perceived risk to samples
- -80°C 'norm' within biobanking
- Practical concerns:
  - Increased risk owing to shared freezer space
  - Internal and display temperature discrepencies
- Funding and regulatory constraints

Recommendations:

- Promotion of successful -70°C practice
- Deconstructing attitudes towards 'sample preciousness'
- Push manufacturers to address temperature discrepancy issues
- Push regulatory and funding bodies for clarity on their stance toward warming up to ease stakeholder concerns

2. ULT Freezer Best Management Practice

Effective ULT management, which are already best practice, is a key hotspot for reducing carbon emissions in biobanking. It includes practices such as **XX**, and ensures that freezers run efficiently with as low as possible carbon emissions**. GIVE AN EXAMPLE OF EMISSIONS REDUCTION HERE**

3. ULT Freezer Replacement

ULT freezer replacement strategies should not be based on the assumption of age-based declining efficiencies. Our Carbon Footprinting found that this approach is flawed because efficiencies may not reduce as quickly as expected and/or lower efficiencies are likely to come from poor freezer management. We recommend:

- Collecting 'in situ' data through energy metering to determine the actual efficiency of the freezer
- First consider how the possible limitations of a biobank site could be contributing to decreases in freezer efficiency, such as **XX I**

LN2 Storage

56-80% of carbon emissions associated with LN2 storage in biobanking are due to the delivery of industrially produced LN2

Case study data showed auto-refill systems can use roughly 7x less LN2 per litre of storage space per annum compared to manual fill dewars

On-site LN2 generation, when combined with auto-refill systems, can potentially reduce the carbon footprint by 54% compared to manual fill, road-delivered LN2 storage

Our Carbon Footprinting revealed that various interventions in LN2 storage systems can reduce a biobank's LN2-based carbon emissions:

- Where the constraints allow, biobanks should consolidate LN2 deliveries in order to avoid multi-runs.
- Where constraints allow, biobanks should implement an auto-refill LN2 system.
- Where constraints allow, biobanks should implement an on-site LN2 generator.

Centralisation & Sample Management

Sample management recommendations

- Electronic sample management systems and regular sample audits
- 'Use, discard, pay' schemes that encourage researchers to use or discard samples, or pay for sample storage on-site or in independent off-site facilities.
- Store samples in appropriate sized equipment and storage boxes
- Change biobank culture: reframe samples as commons, rather than 'belonging' to individual researchers, and encourage communitarian approaches to help address over-attachment to samples and promote sample sharing.

Centralisation recommendations

- Bring benefits of low-carbon benefits into institutional decision-making/planning about biobanking centralisation. Other issues to be considered:
  - Do not build a new biobanking facility due to space constraints before sample management techniques are maximising existing space and preventing expansion for its own sake.
  - Old ULT freezers and LN2 vessels should be carried over to new facilities, unless a new, more efficient, large-scale system has been requisitioned i.e. Nordic system, automated LN2 system.

4. Dissemination activities

- **Four dissemination workshops scheduled with the biobanking community**
  - Imperial College London
  - Swansea University
  - Glasgow University
  - Scientific Laboratory Supplies Ltd. Annual Conference
- **Internal presentations at King's College London**
  - Sustainability in Research Committee
  - International Freezer Challenge Launch
- **Stakeholder workshops also act as a form of engagement**

5. Successes; challenges; further work

- Challenges: getting open access data
  - Key site unable to provide data
  - Lack of cooperation from ULT freezer manufacturers
- Challenges: implementation of recommendations
  - Roadmap offers general recommendations; context-specific decisions & practical will is often required to implement these change.
- Successes: quantitative and qualitative methodologies brought together
  - Allowed a wide set of values to be considered in our recommendations, rather than taking a purely numbers-driven approach.
  - Co-design with biobanking stakeholders more likely to be implemented in practice.
- Further work:
  - Developed recommendations could possibly be adopted into an existing laboratory sustainability certification system, or perhaps a specialised biobanking sustainability certification system.

Thank you!

- **Roadmap for Low-carbon ULT-storage in Biobanking** (Graham et al). Submitted to journal, pre-print available - https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4808756
- **Quantifying the Carbon Footprint of ULT-temperature Storage Space in Biobanking** – forthcoming.

Appendix 3 – Reuse economy for surgical drapes and gowns

Moving to a Reuse Economy

for Surgical Drapes and Gowns

Prof. Mahmood Bhutta

Chair in ENT Surgery & Sustainable Healthcare
Brighton & Sussex Medical School

Consultant and Academic Lead in ENT
Trust Clinical Green Lead
University Hospitals Sussex

Founder
BMA Medical Fair and Ethical Trade Group

THiS Institute Fellow

brighton and sussex medical school

NHS
University Hospitals Sussex
NHS Foundation Trust

CENTRE for SUSTAINABLE HEALTHCARE

THIS.Institute The Healthcare Improvement Studies Institute

2006

Fair trade for surgical instruments

Mahmood F Bhutta

We may all be trying to buy fair trade coffee and bananas, but do we know where our surgical instruments are made, and under what conditions?

The global trade in medical commodities amounts to billions of pounds each year (www.standardsandpoors.com), with much trade between the developed and the developing world. The pricing and availability of pharmaceuticals, medical equipment, and biotechnologies, and the potential conflicts of interest and ethical issues, have all been questioned. Perhaps the most publicised case has been that of the provision of affordable medicines to combat the spread of HIV in the developing world,[1] where international pressure resulted in drug companies cutting prices. Many other medical commodities (such as MRI scanners and endoscopic equipment) are too expensive for the developing world because costs of research and development are high.

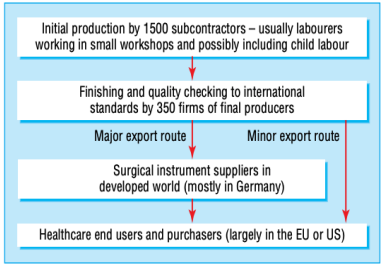


Fig 1 The manufacture and supply process of stainless steel surgical instruments from Pakistan

thebmj

2008

CLIMATE CHANGE

Wanted: a green NHS

We welcome the *BMJ*'s latest issue on climate change (26 January), which suggests some strategies for health professionals in response to global warming, including adaptation and surveillance and forecasting of health risks.[1] "Climate change: what can doctors do?" asks the *BMJ*'s cover. We believe that doctors must do more than respond to the crisis as it unfolds. Health professionals at all levels must lead by example in their own practices.

Rachel C Stancliffe director, Campaign for Greener Healthcare, Oxford OX2 7LG
rachel.stancliffe@soundshealthy.org
Mahmood Bhutta cofounder, Medical Fair and Ethical Trade Group, c/o International Department, BMA, London WC1H 9JP

thebmj

Drapes and gowns

- 93m drapes and gowns in NHS England
  - 60-75% in the UK are single-use
- Reuse typically 55-75 times and has one third carbon footprint

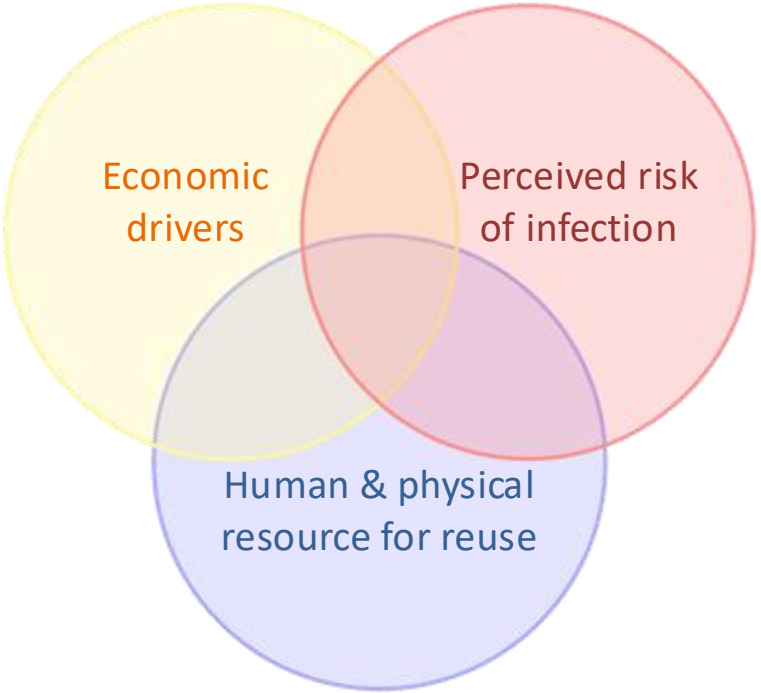
- Knee arthroplasty (>80,000 per annum)
  - 11 drapes/gowns, 14.5kg CO_2 = driving 72 miles in an average UK car
- Carpal tunnel (>45,000 per annum)
  - 3 drapes/gowns, 5.8kg CO_2 = driving 21 miles in an average UK car

Rizan C et al J R Soc Med 2023;116:199-213

Approach

- 14 interviews across a range of professional roles within the NHS, with thematic analysis
- Systematic review of literature, including published studies, grey literature, and industry data
- Creation of an animation to inform stakeholders

Incentives and barriers



Perceived risk of infection

“Drapes and gowns must be made of impervious materials. Thin cotton drapes and gowns have no place in orthopaedic surgery”

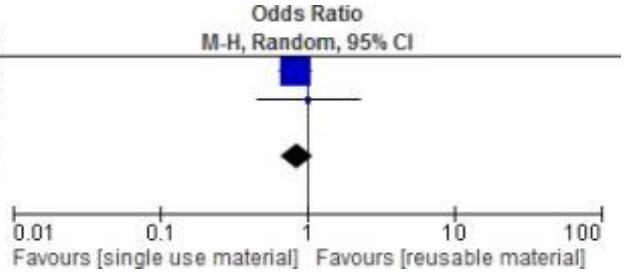
2014 Consultant Advisory Book

British Orthopaedic Association

Infection risk

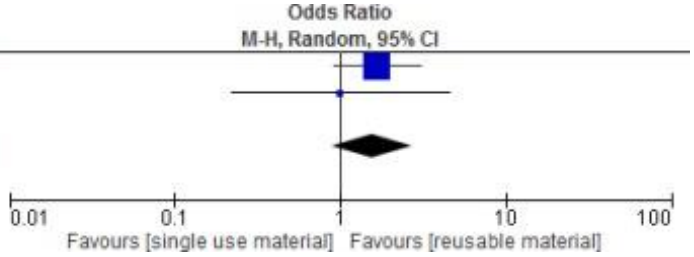
Study or Subgroup	single use material Events	Total	reusable material Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Belkin 1998	108	2139	133	2223	90.5%	0.84 [0.64, 1.08]
Bellchambers 1999	13	250	12	236	9.5%	1.02 [0.46, 2.29]
Total (95% CI)		**2389**		**2459**	**100.0%**	**0.85 [0.66, 1.09]**
Total events	121		145			

Heterogeneity: Tau² = 0.00; Chi² = 0.22, df = 1 (P = 0.64); I² = 0%
Test for overall effect: Z = 1.26 (P = 0.21)



Study or Subgroup	single use material Events	Total	reusable material Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Castro Ferrer 2004	31	421	18	396	86.5%	1.67 [0.92, 3.03]
Treggiari 1992	4	25	4	25	13.5%	1.00 [0.22, 4.54]
Total (95% CI)		**446**		**421**	**100.0%**	**1.56 [0.89, 2.72]**
Total events	35		22			

Heterogeneity: Tau² = 0.00; Chi² = 0.38, df = 1 (P = 0.54); I² = 0%
Test for overall effect: Z = 1.56 (P = 0.12)



Textile performance: standards

- All health textiles are made of plastics (cotton is obsolete)
- Must meet EN13795 standards throughout the lifecycle

Liquid penetration

Microbial penetration

Textile performance: single use vs reusable

Tensile strength

4x higher with reusable

10x higher if wet

Burst

10x lower with reusable

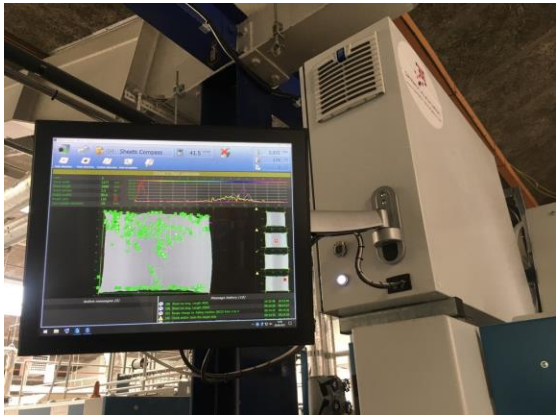
Linting (particle release)

8x lower with reusable

ETSA

EUROPEAN TEXTILE SERVICES ASSOCIATION

Textile laundry and sterilisation standards



Robust decontamination & sterilisation

HTM 0104

Standards and quality assurance

Microbiological monitoring

Bioburden testing on final products

Processing ref: TM-SP-1

Colony Forming Units/100cm² (CFU/100cm²)

	Sample Description/ Alert criteria reference TM-QA-08	~Aerobic Colony Count (ACC) TM-AM-1	Coliforms● (Presumptive) TM-AM-2	*Escherichia coli* TM-AM-2	Faecal enterococci TM –AM-3	*Staphylococcus aureus* TM-AM-4	Fungi (Presumptive) TM-AM-8	*Clostridium difficile* TM-AM-6	Overall alert status
		≤300	≤5	≤5	≤5	≤5	≤5	Absent	
			6-10	6-10	6-10	6-10	6-10		
		>300	>10	>10	>10	>10	>10	Present	
33	70 X 70 Drape	12	<2	<2	<2	<2	<2	<2	Satisfactory
34	42 x 42 Drape	6	<2	<2	<2	<2	<2	<2	Satisfactory
35	Alcoban 100 x 100	4	<2	<2	<2	<2	<2	<2	Satisfactory
36	Alcoban 100 x 140	4	<2	<2	<2	<2	<2	<2	Satisfactory
37	Clean Room Gown	10	<2	<2	<2	<2	<2	<2	Satisfactory

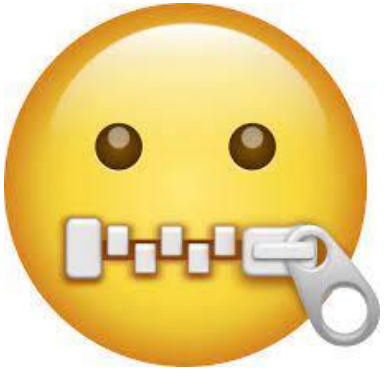
●Coliforms (without E coli and faecal enterococci) regarded as being of environmental origin: Green = ≤5; Amber = 6-25; Red >25

Marketing fear

Mölnlycke®

Infection control with single use

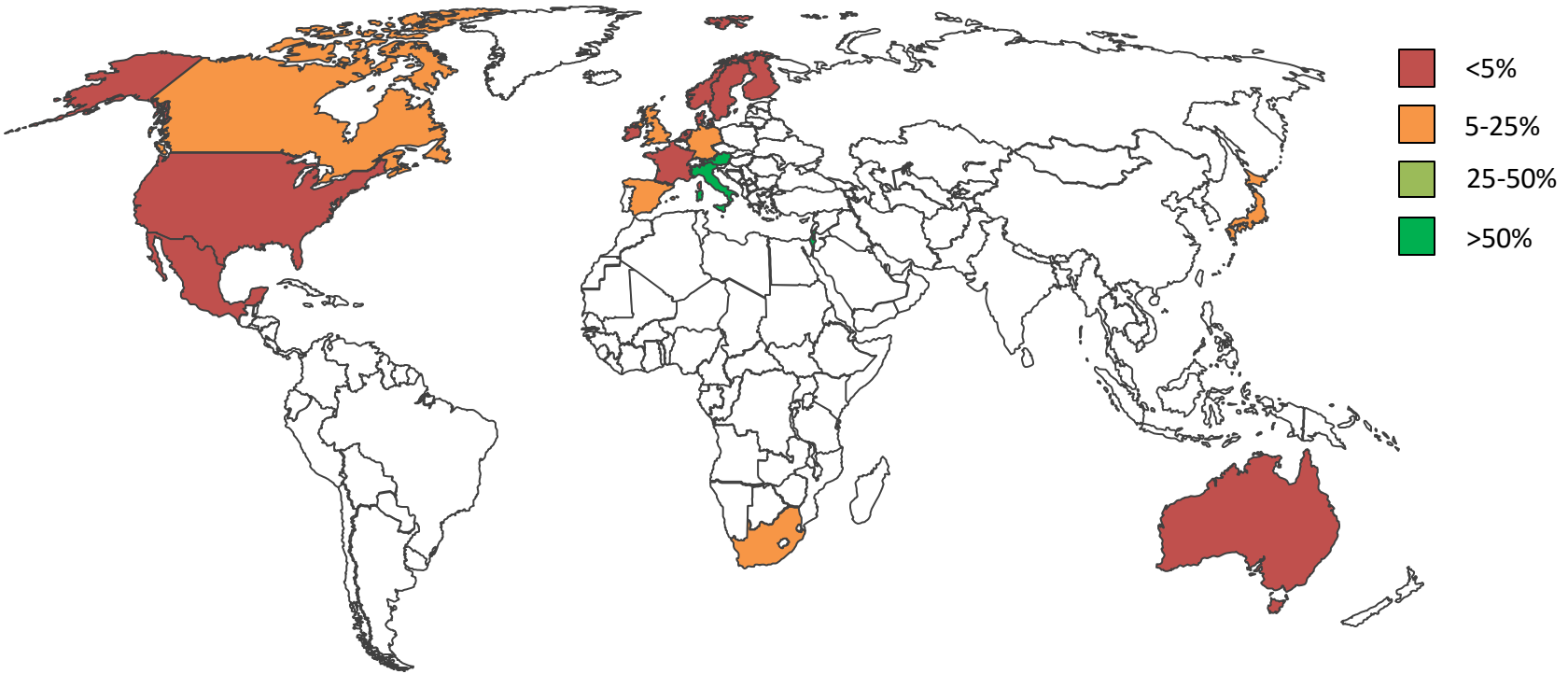
(reusable) “drapes and gowns provide no guarantee of ….infection prevention and control management”



