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Co-designing for the NHS: the development of sustainable theatre garments

Paul Rodgers [1], Euan Winton [2], Lewis Urquhart [1,✉], Jonathan O'Reilly [3] and Carole Anderson [3]

[1] University of Strathclyde, United Kingdom, [2] Heriot-Watt University, United Kingdom, [3] NHS Scotland, Golden Jubilee, United Kingdom

✉ lewis.urquhart@strath.ac.uk

Abstract

NHS Scotland, one of the keystone healthcare providers in the UK, have recently set a wide variety of sustainability targets in an effort to mitigate waste and the intensive energy demands of healthcare. Medical garment production, management and design is an area in which design researchers can explore and offer solutions. This paper presents a series of co-design explorations to examine design alternatives to single-use theatre caps, the majority of which are currently disposed of routinely. Using a series of probes, major insights into how theatre cap design may be improved is presented.

Keywords: healthcare design, sustainable design, NHS

1. Introduction

Problems emerging from the effects of climate change and climate breakdown, will likely put the lives and wellbeing of billions of people at increased risk over the 21st century (Costello et al., 2009). The more we ignore the climate emergency the bigger the impact will be on health and the need for care with poor environmental health contributing to major diseases, including cardiac problems, asthma and cancer. Indeed, NHS Scotland has set a range of targets including achieving net-zero emissions by 2040, ensuring no more than 5% of domestic waste goes to landfill and aiming that at least 70% of this waste is recycled (NHS Scotland, 2022). At the same time, many of the actions to mitigate and adapt to climate change and improve environmental sustainability also have positive health benefits to such an extent that the Lancet Commission has described tackling climate change as 'the greatest global health opportunity of the 21st century' (Wang & Horton, 2015). Within a UK context, an average of 0.5 kg of hazardous waste per hospital bed per day is generated. With around 4% of the UK's carbon emissions, and over 7% of the economy, the NHS has an essential role to play in meeting the net zero targets set under the Climate Change Act (Delivering a 'Net Zero' National Health Service, 2022 report). As a high-income country, the UK is in an excellent position to both explore and understand the highly complex problems of climate change but also to develop and implement solutions that can be exported to the wider-world. Within the healthcare sector, this is more imperative than ever due to the fragility of global healthcare networks (Gerwig, 2022).

This paper describes on-going collaborative research between the authors and NHS Scotland stakeholders including surgeons, anaesthetists, nursing staff, and other staff including members of the quality improvement team and director-level involvement. This research is part of a much larger project titled Design HOPES (Healthy Organisation in a Place-based Ecosystem, Scotland) focusing on sustainability within NHS Scotland. The overarching aim of this research is to reduce significantly or

(better still) eliminate entirely NHS Scotland operating theatre consumables' waste. One of the aims of Design HOPES is to work with NHS Scotland staff to improve systems design and evaluate options for reducing theatre waste. For instance, around 160,000 single use theatre hats are used per year across 25 theatres in the NHS Golden Jubilee hospital. At the same time, an associated aim of this project is to address communication barriers between surgical staff when wearing full personal protective equipment (PPE).

But in what direction should interventions be explored? Should the focus be on large 'systemic' change or lower-level 'local' change? This paper will explore these opportunities from the perspective of practice led design research and set out a number of potential avenues in which interventions could be meaningfully implemented. Firstly, we will more deeply examine the key issues, why the focus on health and social care is a central touchstone for tackling problems relating to waste, sustainability and climate change. Secondly, we will present a case-study in which a co-design workshop with NHS Scotland hospital in Clydebank is presented. The workshop explored the use of theatre caps and how they could be redeveloped through design-thinking and making in order to improve factors of comfort, personalisation and sustainability. Lastly, we will discuss the implications of the workshop outcomes and crucially develop a number of design interventions focusing on reusable theatre caps. By designing a degree of personalisation and self-identity, there is evidence that a much more sustainable approach to garment manufacture and care can be fostered.

2. Background

Our focus, NHS Scotland, is the publicly funded healthcare system in Scotland, which has set an ambitious legally binding target for Net Zero to 2040. NHS Scotland is part of the National Health Service UK, it is supported by seven special non-geographic health boards of which three (NHS Golden Jubilee, NHS Tayside, and NHS Highland) are Project Partners and Public Health Scotland. Health and social care policy and funding is devolved to the Scottish Government who have established a NHS Scotland Circular Economy Programme to support the transition to more circular supply systems. As a crucial contributor to meeting targets, NHS Scotland offers considerable innovation opportunities for a green transition and has committed to 'sustainable development' and meeting the needs of the climate crisis 'without compromising the ability of future generations to meet their own needs' (NHS Scotland, 2022).