Invite to speak at a webinar on sustainable surgical textiles withdrawn

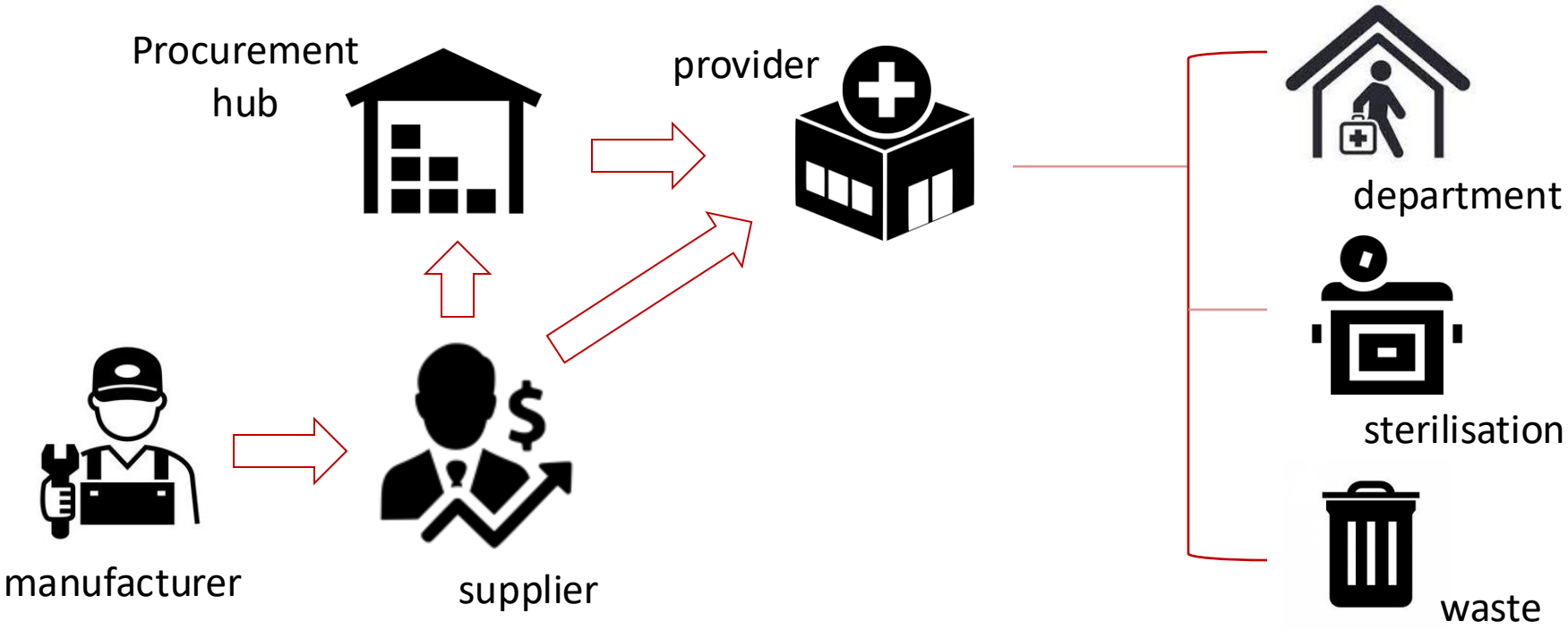
Resource / inertia

Proportion of Surgical Textiles that are Reusable



Costs

Compartmentalised costs

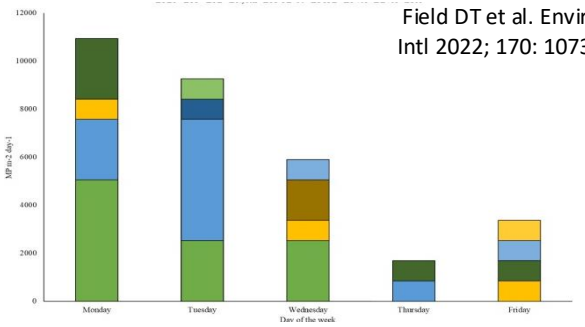


45% costs savings from reuse

Other harms

Other harms from textile use

- Environmental toxins
  - microplastics in the operating theatre 3x background level
  - Per- and Polyfluorinated Substances (PFAS) in drapes and gown

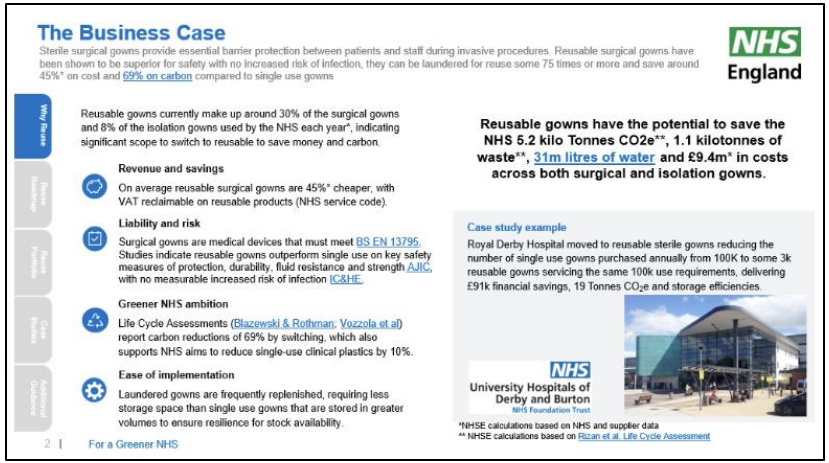


Field DT et al. Environ Intl 2022; 170: 107360

- Labour rights abuse
  - Thailand
  - China

Guidance or mandate?


Green Surgery
Reducing the environmental impact of surgical care
brighton and sussex medical school
CENTRE for SUSTAINABLE HEALTHCARE
UK Health Alliance on Climate Change


The Business Case
Sterile surgical gowns provide essential barrier protection between patients and staff during invasive procedures. Reusable surgical gowns have been shown to be superior for safety with no increased risk of infection, they can be laundered for reuse some 75 times or more and save around 45%* on cost and 69% on carbon compared to single use gowns
NHS England
Why Reuse
Reuse Solutions
Reuse Portfolio
Case Studies
Additional Guidance
Reusable gowns currently make up around 30% of the surgical gowns and 8% of the isolation gowns used by the NHS each year*, indicating significant scope to switch to reusable to save money and carbon.
Revenue and savings
On average reusable surgical gowns are 45%* cheaper, with VAT reclaimable on reusable products (NHS service code).
Liability and risk
Surgical gowns are medical devices that must meet BS EN 13795. Studies indicate reusable gowns outperform single use on key safety measures of protection, durability, fluid resistance and strength AJIC, with no measurable increased risk of infection IC&HE.
Greener NHS ambition
Life Cycle Assessments (Blazewski & Rothman; Vozzola et al) report carbon reductions of 69% by switching, which also supports NHS aims to reduce single-use clinical plastics by 10%.
Ease of implementation
Laundered gowns are frequently replenished, requiring less storage space than single use gowns that are stored in greater volumes to ensure resilience for stock availability.
Reusable gowns have the potential to save the NHS 5.2 kilo Tonnes CO2e**, 1.1 kilotonnes of waste**, 31m litres of water and £9.4m* in costs across both surgical and isolation gowns.
Case study example
Royal Derby Hospital moved to reusable sterile gowns reducing the number of single use gowns purchased annually from 100K to some 3k reusable gowns servicing the same 100k use requirements, delivering £91k financial savings, 19 Tonnes CO2e and storage efficiencies.
NHS University Hospitals of Derby and Burton NHS Foundation Trust
*NHSE calculations based on NHS and supplier data
** NHSE calculations based on Rizan et al. Life Cycle Assessment
2 | For a Greener NHS

chainge®

Beyond drapes and gowns

Consumption of medical goods in the NHS in England

- 10% of the carbon footprint of health systems in high resource settings (0.5% of the entire carbon footpring of the nation)
- Dominated by linear consumption: 73% of products single use
- £10bn medical devices per annum, of 592,000 different product types
- 240,000 tonnes per annum of clinical waste (96% from hospitals, 3% primary care).

Examples (NHS England data)

- >1.7 bn gloves (pre-pandemic)
  - 60% of use unnecessary
- 48m electrosurgical products
- 52m metal instruments

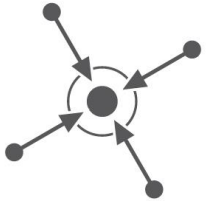
POLICY BRIEF

Reducing the environmental impact of medical devices adopted for use in the NHS

FEBRUARY 2024

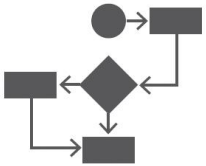
brighton and sussex medical school

UNIVERSITY OF SUSSEX



1. Development of a centralised, consistent, and broadly communicated national medical device circularity strategy, to prevent disjointed (and often inexpert) assessment.

2. National support for the prioritisation of reduce and reuse initiatives across NHS organisations.



3. Evaluation of medical product categories in the NHS with high environmental impact, identifying the key drivers of their environmental impact to facilitate evidenced-based product decision-making, preferential procurement (and so incentivise change in the industry), and progress monitoring.

www.bsms.ac.uk/about/sustainability.aspx

brighton and sussex
medical school

m.bhutta@bsms.ac.uk

Appendix 4 – Circling back to move forward

Revolution-ZERO

More effective, more economic, more sustainable.

Our mission is to displace single use medical textiles with reusable alternatives that are more effective, economic and sustainable.

Revolution-ZERO: the journey

- Problem/s
- Back to Reusables
- Circular Economy System
- Operational Pillars for reuse
- SBRI Healthcare, Decarbonisation – low temperature decontamination and validation
- SBRI Healthcare, Decarbonisation– system optimisation
- Whole Systems Approach

Textiles are a big problem

- Medical textiles contribute the equivalent entire CO_2e emissions of either Sweden or Finland*
- The UK outputs more than 53,000 tonnes of regulated medical textile waste a year**
- Surgical textiles represent 12% of all hospital waste

Derived from:

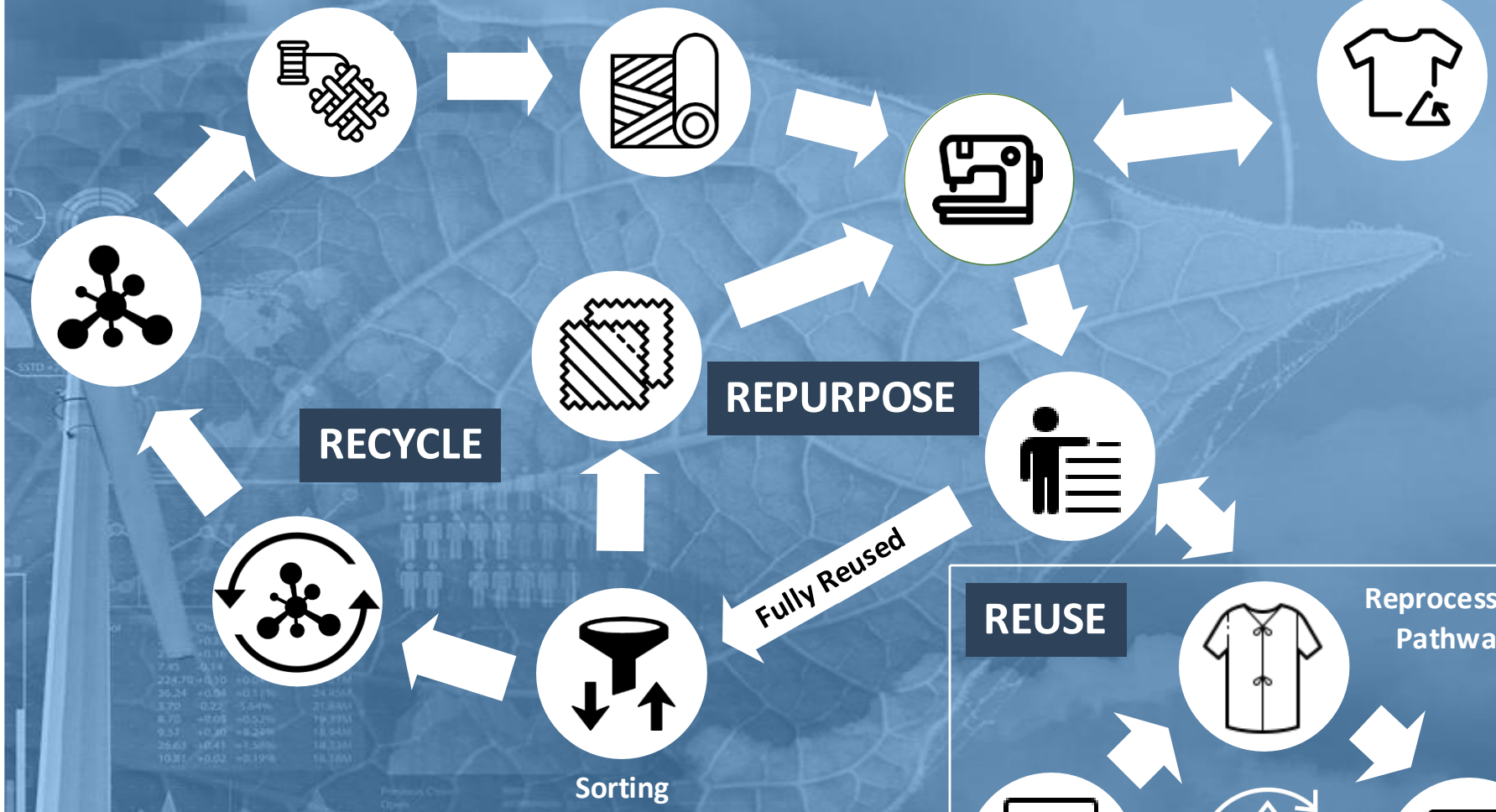
* *Kellera et al., 2021. 33 Swiss Hospital LCA study*

** https://www.gov.uk/government/statistics/ search "PPE"; Operating theatre system audits and extrapolation; NHS England data

Reuse - going back for the/our future

Net Zero Processes

- Engineered efficiency
- Renewable energy
- Chemicals
- Local
  - Manufacture
  - Reprocessing
  - Recycling



Integrated Evaluation tracking:

Assets	Carbon
Process	Waste
Compliance	Water

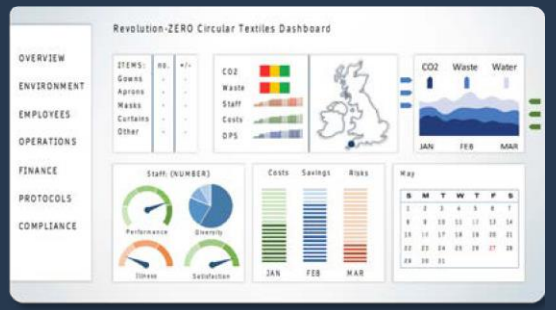
UNIVERSITY OF EXETER

Revolution-ZERO: What we do

Reusables

Processing

Compliance



"In my opinion it is the **best** example of a **circular economy system** design built from scratch. Everything has been thought through **and every challenge and barrier** that you can imagine has been **overcome**.."

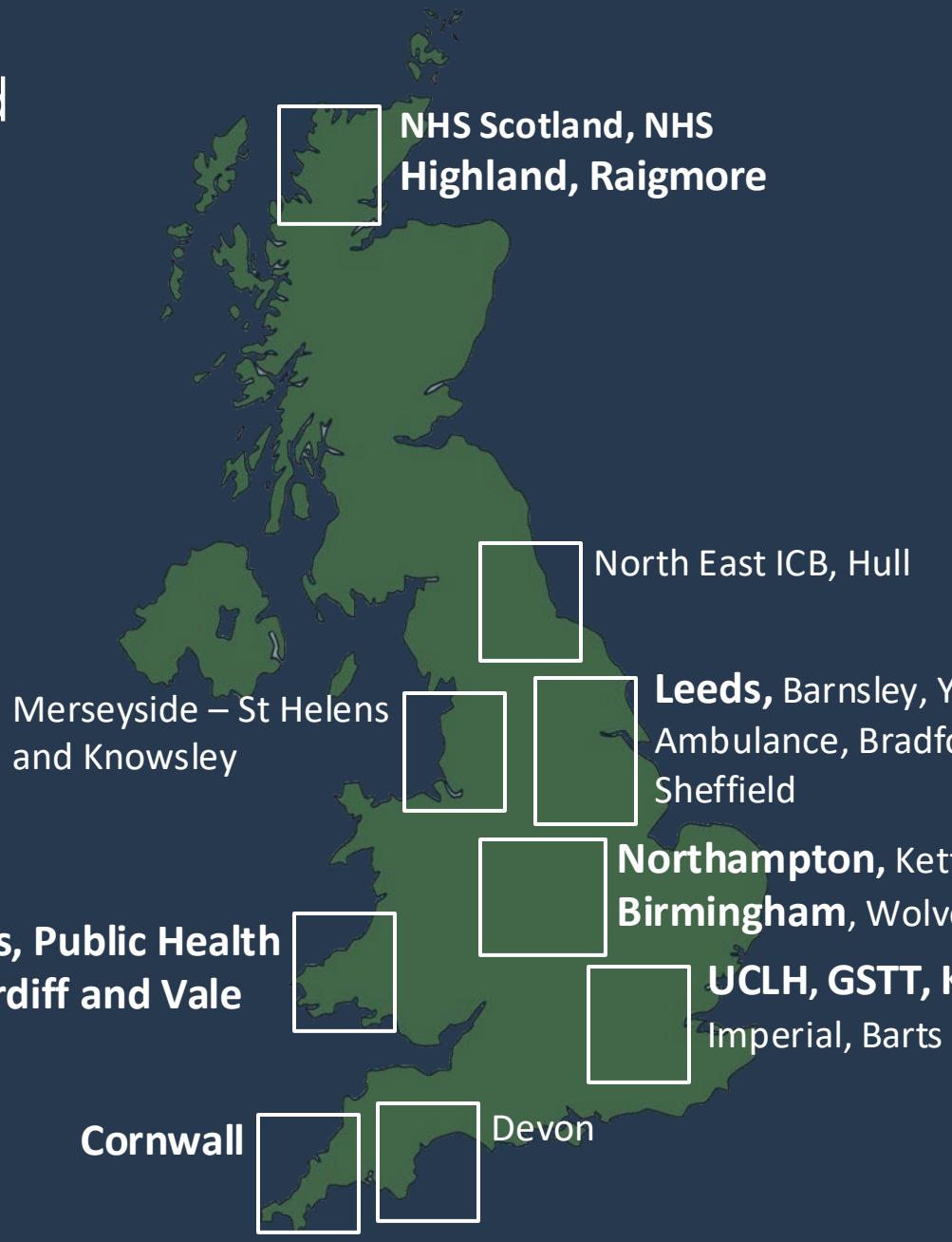
Professor Peter Hopkinson, director of the National Circular Economy Hub at Exeter University

Stakeholder Demand

NHS England

Sales: **29** organisations
Repeat Sales: 5 Trusts
Supply Contracts:

- Sterile, Cornwall
- Non-sterile, UCLH



International and Cross Sector

Bupa eco-Disruptive · Danish Health Authority · Medecins Sans Frontieres · midt regionmidtjylland · CVS Group plc Passionate about animal care · Portman dental care · Vets for Pets · Linnaeus

Low temperature decontamination – SBRI Healthcare

190,000 tonnes of CO_2e equivalents*

£90 million in **direct costs**

>£50 million in **indirect savings**

Local Return on Investment

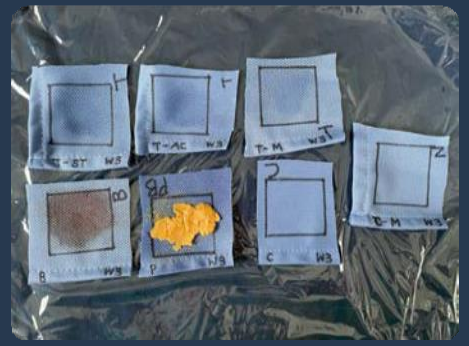
Phase 1

Test Infrastructure

Washing

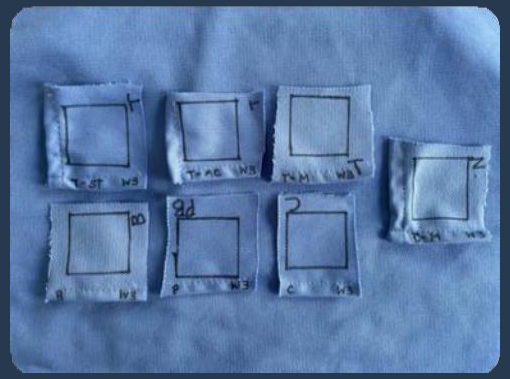
Drying

Test Process



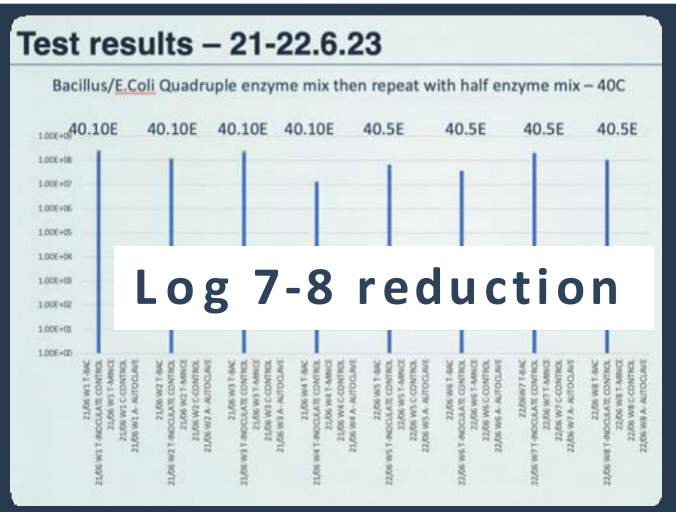
Pre-Wash

During Wash

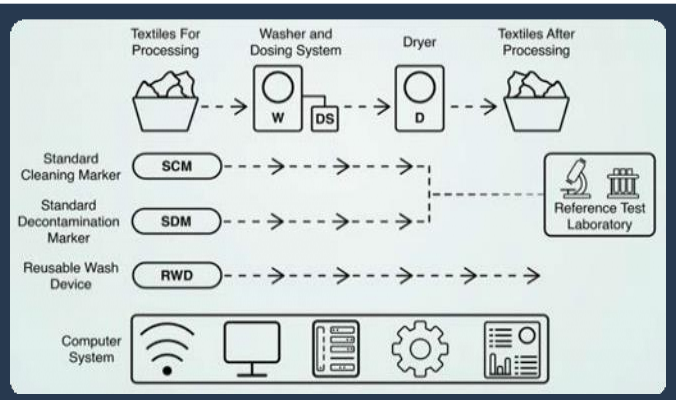


Post Wash

Microbial Validation

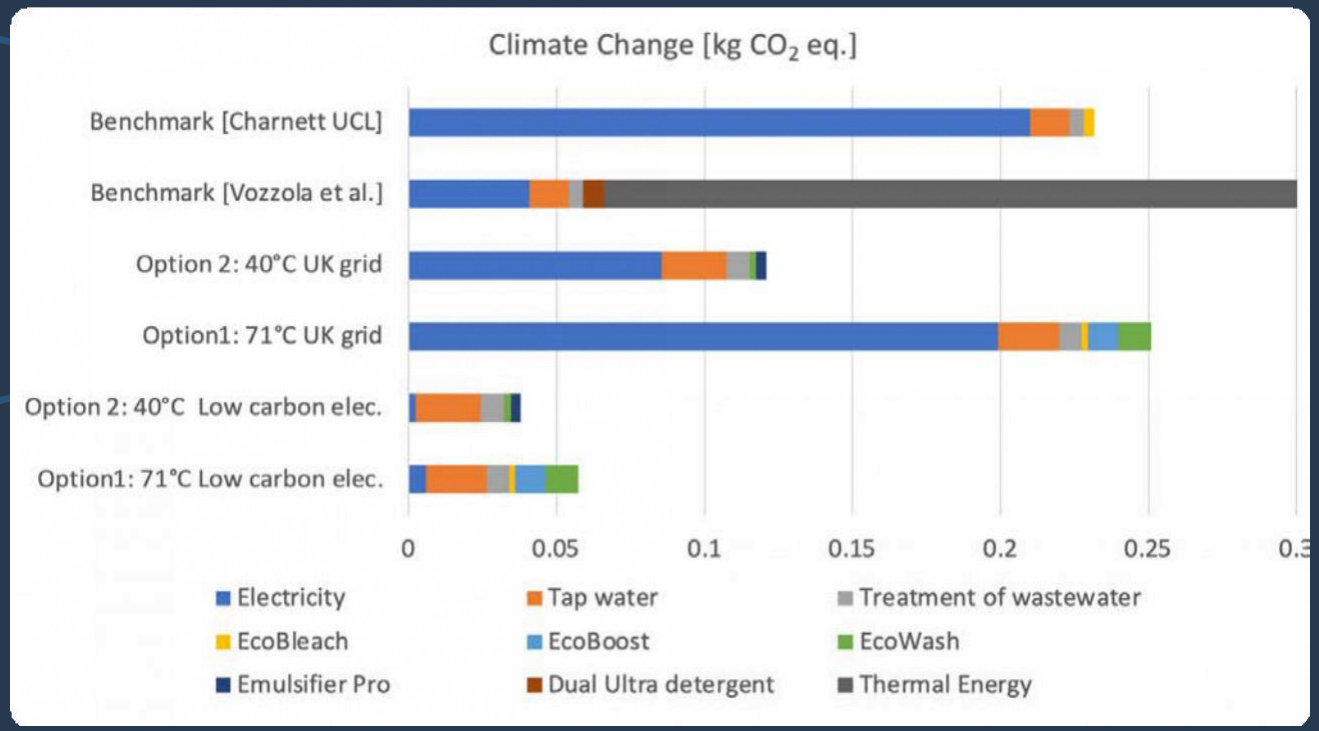


Process Validation



Decarbonising Surgical Theatres – Impact of low temperature washing and…

Scope: Washing only



60-87% Reduction

System Optimisation – SBRI Healthcare

Supply Chain Resilience

£50 million in **direct costs**

>£33 million in **indirect savings**

At least

100,000 tonnes of

CO_2e equivalents

25,000 tonnes of **waste**

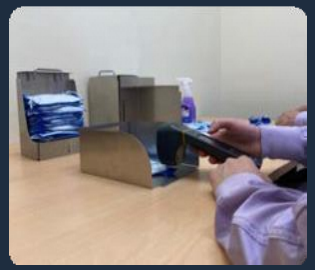
Local Return on Investment

Case Study

NHS Cornwall Hospitals Trust

Masks

Digital Tracking



Reusable Textiles

Aprons

Gowns

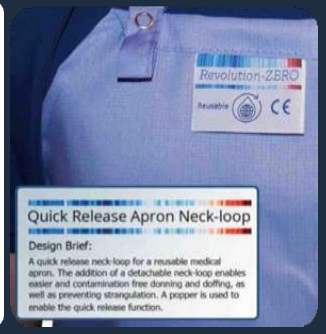
Drapes

High Risk Gowns

Reusable Packaging

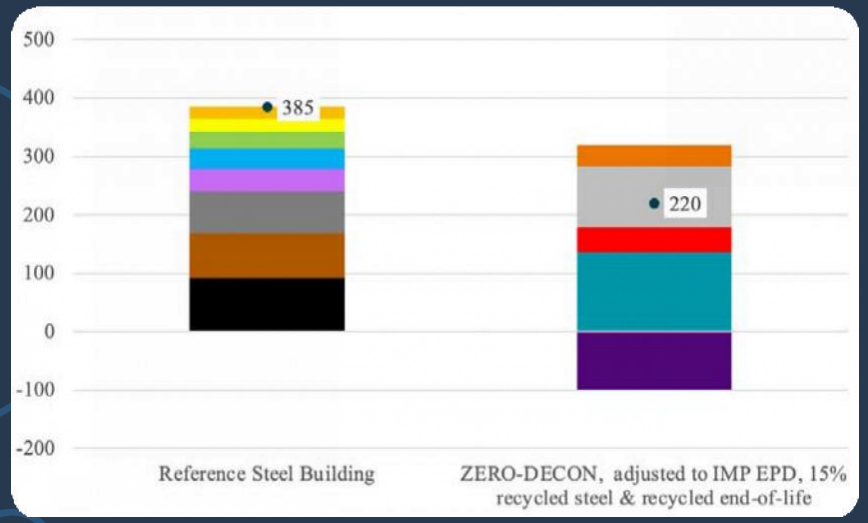
Operational Rollout

Partnerships: Co-Design with NHS Surgical Teams



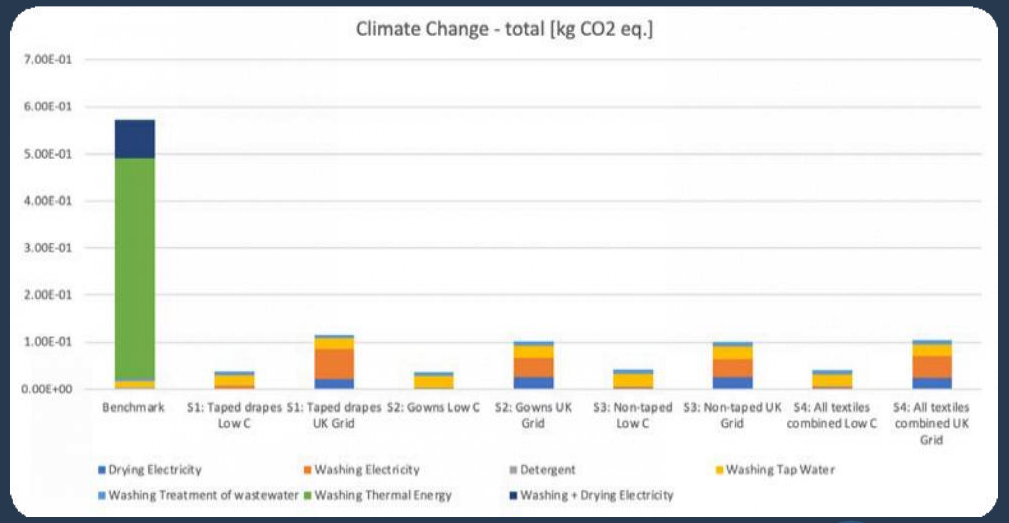
Decarbonising Surgical Theatres – SBRI Healthcare

Scope: Build and end of life



43% Reduction

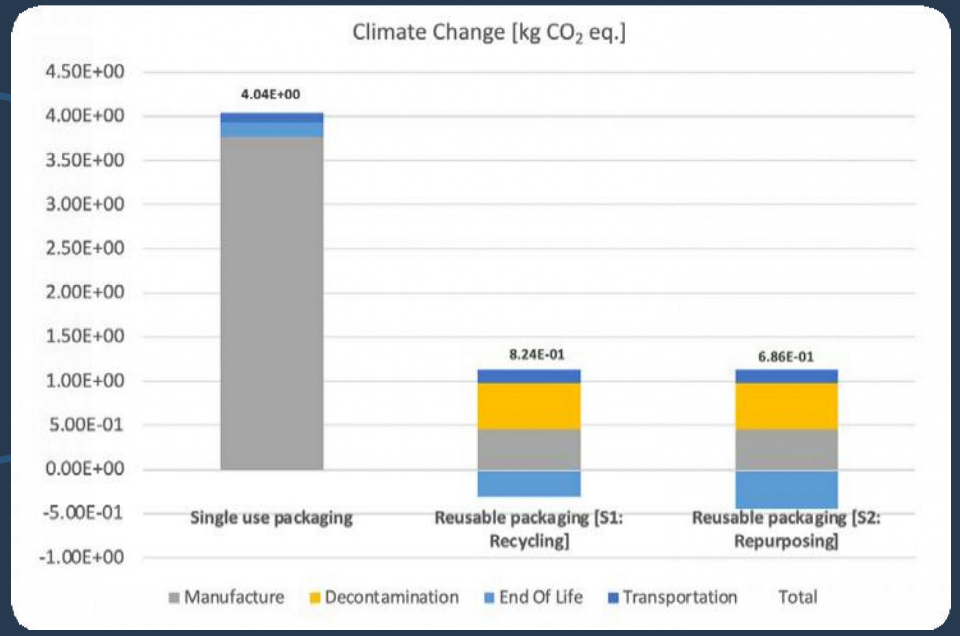
Scope: Wash, Dry, HVAC



80-94% Reduction

Decarbonising Surgical Theatres – SBRI Healthcare

Scope: Packaging Life



IPC Report – UKSCA SSI surveillance data

2021/22
Hip replacements: 6%
Knee replacements: 2%

2023/24
Hip replacements: 0%
Knee replacements: 0%

70-80% Reduction

Preserving Resources saves Carbon, Waste and Money

>250,000 tonnes of **CO_2e** equivalents

>20,000 tonnes of **waste**

> 80% carbon improvement over **standard reuse**

Up to **40%** direct cost savings

A whole systems approach

Revolution-ZERO

Traceability, transparency and accountability

Team and community is key

Supply chain security

Assurance

A fully circular approach

Environmental impact

Digitisation

Innovation

"Absolutely amazing team, well done to all involved. Now for scale and spread." 9 August 2023

Clare Nash, Head of Clinical Products Management at the Black Country Alliance (a partnership between The Dudley Group NHS Foundation Trust, Sandwell and West Birmingham Hospitals NHS Trust and Walsall Healthcare NHS Trust)

Key messages

- Careful consideration to system engineering is critical for effective uptake
- The financial model and value proposition must stack up
- Collaborative working and independent validation
- Learning through action, evaluation and iteration
- Sustainability is a whole system improvement opportunity

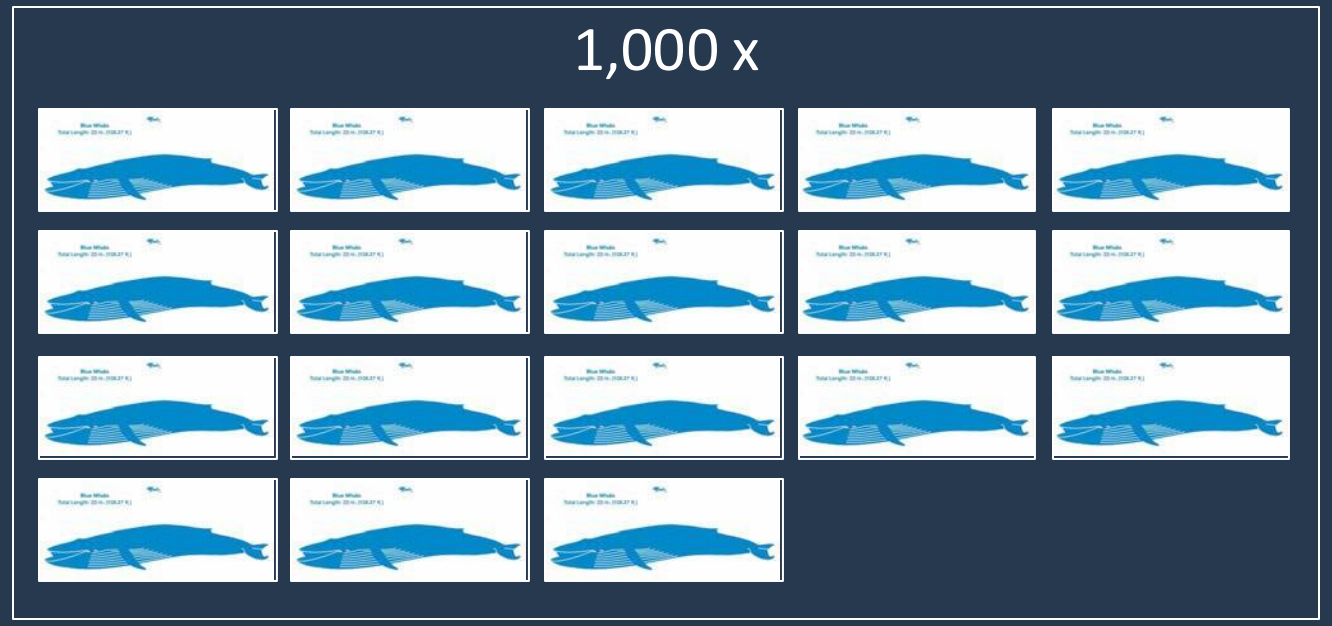
Contact: tom.dawson@revolution-zero.com

Appendix

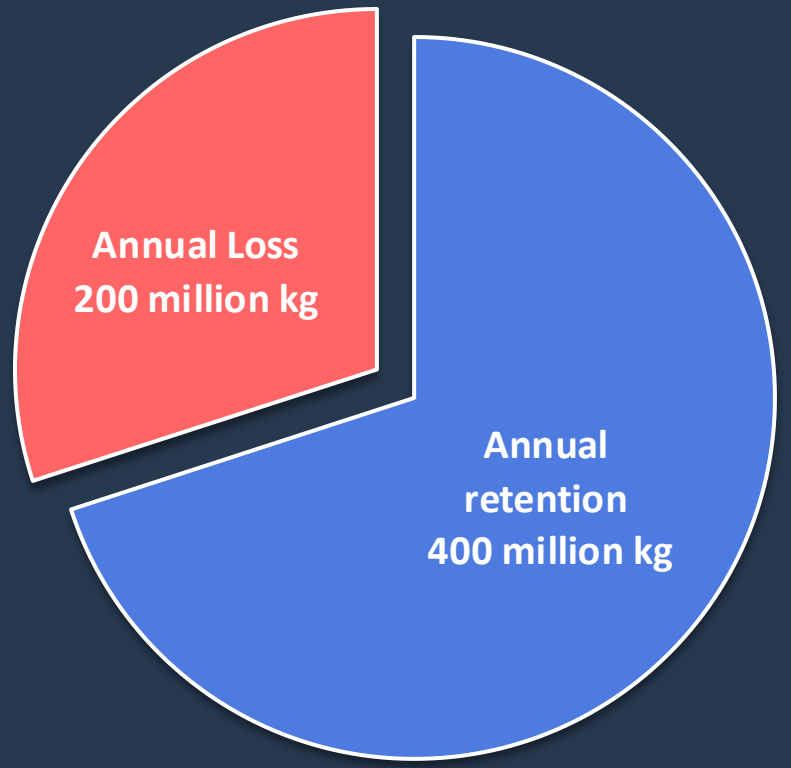
There's also a textile reuse problem

600 million kilograms of linen and clothing are utilised by the NHS every year. A high proportion of this is processed in-house or by subcontract laundries. The loss rate for items both in the NHS and in Europe is around 2.5% per month or 30% per year.

200 million kg of wasted textiles by the UK NHS is equivalent to the weight of more than **18,000 blue whales**



UK NHS 600,000,000 KG
Linen and Clothing Processed



Healthcare Problem/Drivers

Supply Chain

Critical supplies for critical services

Geopolitical Instability

Environment

Carbon Targets

Waste Targets

Regulations

Duty of Care

Duty to the Environment

Medical Device Regulations

Health and Social Care Act 2022 and ISO13485 requirements

Costs

Product, Storage, Logistics, Waste

Of failed service delivery

Regulatory Drivers

- CE/UKCA Mark
- ISO-13485
- EN14065/HTM01-04
- ISO-13795/ISO-14683

Although the UK MDR and MHRA require an organisation to have an accredited QMS in place to meet medical device compliance, it is not specified or mandated that this be ISO 13485. However, if you intend to place your medical device in other markets, having a QMS that other countries will recognise makes sense.

ISO 13485 certificates issued under the UKAS accreditation do not need to be transferred to an EU-27 conformity assessment body.

Digital Infrastructure and Technologies - SaaS

Our proprietary technology:

- The only solution that allows for certified regulatory compliance across organisations and territories
- End to end asset track and trace for stock control
- Measures real-time environmental and economic impact of processes
- IP protected process compliance validation

IP-protected digitally enabled cold water laundry solution

- **£45 million revenue generation**
- **193,000 tonnes** of **CO_2e** emissions

Appendix 5 - Crossover

SBRI HEALTHCARE

CrossCover

NHS England

PRIMUM DIGITAL

Dr Nathan Moore
Director of Primum Digital Ltd
Clinical Safety Officer
NHS Clinical Entrepreneur

Case Study:

Delivering Clinical Pathway Optimisation with Velocity

CrossCover

PRIMUM DIGITAL

CrossCover

Mission Statement

"Enable our experts to **collaborate** at scale,
consolidate optimal clinical decision support processes
and **spread** this knowledge into
the **core workflow** of all staff ensuring patients
receive the **best treatment every time**"

PRIMUM DIGITAL

CrossCover

The Challenges

Bottlenecks in efficiency

Fast and effective decision making is the biggest bottleneck to primary and emergency care delivery

Operationalising Best Practice

Majority of decisions made by non-experts. Primary care, ED, MIU and Surgical Specialty staff have knowledge gaps

Variation in practice

Patients receiving variable treatment/ advice

Referrals to Secondary Care from Primary Care

Large number of potentially avoidable referrals and investigations

Follow-up appointments

Does the patient need follow-up?
If so, when, where and with whom?

PRIMUM DIGITAL

CrossCover

The Solution

Cloud hosted

An application for every surgical specialty available on all devices

Force Multiplier

Maximise the influence of our experts on the patient journey through sharing their knowledge

Fully mapped processes

Step-by-step clinical decision support

Fully illustrated

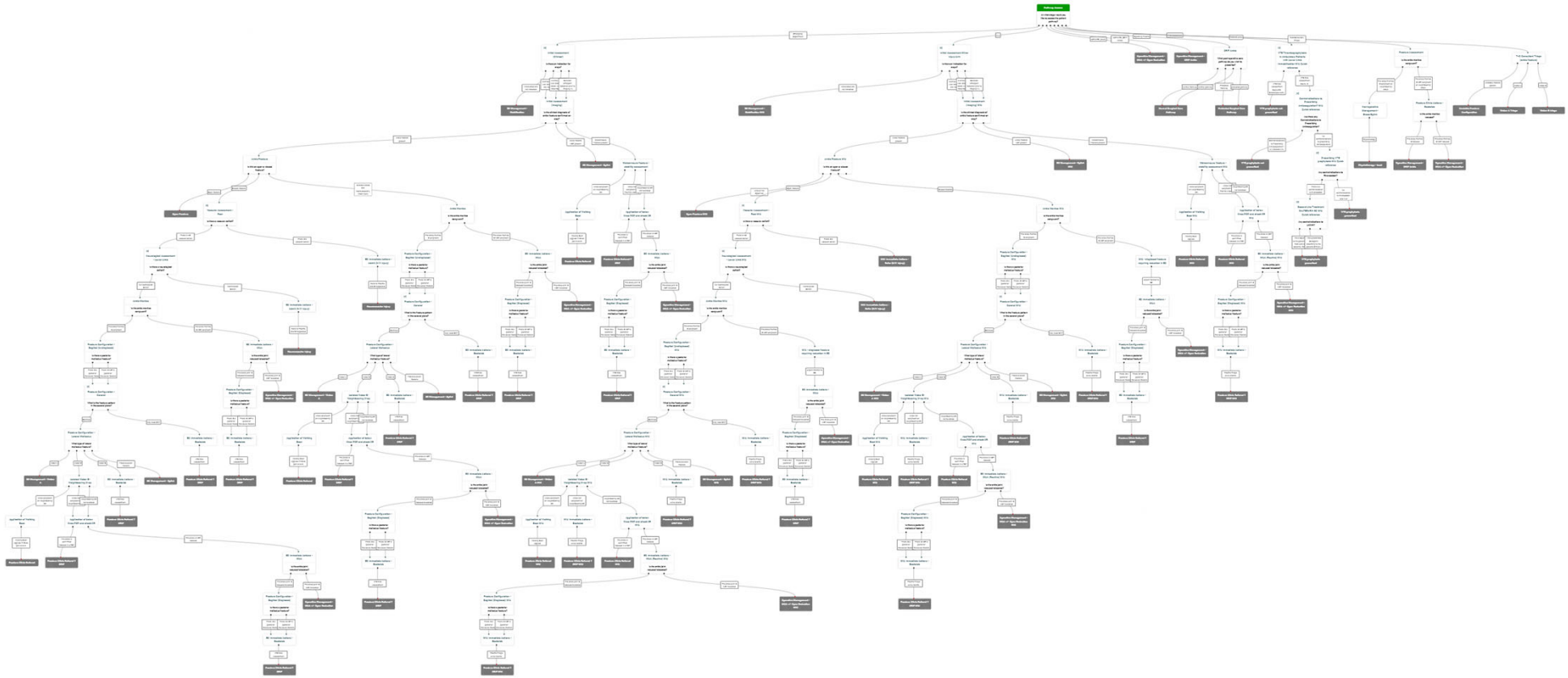
Thousands of medical illustrations

Completely editable pathways

Every pathway is editable to local resources

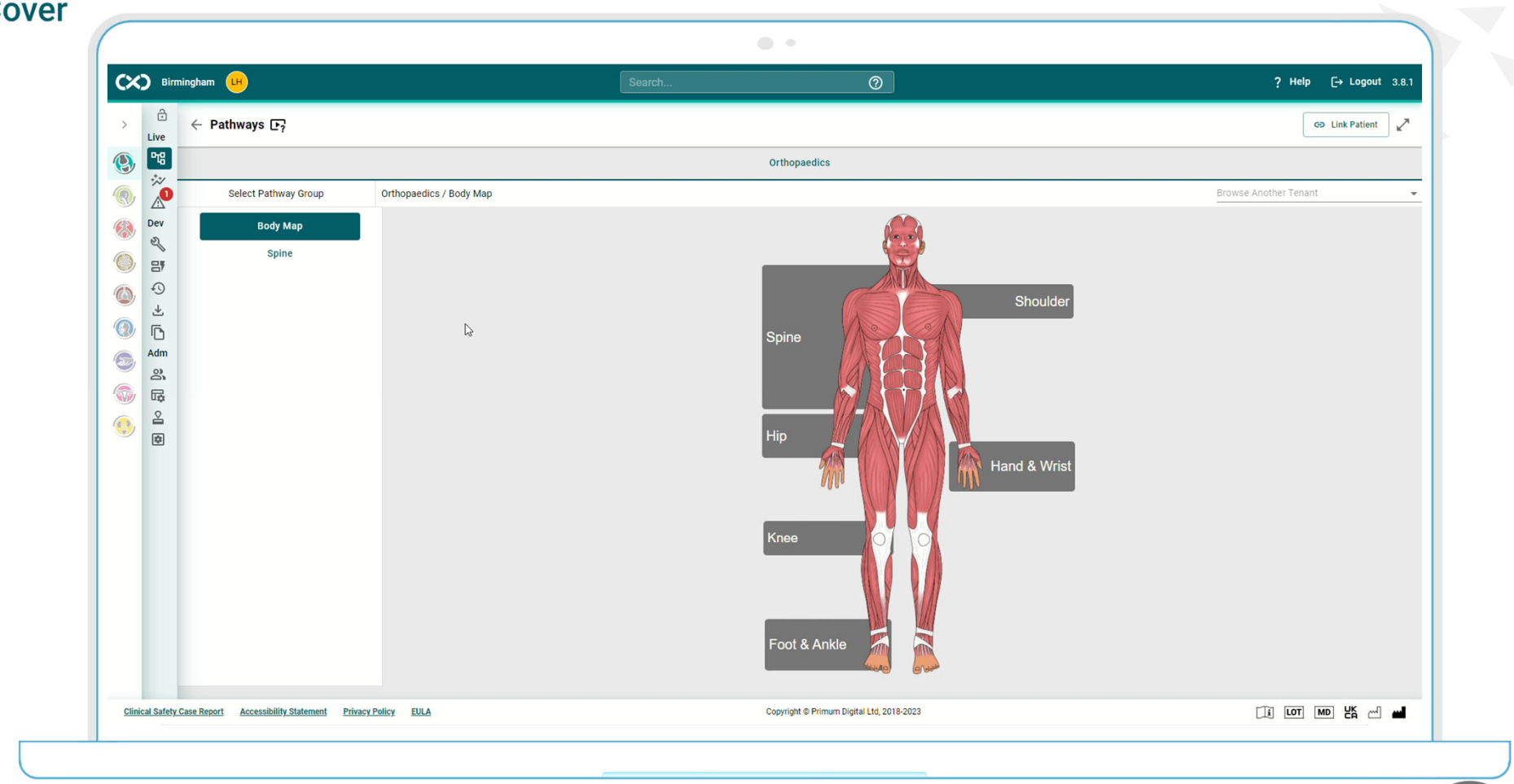
PRIMUM DIGITAL

CrossCover

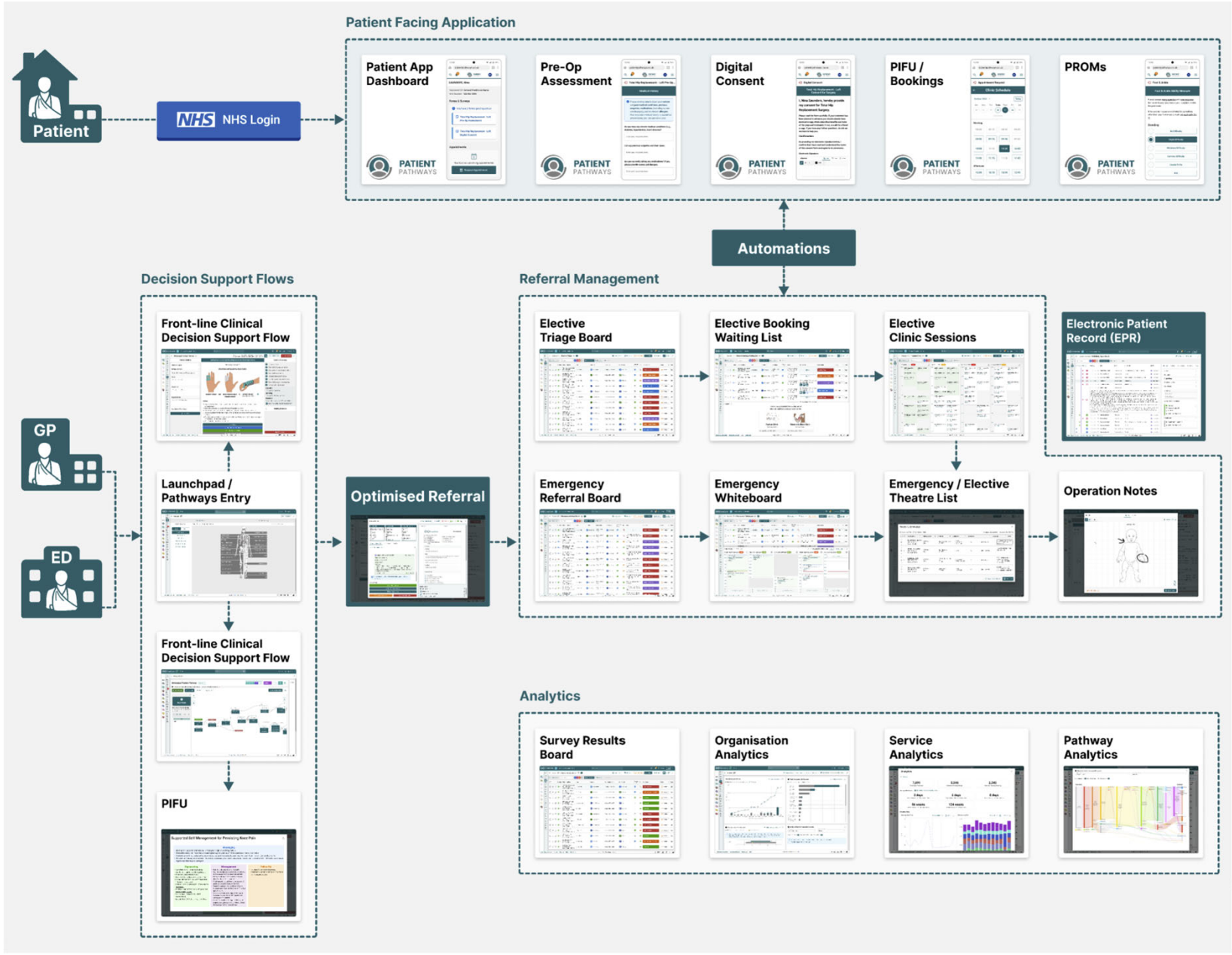


PRIMUM DIGITAL

Example Pathway Usage



CrossCover



PRIMUM DIGITAL

CrossCover

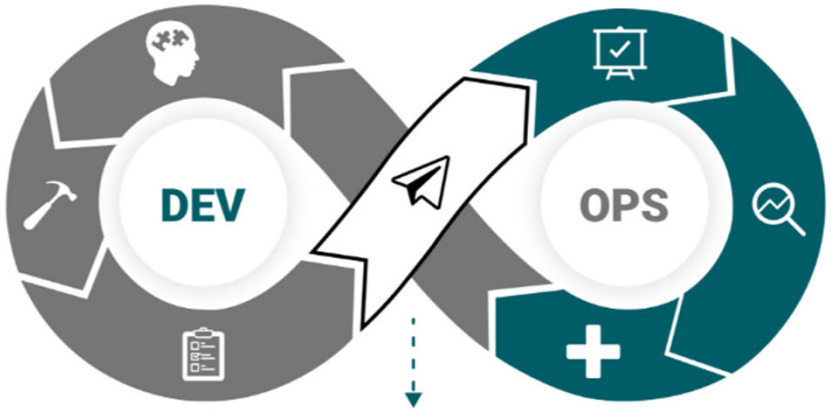
DevOps for Clinical Pathways

Design

Your experts can collaborate at scale to design clinical pathways with our collaborative tools.

Operate

Pathways fit into the core workflow of all staff by integrating with existing systems



Build

Using our visual designer your experts can build clinical pathways

Monitor

Realtime operational data insights into your clinical pathways

Test

In our sandbox pathway development environment the pathways can be tested before going though a dynamically configurable sign off procedure

Deploy

Clinical Effectiveness

Increases concordance with local, national and international standards of care. Helps to link clinicians with guidelines when they need them which improves quality of care.

PRIMUM DIGITAL

Cost Effectiveness

Independent health economic assessment across 5 NHS Trusts led by Professor Fordham and his University of East Anglia economics team 2021

Table 3: Deterministic and probabilistic findings per pathway

Pathway	Deterministic reduction per patient	Average Probabilistic Outcome	Upper 95% Confidence interval	Lower 95% Confidence interval	Cost–Saving Probability (%)
Ankle Fracture	- £ 95.79	-£ 107.62	-£ 134.54	-£ 84.60	100
Fifth Metatarsal Fracture	-£ 82.49	-£ 82.72	-£ 113.91	-£ 54.09	100
Carpal Tunnel Syndrome	-£ 57.99	-£ 57.84	-102.016	- £ 15.37	99.8
Soft Tissue Knee Injury	-£ 136.41	-£ 136.41	-£ 161.27	-£ 112.62	100.00
Metacarpal Fracture	-£ 106.00	-£ 106.45	-£ 136.91	- 76.96	100

CrossCover

Deliverables to Date

PRIMUM DIGITAL

SBRI Healthcare
"Delivering a Net Zero NHS" Project Outcomes

Expert groups of clinicians at Birmingham and Solihull ICS created standardised best practice clinical pathways deployed through CrossCover OrthoPathway. Funded by the SBRI Healthcare "Delivering a Net Zero NHS" Award.

Method – At GP practices across BSol ICS

- 2 clinical case scenarios for each MSK presentation. OSCE format. Patient actor
- Each GP carried out 4 assessments using their usual assessment and documentation on their clinical system. They then carried out 4 further assessments using CrossCover OrthoPathway through a web portal

Results – 19 GPs involved for 152 MSK clinical scenarios

Arm	Average Consultation Time	Achieved Best Practice Outcome	Unnecessary Appointment	Unnecessary Investigation
Usual Care	11 mins 40 seconds	27%	50%	34%
OrthoPathway	**7 mins 22 seconds**	**96%**	**3%**	**4%**

CrossCover

Randomised Control Trial

- **AIM**
  To test the clinical and cost effectiveness of point of care use of OrthoPathway for Musculoskeletal conditions in Primary Care vs Usual Care
- **Population:** MSK consulters to participating GP practices in (GPs and FCPs)
  Intervention: OrthoPathway's MSK clinical decision support system for GPs and FCPs
  Comparator: Usual primary care (using a cluster RCT design)
  Outcomes: Patient reported outcomes (MSK-HQ via KHS), Costs (analysis from York), MSK processes of care via EHR (as per MIDAS) including relevant; prescribing, referrals, imaging/tests, self-management support, repeat primary care visits and fit notes
- **METHODS**
  Parallel-group, pragmatic cluster-RCT
  Recruitment of approx. 40 GP surgeries with 20 patients per practice

Keele University

YHEC
York Health Economics Consortium

Birmingham and Solihull Integrated Care System
Caring about healthier lives

PRIMUM DIGITAL

MIDAS GP Trial Cost and Carbon Analysis

Keele University Team - Alex Braybrooke, James Bailey, Dr Roanna Burgess, Dr Dahai Yu, Prof Kelvin Jordan, Dr Anirban Banerjee, Prof Jonathan Hill

York Health Economic Consortium Team - Melissa Pegg, Rebecca Naylor, James Scott, Robert Malcolm, Dr Hayden Holmes

The Keele MIDAS GP trial- A multi-site GP observational cohort study designed to provide MSK health intelligence to support initiatives that reduce variation in the outcomes and experiences of primary care between groups of MSK patients and between different services

CrossCover OrthoPathway Trial - Keele and YHEC are collaborating on the MSK Pathways clinical trial to test the clinical effective of Orthopathway software. As part of this the team has created a MSK pathways cost carbon calculator model. We tested this model using data from the MIDAS GP trial

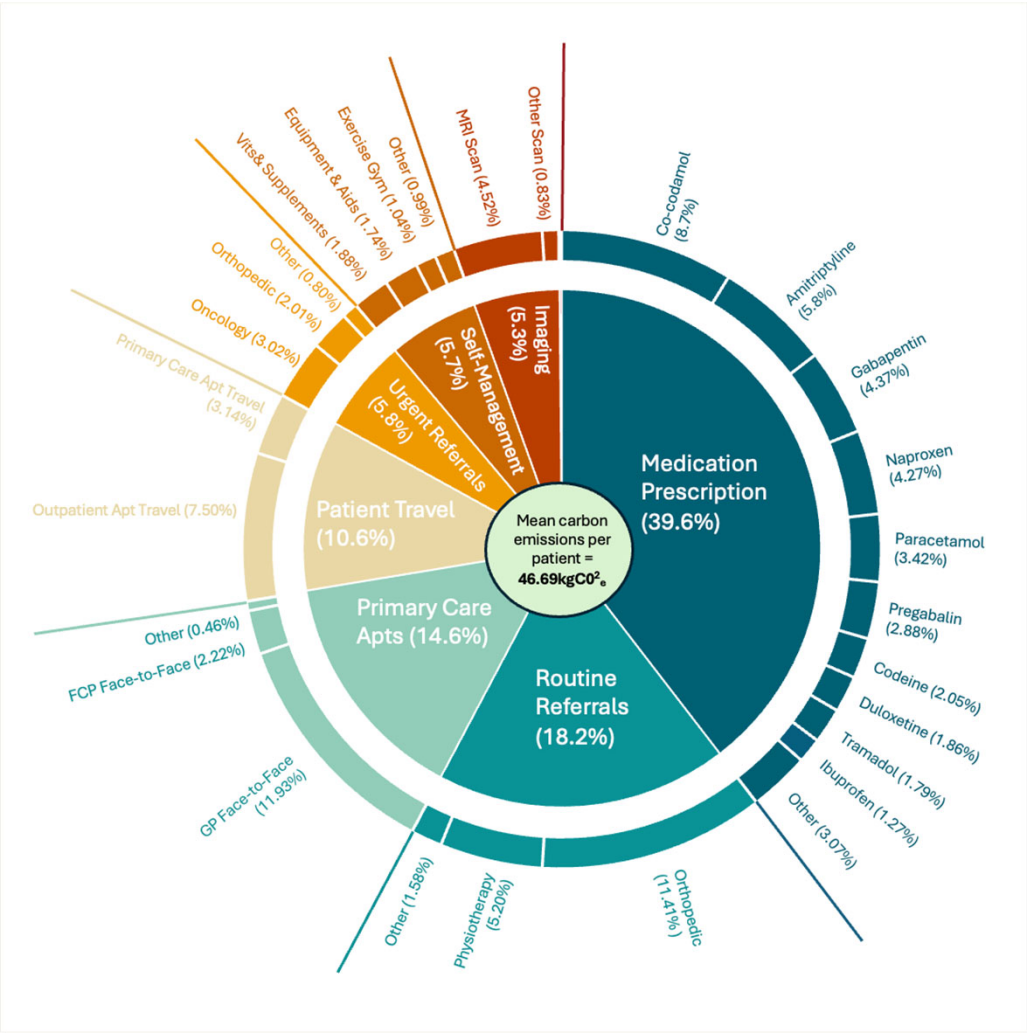
Project Aims and Methods

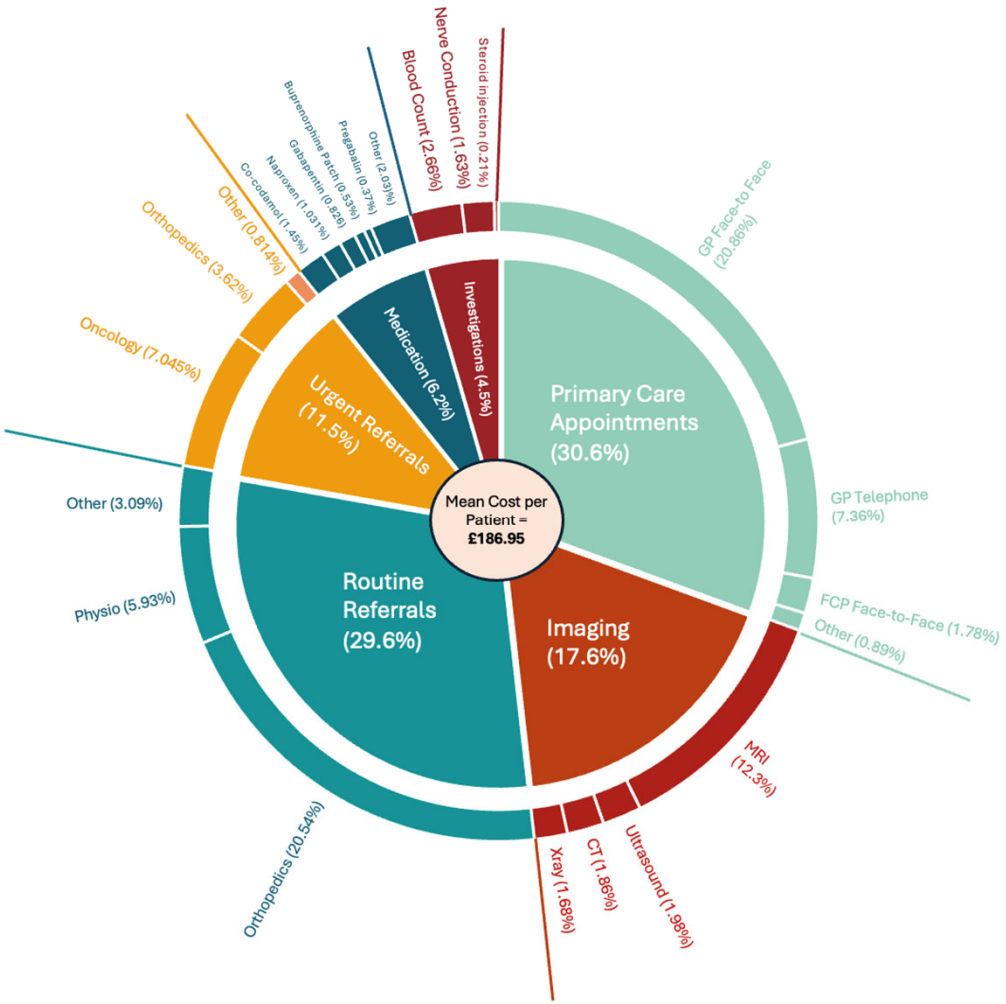
Project Aims

- To test the feasibility of populating a cost-carbon model using primary care electronic healthcare record data extraction techniques
- Estimate the cost and carbon output of MSK primary care clinical management decisions
- Describe where the variation lies between MSK pain sites and across primary care networks

Methods

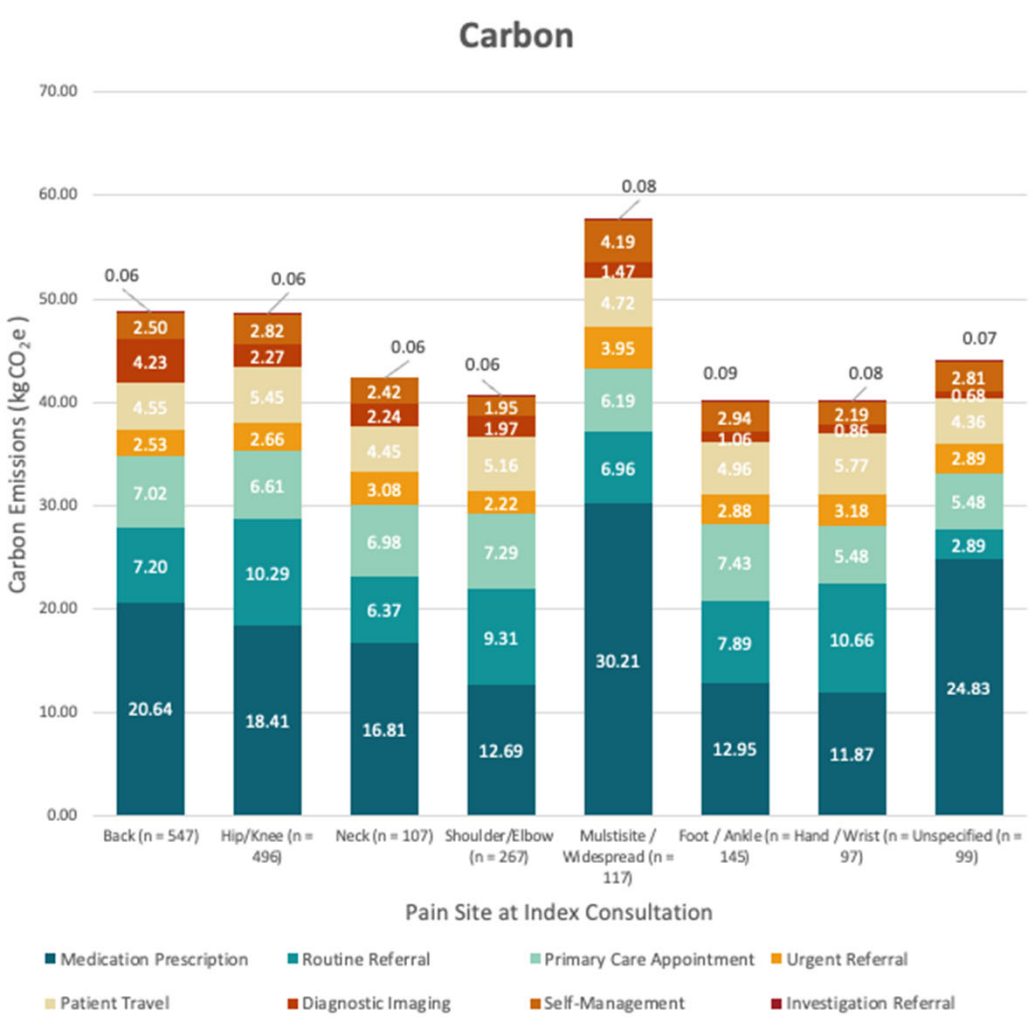
- Study design - Retrospective analysis of data collected during the Keele MIDAS GP study.
- Firstly, we developed a data extraction query to identify healthcare resource use in the six months following a patient's primary care index consultation for an MSK coded condition
- We used these resource counts (mean per patient) to populate an economic and environmental impact calculator model designed for the CrossCover OrthoPathway randomised control trial
- The model provided us with estimates for the mean cost and carbon output of MSK primary care management decisions

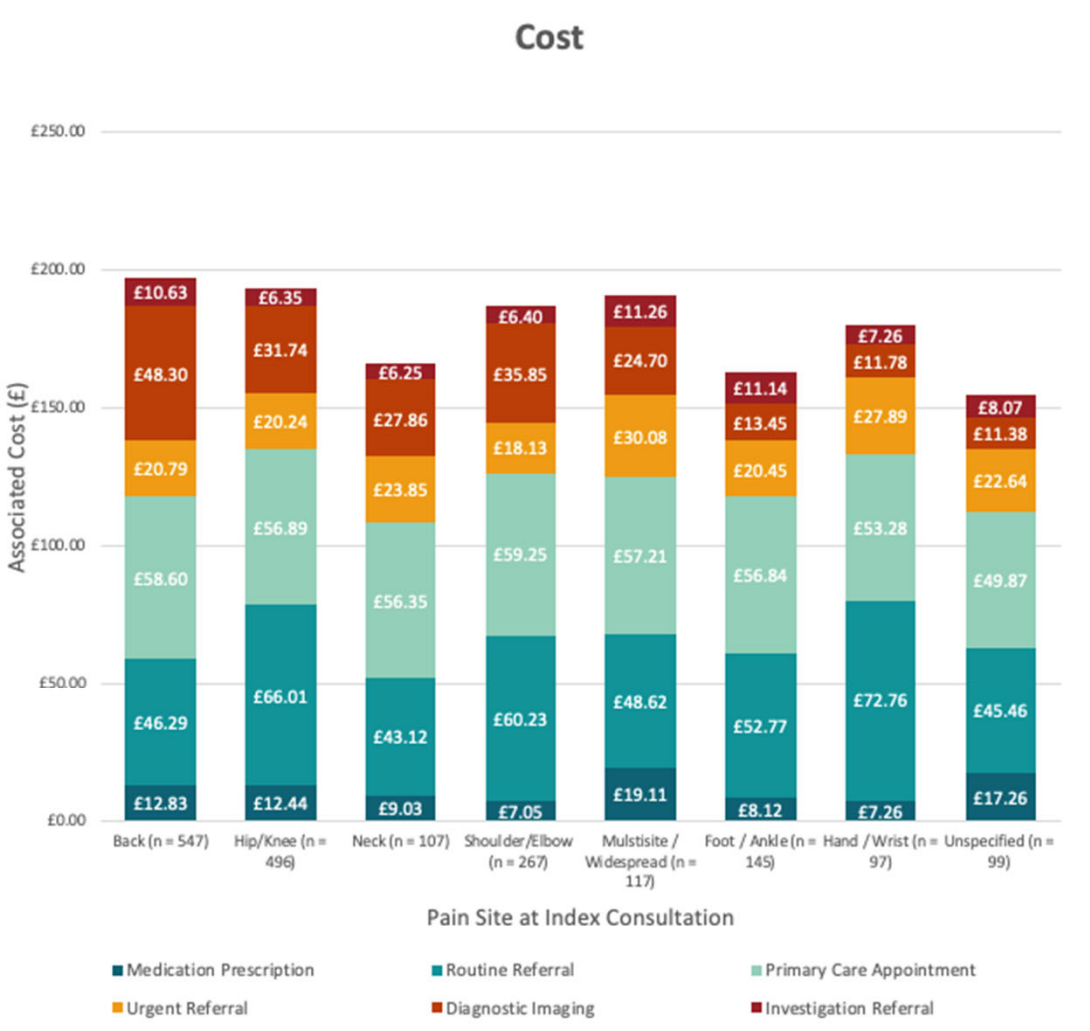




Mean cost and carbon output per person split by resource category

Unpublished findings



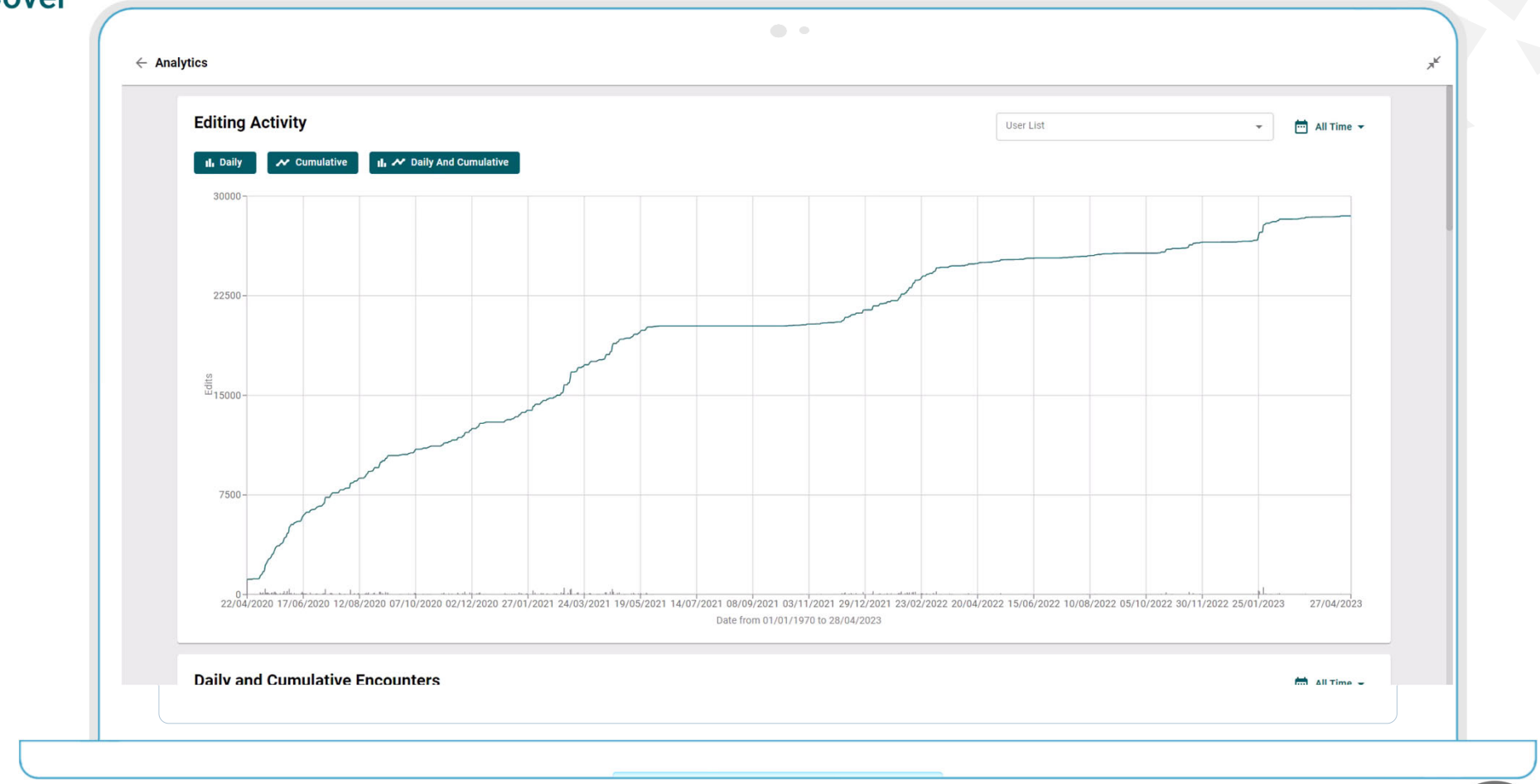


Mean cost and carbon output split by pain site coded at index consultation

Unpublished findings

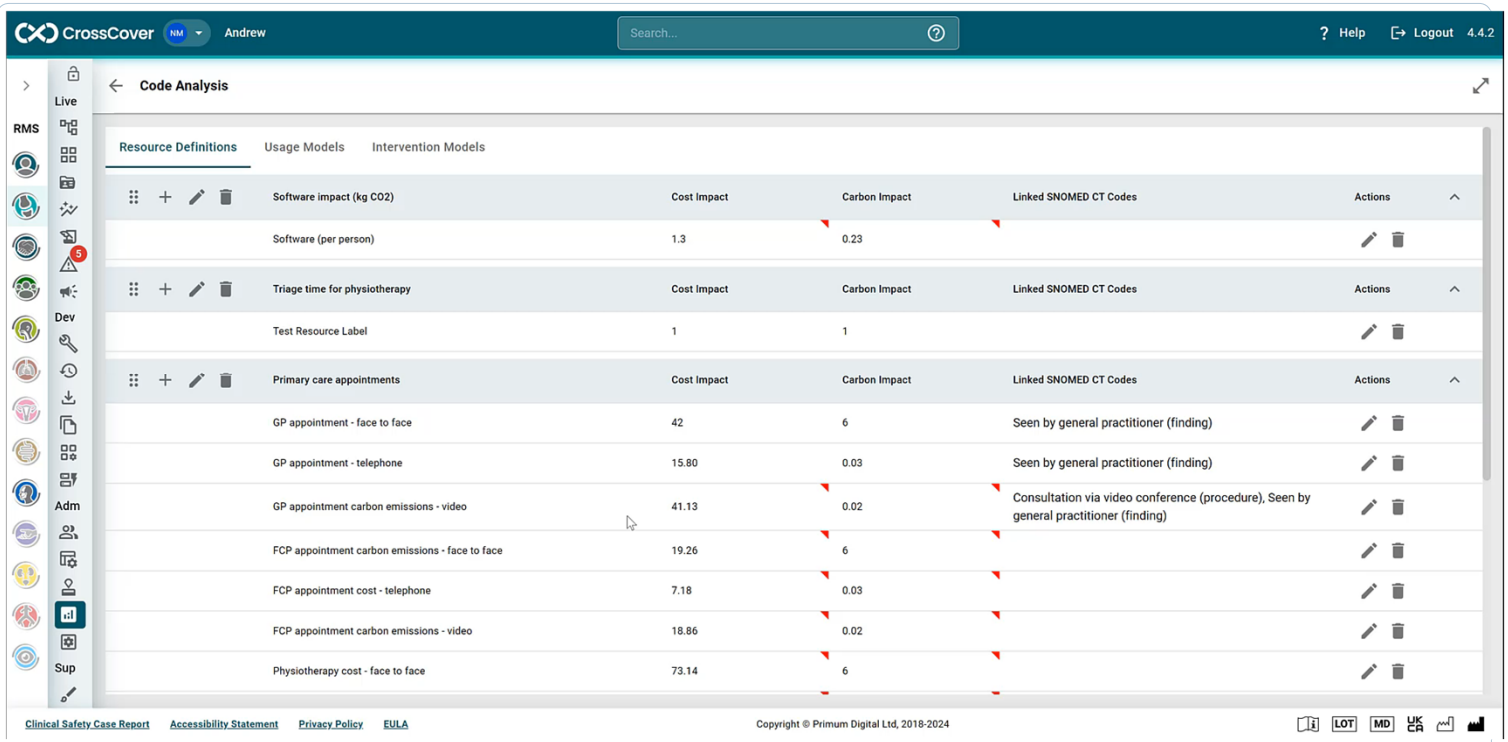
CrossCover

Real Time Carbon and Budget Impact Analysis



PRIMUM DIGITAL

Real Time Carbon and Budget Impact Analysis

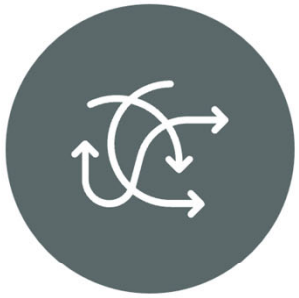


CrossCover

Lessons Learned

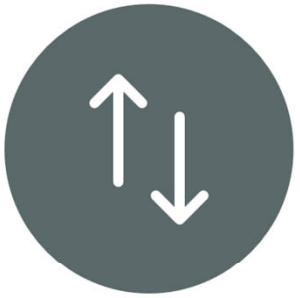
Win Hearts and Minds

Support Your NHS Champions



Be Agile

Have a plan B



Top-down & Bottom-up support needed

CrossCover

Summary

- Improve Clinical Effectiveness
- Improve Efficiency
- Optimise Patient Outcomes
- Sustainable Models of Care

PRIMUM DIGITAL

SBRI HEALTHCARE

ACCELERATED ACCESS COLLABORATIVE

The AHSN Network

NHS England

THANK YOU

PRIMUM DIGITAL

Dr Nathan Moore

nathan.moore@crosscover.co.uk

www.crosscover.co.uk

Acknowledgements

CrossCover

MIDAS Programme Lead George Peat

Co-Investigators

James Bailey
Lorna Clarson
Lizzie Cotterill
Stephen Dent
Krysia Dziedzic
Jonathan Hill
Kelvin Jordan
Emma Parry
Kay Stevenson
Katie Tempest (dec)
Karen Walker-Bone
Simon Wathall
Ross Wilkie
Dahai Yu

Keele CTU

Sarah Lawton
Clare Thompson
Steff Garvin
Jo Smith
Jacqui Carter
Rachel Heath
Steve Harper
Karl Rogers

Patient Advisory Group

Lyndsey Brown
Stephen Dent
Jane Hall
John Haines
Ruth Haines
Sue Maddison
Kanta Sandhu

Advisory Group

Nuzhat Ali
Andrew Bennett
Peter Croft (chair)
Amanda Hensman-Crook
Deborah Hick
Andrew Judge
Nicolas Steel

CRN: West Midlands

Gerri Mulcahy

Midlands Partnership University NHS Foundation Trust

Dom Ellington

VUIT

M·E·L Research Ltd

Accurx

Nuffield Foundation

The MIDAS project is funded by the Nuffield Foundation and Versus Arthritis (OBF/4390), but the views expressed are those of the authors and not necessarily the funders. Visit www.nuffieldfoundation.org

VERSUS ARTHRITIS

PRIMUM DIGITAL

Assumptions and Limitations

Assumptions

- FCP have the same carbon output as GP appointments
- All medications and outpatient referrals have the same carbon output
- As a result of not having individual patient travel data, national averages were used to estimate carbon emissions for both travel to primary care and secondary care outpatient appointments
- Finally, a top-down approach was used to calculate the carbon output of medication prescription, whereby:

1) The NHS carbon footprint in 2020 was 24.9million tons of CO_2e;
2) Medication make up approximately 20% of the total NHS carbon footprint = 4.98millions tons CO_2e;
3) There were 1,123,515,663 prescriptions in England in 2020;
4) Therefore 4,980,000,000/1,123,514,663 = 4.4325 $kgCO_2e$ per prescription.
5) All medication prescription types were given the same associated carbon output.

Limitations

- We only had access to patient's primary care electronic health care records and, therefore, were unable capture condition management past primary care management and referrals

Appendix 6 – Towards reducing environmental pollution from healthcare practices

Developing frameworks for eco-directed sustainable prescribing: Towards reducing environmental pollution from healthcare practices

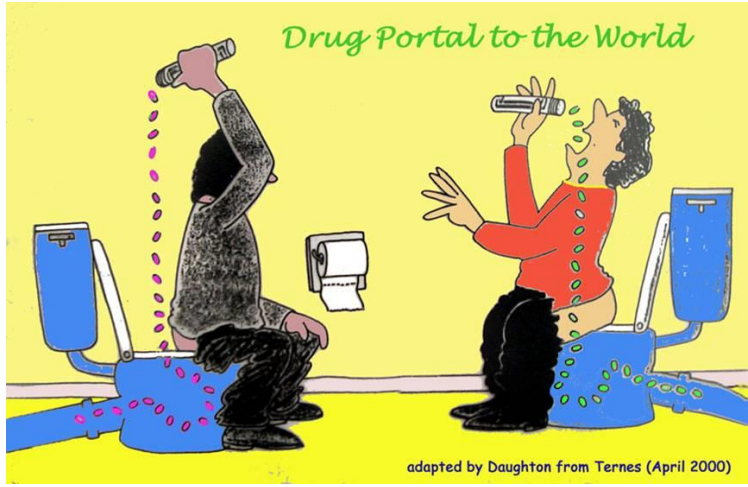
Prof Sharon Pfleger[3] *(PI)*

Lydia Niemi[1]; Stuart Gibb[1]; Mark Taggart[1]; Naoko Arakawa[2]; Claire Anderson[2]; Sharon Pfleger[3]

(1) Environmental Research Institute, University of the Highlands and Islands, Castle Street, Thurso KW14 7JD;
(2) University of Nottingham, School of Pharmacy, University Park, Nottingham, NG7 2RD;
(3) NHS Highland, Larch House, Stoneyfield Business Park, Inverness, IV7 2PA

Pharmaceuticals in daily life

- Most common medical intervention- over £22 billion per year on medicines in NHS across the UK
- Prescribing rates rising- ageing population, new tech, “pill for very ill” society
- 30-100% excreted and enter the environment mainly with effluent from wastewater treatment plants (WWTPs)



Environmental contaminants

- Global public health & environmental issue
- Linked to adverse environmental effects
  - Feminisation of male fish (Godfray et al., 2019; Nash et al., 2004)
  - Reproductive changes in wild bivalves (Almeida et al, 2020)
  - Physiological changes in amphibians (Foster et al., 2010)
  - Behavioural changes in crustacean spawning (Fong and Ford, 2014) and fish predator avoidance (Hellström et al., 2016)
  - Potential contamination of raw water sources (Ebele et al., 2017; Focazio et al., 2008; Pinasseau et al., 2019)
  - Assistance in the spread of AMR (Giebułtowicz et al., 2020; Larsson and Flach, 2021)
- **AMR – Critical public health concern**

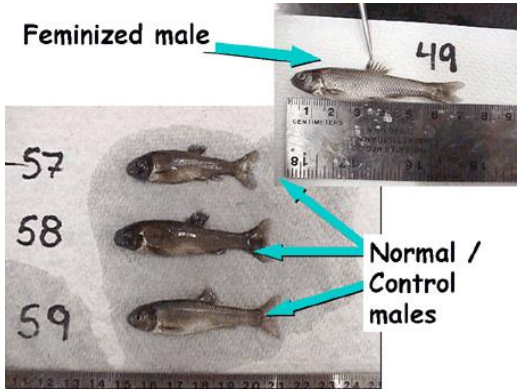
Science & Environment

BBC NEWS

Pharmaceuticals in rivers threaten world health - study

By Jonah Fisher
BBC Environment Correspondent

15 February | Comments



UN environment programme 50 1972-2022

Project partners

Scottish Water scientific and wastewater regulatory guidance and data access, support dissemination

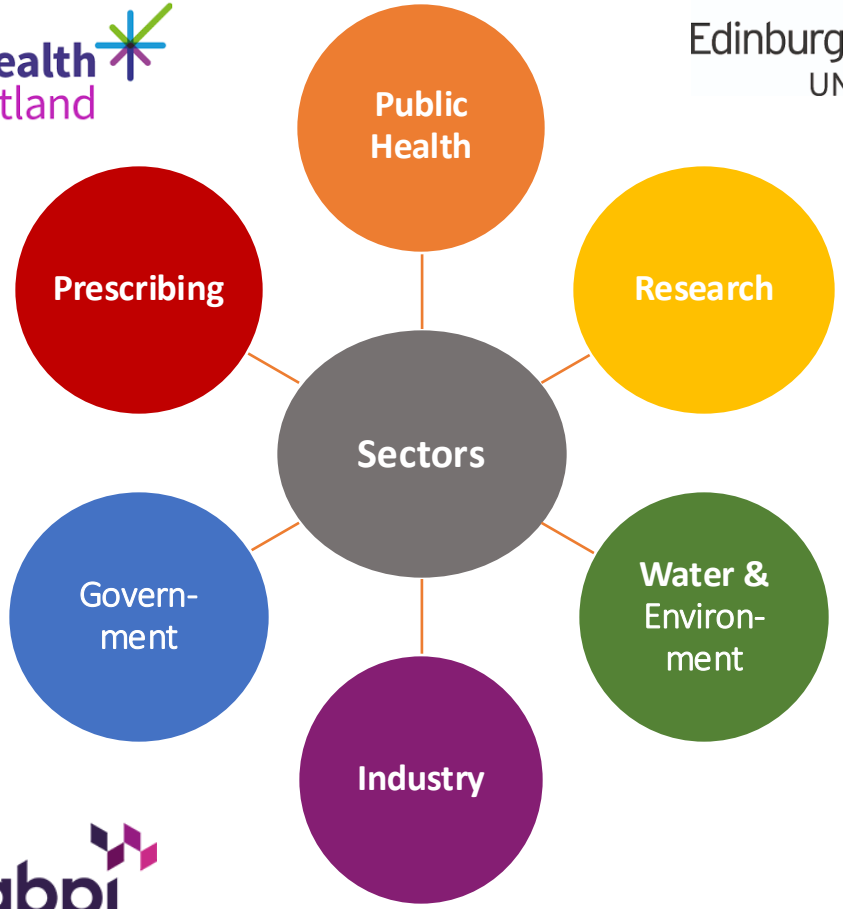
Match funding of £20K for the RCo-I's salary costs

James Hutton Institute technical expertise in modelling and environmental science to develop the framework (via Bayesian Network modelling), support dissemination

Scottish Environment Protection Agency scientific, policy and regulatory guidance and data access, support dissemination

University of Uppsala technical expertise in environmental impact of pharma, support development of eco-directed formulary, engagement with relevant European groups, dissemination

Project stakeholder group



Research question

How can the incorporation of environmental data into medicine decision making processes help better inform patients and prescribers about the environmental impact of medicines and drive more sustainable prescribing?

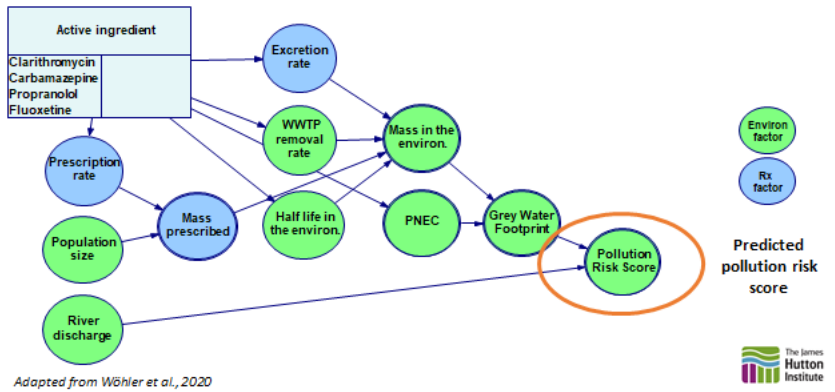
What did we do?

<u>AIM</u>: To develop a **formulary framework that incorporates environmental criteria on medicines to be considered alongside clinical and cost effectiveness**

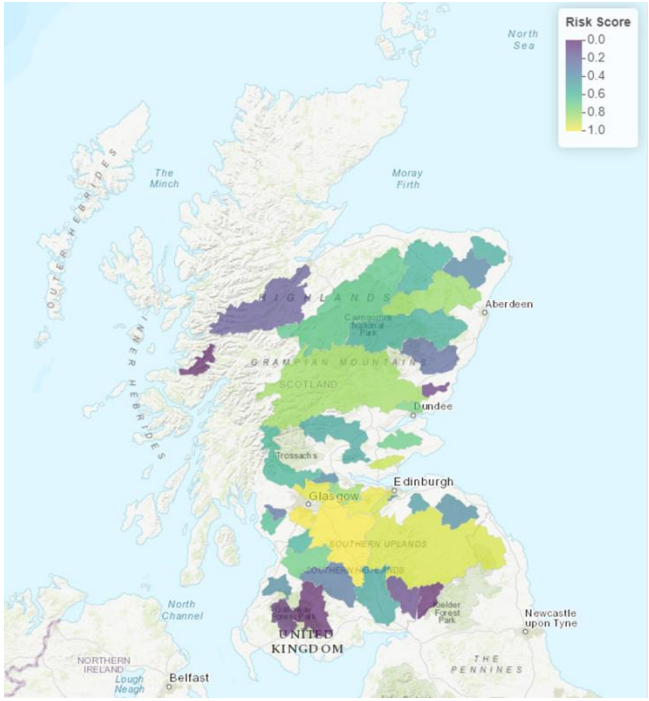
<u>Methods</u>:

1. ***Select pharmaceuticals and framework criteria through Nominal Group Technique (NGT) consensus methods considering environmental and clinical perspectives***
2. ***Apply Bayesian Network modelling to create the framework with environmental impact data***
3. ***Explore prescriber and public perceptions of eco-directed prescribing through focus groups***

What did we find out?



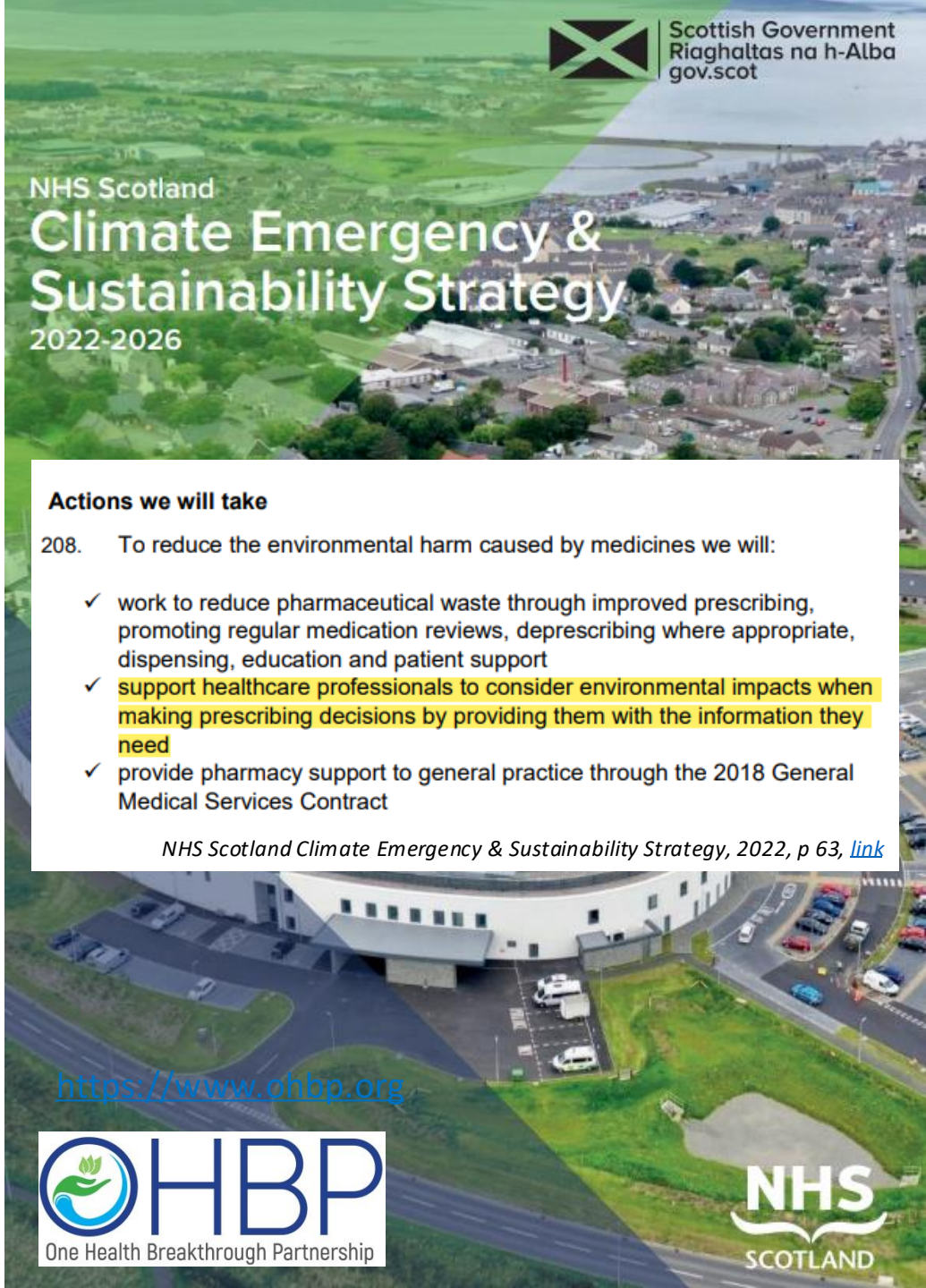
- Yes, it is possible to combine prescribing and environmental data to predict environmental risk
- Yes, env info should be included in formularies
- Prescribers- need education (curricula/ CPD), tools, resources, and patient education
- Public- some were aware, need early education, simple messaging, need more time with prescribers, hesitancy in changing unless equally effective and safe



PLEASE DO NOT PHOTOGRAPH OR SHARE THIS SLIDE

Project Impact & Significance

- **Progresses activity towards national sustainability policies & targets** on medicine prescribing
- **1st time innovation in UK –Trials novel, trans-disciplinary approach –** integrates prescribing, environmental & social science methods
- **Advances cross-sector work** in UK addressing pharmaceutical pollution in the environment
- **Increased awareness** amongst stakeholders
- **Potential to**: change prescribing decisions and choices across the world, future proof HTA processes, reduce impact of pharma pollution, reduce biodiversity loss, protect human, animal and env health



Research Partnership Significance

Generating new knowledge & novel resources on environmental pollution

High level impact & recognition in the UK and internationally

Driving cross-sector engagement to address One Health issues such as AMR, pollution, food security

https://www.ohbp.org

@OneHealthBP

https://ohbp.org/category/mrc-project/

sharon.pfleger@nhs.scot

Future work

- **Next stages**: £££
  - Refine environmental model
  - Include clinical & cost data
  - Improve accessibility & communication of framework – e.g. risk rating scheme (red-amber-green)
- **Challenges:**
- Methods to weight between environmental impact, cost- & clinical-effectiveness and carbon footprint to give a true “One Health” picture
- Future proof HTA processes
- Plugging the data gaps

Appendix 7 – Posters

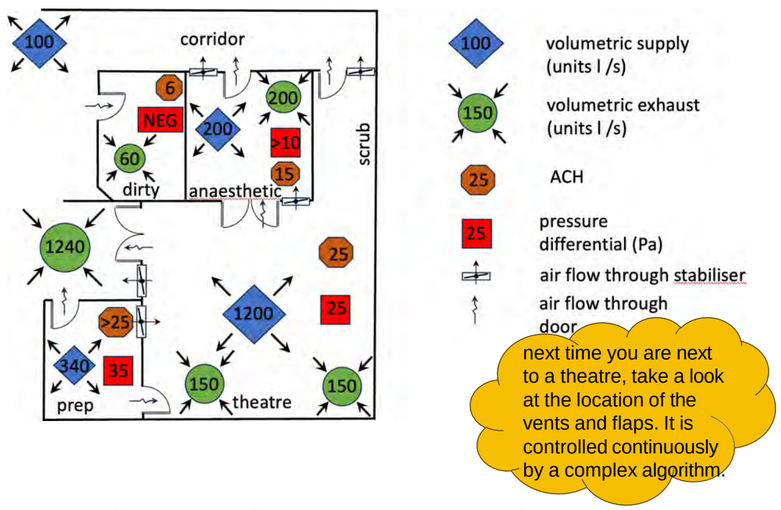
Towards NetZero for Hospital Theatres – reducing energy burden by change of use and improved efficiency

Mechanical Engineering Finalists

Fahim Ahmed
Tanzim Ahmed
Muhammad Ahsan
Mahfuz Ali
Somraj Birdi
Mutammim Chowdhury
Jenice Sastrawaha
Partis Phungjitisant
Daniel Chen
Max Pheng
Jo Lee
Palida Yimsiri

An interdisciplinary team, supported by UCL Partners, was tasked with addressing the NetZero challenge posed by clinical leads **Dr Jonny Groome** (Barts NHS Trust) and **Dr Lyndsay Muirhead** (UCLH NHS Trust). The challenge was to reduce carbon emissions while preserving safety. An interdisciplinary team was assembled from across UCL that consisted of a mechanical engineer (**Ian Eames**), health care architect (**Anne Symons**) and sensor specialists (**Duncan Wilson, Yaman Rawas-Kalaji**). The team were supported by Mechanical Engineering finalists. The activity benefited from extraordinary support from Estates teams at UCLH, Barts, Nuffield Health. Special thanks to **Claudia Rees** at UCLP.

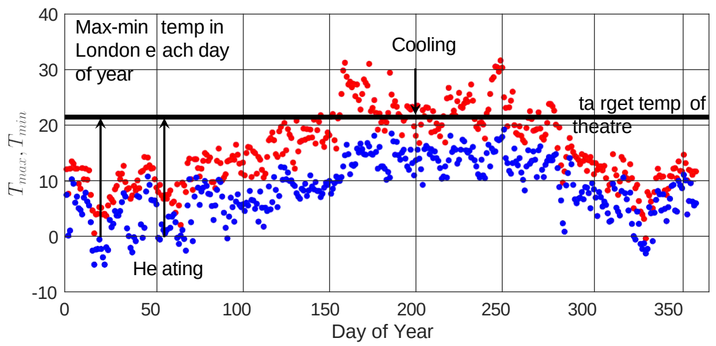
What is a hospital suite ?



next time you are next to a theatre, take a look at the location of the vents and flaps. It is controlled continuously by a complex algorithm.

It is a collection of spaces that are linked together to provide a tiered level of cleanliness and air quality. The space is managed by a complex ventilation system to supply clean air and exhaust the air to create pressure differentials.

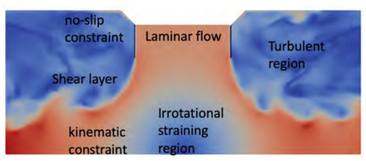
The complex systems that deliver clean air continuously. Even on cold days, the outside air has to be raised very quickly to 21C.

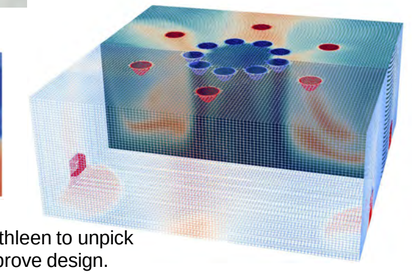


The volume of air passing through a theatre is enormous – typically about 1200 litres / s – and this represents a large energy cost (about £30k per theatre per year).

Ultra-clean canopy flow

Temperature controlled ventilation – Maximuse Designs at Sint Maartenskliniek



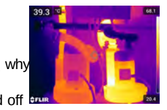


CFD simulation run on UCLs cluster Kathleen to unpick the physics of ventilation patterns to improve design.

Three ways to reduce carbon emissions

1. Switch off when not in use !

Not simple at all. There is no magic button to turn off these complicated systems and turn them back on. A protocol has been developed at a number of hospitals already but it application depends on the theatre use. This can reduce total energy consumption by 60%. Through this research, Whipps Cross have turned off their theatres over the weekend, reducing energy costs. The potential for SSI is being assess using real-time pressure monitoring. Many hospitals are set to follow their approach. Nuffield Health have designed a new theatre panel to enable switch off to be achieved safely.



Thermal image capture showing why gas scavenger should be turned off when not in use

Typical BMS system

2. Innovate !

A new whole theatre suite concept (temperature controlled ventilation – see photo to the left) has been designed by Remko Noor. It uses a clean room concept that affords the same protection as a laminar flow system but 30% reduction in energy expenditure. We are exploring the impediments to it being adopted in the UK under HTM-03. Royal National Orthopedic Hospital are using solar to support an all electric air-handling unit.

Royal National Orthopedic Hospital new solar array and heat pump technology. A glimpse of a possible NetZero future.

3. Recover the heat !

The air is handled by the units on the righthand side. They control the humidity and temperature. One way to save energy is to 'pump' the heat from the exhaust into the supply. This is done through a heat engine. Design improvements being considered will increase their efficiency.

Psycho – has two meanings –soul or breath. The physics of managing the air quality is described by psychometric charts.

Embedding carbon measurements within orthopaedic trials: from stakeholder engagement to guidelines for researchers

Catherine Borra 1,2, Rebecca Wood 1,2 and Catherine Hilton 1,2
1 Trauma & Orthopaedics, Barts Health NHS Trust; 2 Barts Bone & Joint Health, Queen Mary University London

Research and sustainable orthopaedics

Orthopaedics is a carbon-heavy medical specialty. Orthopaedic research may provide opportunities to support sustainable orthopaedic practice:
a) by providing estimates of the carbon emissions of different interventions to help clinicians, patients and commissioners choose the most effective interventions for patients and the environments;
b) by reducing resource inefficiencies through intervention optimisation *before* they are implemented in healthcare pathways.

Methods

Stakeholder engagement
- Focus group with patients
- 1:1 Interviews with orthopaedic clinicians, clinical services, management, research staff

Carbon footprint of orthopaedic trial interventions
- Protocol design
- A-priori intervention carbon estimates
- Data collection & analysis

Guidelines for embedding carbon measurements within clinical trials
- Draft
- Stakeholder feedback (orthopaedic researchers, CTU leads, academic leads)

Stakeholder engagement

	Patients	Clinical	Estates	Research
Barriers & threats				
Fear of limiting clinical judgement	*	*		*
Fear of decrease in quality of care	*	*		
Increased burden on staff & patients		*		*
Strategies				
Integrated services	*			
Focus on patient outcomes	*	*		*
Engaging stakeholders in research design	*	*	*	*

Carbon footprint of an orthopaedic trial

Protocol & methods design	Intervention estimates	Data collection & analysis
Amendments	Resource use	Pathway mapping
Feedback from trial team	Carbon estimates	Health economics
Feedback from ethics		

Guidelines for researchers

- Optimize trial design for reduced emissions
- Calculate carbon emissions for trial interventions
- Optimize trial interventions
- Design data collection & analysis for intervention pathway

Conclusions

Orthopaedics is a carbon-heavy medical specialty. Orthopaedic research may provide opportunities to support sustainable orthopaedic practice:
a) by providing estimates of the carbon emissions of different interventions to help clinicians, patients and commissioners choose the most effective interventions for patients and the environments;
b) by reducing resource inefficiencies through intervention optimisation *before* they are implemented in healthcare pathways.

SUMU-Endo: Single-use versus Multiple-use Endoscopes in gastroenterology

Multi-methods analysis to balancing infection control and environmental impact

NIHR152311

Summary of whole project:

Fostering efforts to deliver a Net Zero NHS, this is a multidisciplinary programme of work aiming to draw up a framework for incorporating broader environmental aims into health care decision making. The programme has 5 work packages, undertaken collaboratively between researchers at University Hospital Coventry and Warwickshire, Warwick Manufacturing Group, and the Divisions of Health Sciences and Clinical Trials at the University of Warwick.

Ramesh Arasaradnam: PI (WMS & UHCW)

Main goal of WP2:

Using a de novo economic analysis of the costs and consequences of using single-use endoscopes (as opposed to multiple-use devices) as a case study, Work Package 2 sets out to identify ways of accounting for broader 'costs' and wider outcomes of interest to decision makers, beyond health and wellbeing.

Yufei Jiang: Health economics analyst; **Lazaros Andronis, Mandana Zanganeh:** Health economics co-investigators (Warwick CTU)

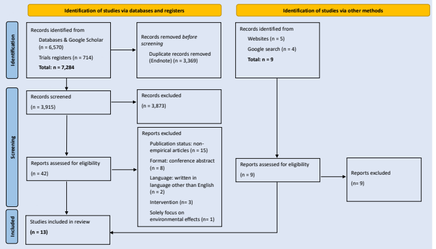
WP2 systematic review:

Are environmental considerations taken into account in economic evaluations? Evidence from a systematic literature review on single-use versus multiple-use endoscopes in gastroenterology

Background: In July 2022, the NHS became the first health care system to set a target of being a net zero health service by 2040. To achieve this, decision making around new technologies and interventions made available to the population will need to take into account broader environmental and sustainability considerations. A prominent example is the adoption of single-use endoscopes as a replacement for reusable endoscopes in gastroenterology due to perceived benefit in reducing cross-infection. Besides considerations related to technical and clinical performance, there are differences in the cost to the NHS and the impact they have on the environment.

Objectives: The aim of this review is two-fold. First, it sets out to identify, assess and summarise evidence on the costs and consequences arising from use of single-use gastrointestinal endoscopes compared to multiple-use ones, and secondly, it seeks to investigate whether (and how) broader environmental considerations are taken into account in economic evaluations of technologies that have a conspicuous environmental impact.

Methods: We searched 9 databases (MEDLINE, Embase, Web of Science, Cochrane Library, HTA, NHS EED, INAHTA, EconPapers and CEA Registry) for relevant economic evaluations published from each database's inception date until 4th March 2024, as well as Google Scholar and prominent HTA agency websites (NICE, CADTH, ICER). Study selection, quality assessment and data extraction were carried out according to published guidelines.



Study Characteristics		Number of Studies
Year of publication	2000-2011	6
	2012-2024	7
Country	USA	7
	European countries	5
	Korea	1
Type of economic evaluation	Partial economic evaluations: all cost analyses	7
	Full economic evaluations: 4 cost utility analyses (CUA), 2 cost minimisation analyses (CMA)	6
Study approach	Model-based	5
	Others	8

Preliminary results: Thirteen relevant economic analyses were identified. The most commonly considered costs included purchase and reprocessing/decontamination, and the most commonly used types of outcomes were infection risk and quality adjusted life years (QALYs). There was very limited evidence on environmental impact being considered. An in-depth analysis is currently in progress.

Other work in progress for WP2: The finding of this systematic review and micro-costing, and the ways they can be used in subsequent economic analysis prepared for the purposes of this study, will be discussed in upcoming conferences.

WP3 title:

Assessment environmental impact of Single-use versus Multiple-use Endoscopes in Gastroenterology using Life Cycle Assessment (LCA)

Main goal of WP3:

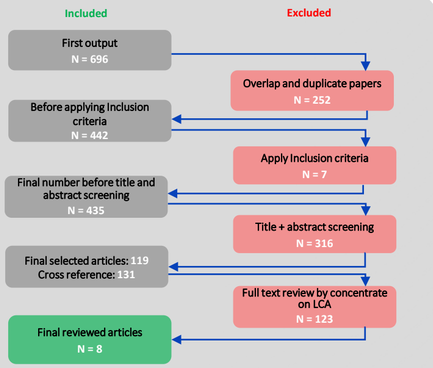
Assess the wider environmental consequences of a shift to single-use endoscopes including impact on scarce resources for their production and effect of disposal, including landfill and incineration, and the greenhouse gases and waste generated (including transport and storage) by using life cycle assessment (LCA) tools.

Stuart Coles: Co-investigator; **Mojtaba Ahmadinozari:** Health economics analyst (WMG)

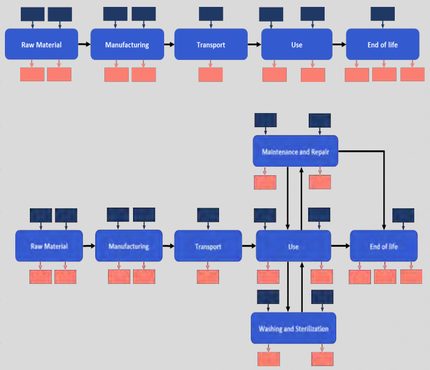
What has been done on WP3:

A systematic literature review of environmental aspects and Life Cycle Assessment (LCA) of Single-use (SU) versus Multiple-use (MU) Endoscopes in Gastroenterology was conducted. Regarding this, relevant studies that examine and compare the LCA and environmental aspects of SU and MU endoscopes were reviewed. Alongside this, some other results contributed, such as the following:

- Preparing a comprehensive data base on the life cycle assessment of SU and MU endoscopes in gastroenterology that can serve as a valuable resource for researchers, healthcare professionals, policymakers, and industry stakeholders.
- Review and comparison of the environmental impact of SU versus MU endoscopes in gastroenterology according to the different stages of the life cycle of SU and MU endoscopes.
- Preparing a table of system boundaries and analytical units of reviewed studies.



Title		YES/NO	Raw material	Manufacturing	Transportation	Using	Sterilization	Repair	End of life
Life cycle analysis – single use scopes vs. Reusable scopes: a framework for sustainable endoscopy	Single-Use	✓	✗	✓	✗	✓	-	-	✗
	Multiple-Use	✓	✗	✓	✗	✓	✗	✗	✗
Estimating the environmental impact of disposable endoscopic equipment and endoscopes	Single-Use	✓	✗	✗	✗	✓	-	-	✓
	Multiple-Use	✓	✗	✗	✗	✓	✓	✗	✓
Comparing the Impact of Reusable and Single-Use Duodenoscopes Using Life Cycle Assessment	Single-Use	✓	✓	✓	✓	✓	-	-	✓
	Multiple-Use	✓	✓	✓	✓	✓	✓	✗	✓
The Carbon Footprint of Single-Use Flexible Cystoscopes Compared with Reusable Cystoscopes	Single-Use	✓	✓	✓	✓	✗	-	-	✓
	Multiple-Use	✓	✓	✓	✗	✗	✓	✗	✓
Comparative study on environmental impacts of reusable and single-use bronchoscopes	Single-Use	✓	✓	✓	✗	✓	-	-	✓
	Multiple-Use	✓	✗	✗	✗	✗	✓	✗	✗
Carbon Footprint in flexible ureteroscopy: a comparative study on the environmental impact of reusable and single-use uretero-scopes	Single-Use	✓	✓	✓	✗	✓	-	-	✓
	Multiple-Use	✓	✓	✓	✗	✓	✗	✓	✓
Environmental and health outcomes of single-use versus reusable duodenoscopes	Single-Use	✓	✓	✓	✓	✓	-	-	✗
	Multiple-Use	✓	✗	✗	✗	✗	✓	✗	✗
Life Cycle Assessment of Reusable and Disposable Cystoscopes: A Path to Greener Urological Procedures	Single-Use	✓	✓	✓	✓	✓	-	-	✓
	Multiple-Use	✓	✓	✓	✓	✓	✓	✓	✗



Go Green: Reducing the Environmental Impact of Operating Theatres

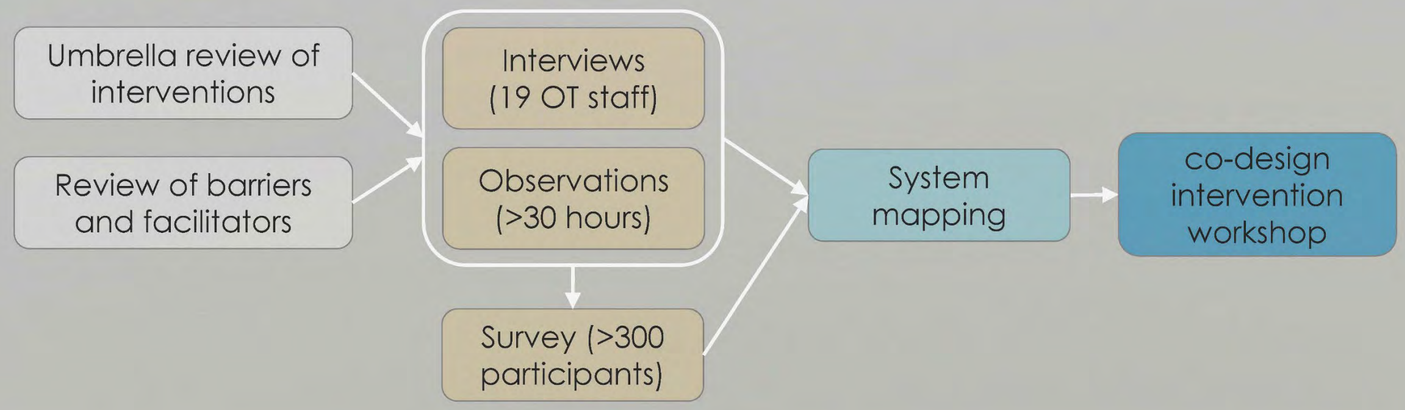
A behavioural science approach

Dr Talya Porat, Dr Pelin Demirel, Dr Gaby Judah, Aws Almukhtar, Carys Batcup, Dr Anouk Zeeuw van der Laan, Dr Sadhana Jagannath

Background

- NHS accounts for 4% of England's total carbon footprint.
- Operating Theatres are 3-6 times more energy intensive than the rest of the hospital.
- 30% of waste in hospitals is generated by Operating Theatres.
- Carbon footprint of Operating Theatres in 2019 was 5.7 million tonnes CO2e (represents 1.25% of the UK's total greenhouse-gas emissions).

What we did



WE FOUND

Photo by Clay Banks on Unsplash

Non-Sterile Glove Use

9 **Pairs** (+/- 2) wasted per procedure

≈ LON ✈ NYC

6650 round trips/year

Are easily available – not enough alternatives

Promote a sense of safety, readiness, competence, professionalism

Inconsistencies between and within individuals

HABIT

Project challenges

- Safety vs Sustainability: "*better safe than sorry*"
- Recruitment of participants and continuous involvement
- No clear guidelines or a responsible body

Project insights

- Having a Surgeon (or Operating Theatre staff) as collaborator (Co-I) is critical for project success.

barriers and facilitators paper

IMPERIAL

UKRI Medical Research Council

Measuring and reducing the carbon footprint of computing for fMRI data processing

Nicholas E. Souter (1), Nikhil Bhagwat (2), Chris Racey (1), Reese Wilkinson (1), Niall W. Duncan (3), Loïc Lannelongue (4), Gabrielle Samuel (5), Raghavendra Selvan (6), Charlotte L Rae (1)

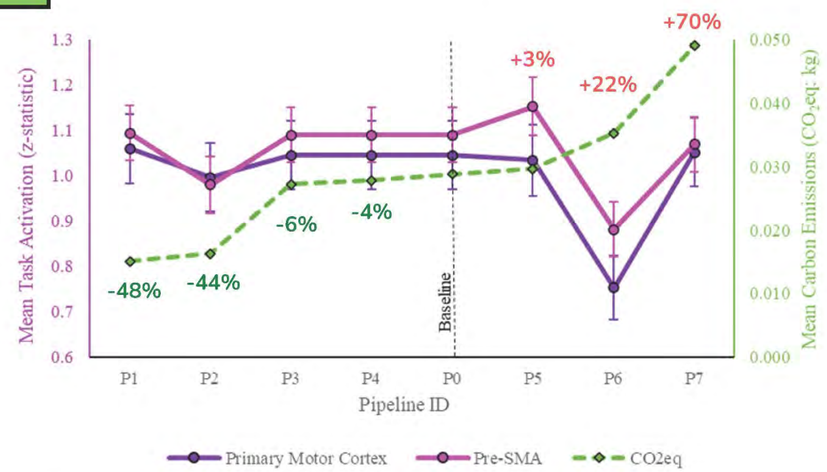
1 University of Sussex, 2 McGill University, 3 Taipei Medical University, 4 University of Cambridge, 5 King's College London, 6 University of Copenhagen

Our project measured the **carbon footprint** of energy used for **computing** for **functional magnetic resonance imaging (fMRI)** brain scan research. This facilitated **(1)** A review guide providing **10 recommendations** to reduce the carbon footprint of neuroimaging computing. **(2)** A study comparing the carbon emissions of 8 variants of a **preprocessing pipeline**, using a novel carbon tracking tool. **(3)** An internal seed fund supporting a study comparing emissions across **three fMRI data processing packages**. Collectively, these identified best practice for reducing MRI analysis emissions.

1 Ten recommendations for reducing the carbon footprint of neuroimaging computing

1. **Preregister** a study analysis plan in order to avoid repetitions
2. **Track and report** the carbon footprint of your computing
3. Only run the **preprocessing and analysis steps that you need**
4. Run your computing at **lower carbon intensity times** and locations
5. Regularly **remove files** that you do not need
6. **Plan** where, and for how long, you will **store files**
7. Advocate for **non-commercial and centralised data storage** solutions
8. Publicly share data, but consider the extent of what others will **actually need or use**
9. Make use of **existing preprocessed data** when possible, instead of processing new data
10. **Discuss greener computing** with other neuroimagers and advocate for change

2 Reducing the footprint of fMRIPrep

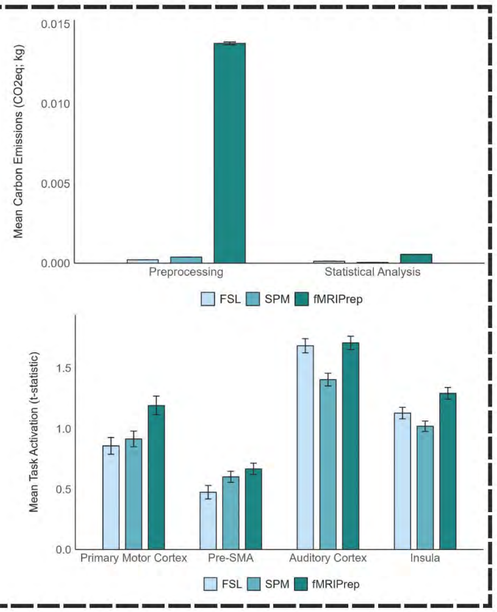


Significant effects of pipeline on emissions and preprocessing performance (task activation). Comparing pipelines to baseline (P0), we observed differences including:

- **Disabling FreeSurfer surface reconstruction** (P1) reduced emissions by **48%** without losses in performance.
- **Increasing output space resolution** (P7) increased emissions by **70%** with no gains in performance.

3 Comparing the footprint of fMRI packages

We compared estimated emissions from preprocessing and statistical analysis in the **three most common fMRI packages**.



Comparing emissions:	Comparing activation:
SPM = 1.3x **FSL**	**FSL** = 1.1x **SPM**
fMRIPrep = 43x **FSL**	**fMRIPrep** = 1.2x **FSL**
fMRIPrep = 34x **SPM**	**fMRIPrep** = 1.2x **SPM**

There is a trade-off: researchers can achieve slightly better results, but with a large relative increase in emissions.

(1) Souter et al. (2023). Ten recommendations for reducing the carbon footprint of research computing in human neuroimaging. *Imaging Neuroscience*

(2) Souter et al. (2024). Measuring and reducing the carbon footprint of fMRI preprocessing in fMRIPrep. *OSF Preprints*

N.Souter@sussex.ac.uk

https://www.sussex.ac.uk/psychology/abc-lab/

Funded by a grant from UKRI Medical Research Council

Appendix 8 - Contact details

CONTACT DETAILS:

Conference Host:

Professor Sir John Iredale, Honorary Consultant Physician and Former Executive Chair at the Medical Research Council, UKRI

Presenters:

- **Professor Paula Williamson**, Professor of Biostatistics and NIHR Emeritus Senior Investigator [**email address:** prw@liverpool.ac.uk]
- **Dr Gabrielle Samuel**, Lecturer, Environmental Justice and Health, King's College London [**email address:** gabbysamuel@gmail.com]
- **Matthew Graham**, Research Assistant, King's College London [**email address:** matthew.1.graham@kcl.ac.uk]
- **Professor Mahmood Bhutta**, ENT surgeon and Professor of Sustainable Healthcare, Brighton and Sussex Medical School [**email address:** m.bhutta@doctors.org.uk]
- **Dr Tom Dawson**, Founder of Revolution ZERO Group Ltd [**email address**: tom.dawson@revolution-zero.com]
- **Dr Nathan Moore**, T&O Specialty Training Registrar and Founder of Primum Digital Ltd [**email address:** nathan.moore@orthopathway.com]
- **Professor Sharon Pfleger**, Consultant in Pharmaceutical Public Health, NHS Highland [**email address**: sharon.pfleger@nhs.scot]

Panel members/ Discussion 1:

- **Dr Alyson Fox,** Director of Research Funding, Wellcome Trust [**email address**: a.fox@wellcome.org]
- **Mr. Chris Gormley,** Chief Sustainability Officer, Greener NHS programme, NHS England [**email address**: christopher.gormley1@nhs.net]
- **Dr Angela Hind,** Chief Executive at the Medical Research Foundation [**email address**: angela.hind@medicalresearchfoundation.org.uk]

Panel members/ Discussion 2:

- **Dr Clifford L Shelton,** Consultant Anaesthetist, Wythenshawe Hospital Senior Clinical Lecturer, Lancaster Medical School [**email address**: cliff.shelton@nhs.net]
- **Dr Deirdre Black,** Head of Science and Sustainability Strategy Lead at the Royal Society of Chemistry [**email address**: blackd@rsc.org]
- **Dr Marina Romanello,** Executive Director at the Lancet Countdown on Health & Climate Change [email address: m.romanello@ucl.ac.uk]
- **Rachel Sturtees,** Director of Implementation at UCL Partners [**email address**: rachel.surtees@uclpartners.com]
-

Poster presenters:

- **Dr Nick Souter**, Postdoctoral Research Fellow, University of Sussex [**email address**: n.souter@sussex.ac.uk]
- **Dr Catherine Borra**, Research Physiotherapist, Royal London Hospital [**email address**: catherine.borra@nhs.net]
- **Dr Talya Porat**, Senior Lecturer - Human Factors Engineering, Imperial College London [**email address**: t.porat@imperial.ac.uk]
- **Dr Mandana Zanganeh,** Assistant Professor, CTU, University of Warwick [**email address**: mandana.zanganeh@warwick.ac.uk]
- **Dr Mojtaba Ahmadinozari,** Research Fellow, WMG, University of Warwick [**email address**: mojtaba.ahmadinozari@warwick.ac.uk]
- **Prof Ian Eames,** Professor of Fluid Mechanics, Dept of Mechanical Engineering Faculty of Engineering Sciences [**email address**: i.eames@ucl.ac.uk]

Organisers:

- **Dr Fanny Burrows**, Senior Lead, Net Zero Research & Innovation, Greener NHS Programme**, Email address**: fanny.burrows@nhs.net;
- **Dr Sophia Lentzos**, NIHR Head of Sustainability, National Institute of Health Research, Email Address: sophia.lentzos@nihr.ac.uk
- **Jennifer Ekelund,** Interim NIHR Head of Climate, Health and Sustainability National Institute of Health Research, Email Address**:** jennifer.ekelund@nihr.ac.uk
- **Dr Susan Simon**, MRC Chief Environmental Sustainability Officer, Director UKRI Environmental Sustainability Programme, email: susan.simon@mrc.ukri.org