The garments worn by doctors, nurses and other hospital staff present a notable problem. Due to the constant need for hygiene and infection free equipment, many dirty garments need to be industrially washed or disposed of. This generates huge amounts of waste and has created a reliance on synthetic materials (notably viscose) for the constant production of clean garments, much of which is manufactured off-shore and transported across significant distances. This creates a problem as NHS Scotland is on record committing to a 70% reduction in waste compared to its 2012 'baseline'. With respect to this, the current use practices of medical garments are unsustainable. Theatre caps are an interesting example in which we can develop a response. Though estimates vary one reports states that around 120,000 caps are used and disposed of every single month within the NHS, contributing to a cost of approximately £320,000 annually in procurement (NHS, 2020). The theatre cap is a fairly simple piece of equipment but is viewed as vital for the avoidance of contamination by containing loose hair and skin cells and is near-universally utilised in surgical settings (Figure 1).

Figure 1. Examples of theatre caps worn by surgeons (public domain via Wikimedia Commons)

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There are numerous designs but most are focused on the functional elements of the product i.e. particle containment. At present, available scientific evidence interestingly does not demonstrate any association between the type of theatre cap and surgical site infection rates. One recent study on head coverings (disposable bouffant, disposable skullcap and cloth cap) identified that the commonly available disposable bouffant hat is the least effective barrier to transmission of particles (Markel et al., 2017). With respect to these findings, there is scope for improving the overall functionality of the caps and exploring means in which additional functionally could be introduced that might aid aspects of workplace communications and practical operations within a hospital setting by eliminating misidentification.

The concept of *reusability* presents a set of realistic design interventions. Reusable caps have already been trialled in NHS Fife but there are numerous dimensions that were not explored by this project such as the ideal placement of hat information, the format of information for communication and means of manufacturing the hat to make them more sustainable such as allowing for material recycling. Reusable theatre hats present a highly suitable location for clear staff name and role identification given the workflows of operating theatres, but there is scope to use design-thinking to understand this better and provide a full account of the iconography that could improve the effectiveness and sustainability of surgical procedures within the NHS. It is recognised that clearly visible name and role identification is associated with improved communication, team work and ultimately patient safety outcomes. Furthermore, the significant environmental benefits of reusable theatre caps over disposable ones is widely acknowledged.

2.1. NHS Golden Jubilee Current Position

We worked closely with the NHS Golden Jubilee national hospital in Clydebank to develop this project. The hospital currently has 21 operating theatres, which will increase to 31 theatres on completion of the phase 2 expansion over the next couple of years. On this basis, the hospital has the potential to discard an estimated 160,000 single use surgical theatre caps every year. Thus, introducing eco-friendly, reusable cloth theatre caps has the potential to reduce waste and associated costs. Reusable theatre caps can be made unique to each member of staff and display the staff member's name and role. This benefits patient safety and has been proven to positively impact communication, incident management and staff identification. Current evidence supports the use of reusable theatre caps wherein:

- *70% of adverse events associated with poor patient outcomes are related to communication errors.*
- *Communication failures in 30% of theatre team exchanges lead to inefficiency and increased tension between hospital staff.*
- *4 out of 5 (80%) female doctors report being misidentified leading to feelings of inadequacy or sexism.*

3. How can design respond?

A recent review of health service design, delivery and improvement presented clear evidence that a systems approach to addressing health delivery challenges may lead to significant improvements in both patient and service outcomes (Ward et al., 2022). With a view to this, we can approach the development of solutions from a design-thinking perspective, more specifically using co-design methods.

Co-design is a form of open innovation where people from different backgrounds, experiences, skills, and organisations come together to share and combine ideas and knowledge. Often this involves users or customers as participant designers in the design process (Chesbrough, 2003). It could be argued, however, that design is (and always has been) a collaborative pursuit because it is inherently a social process carried out by teams of humans (Bucciarelli, 1994). Co-design can involve a range of approaches such as applied ethnography and the use of design tools focussing on user involvement (e.g., usability testing) to approaches where participants are directly involved in the design process. By integrating multiple forms of qualitative and quantitative data and more intangible tacit knowledge, design proposals are developed that aggregate a solution space built on an understanding of human needs within a particular context (Sanders & Stappers, 2008).

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3.1. Co-design in healthcare

A number of efforts have been applied in recent years to integrate co-design methods into the development of healthcare products, services and systems (Bird et al., 2021). Co-design in health and social care contexts have been widely adopted and used to facilitate:

1) Prioritisation and research agenda-setting (Domecq et al., 2014; Schilling and Gerhardus, 2017)
2) Analysis of proposals (Brett et al., 2014).

For example, the work of Schilling and Gerhardus (2017) describe a prioritisation process that included an initial survey of older adults with dementia followed by a co-design workshop. Also, Cukor (2016) describe how a community advisory board drawn from patients with kidney disease and their caregivers reviewed and provided feedback on initial proposals. In these works, and elsewhere, many different roles for co-design participants are described that includes advisors and committee members who provide advice, reviewers who scrutinise plans and materials, and co-design and co-creation roles where the co-designers initiated, and/or shared control of the project.

An early exploration examined how diagnosis could be developed in a more 'person-centred' direction, setting the tone for a more general shift in thinking, to quote; 'there has been a progressive development of diagnostic schemas with increasing levels of informational richness from a simple, typological, single-label diagnosis denoting a symptom, problem, syndrome, or illness to more complex multiple illness formulation' (Mezzich et al, 2010). This general shift in thinking has meant that innovation in healthcare has been increasingly involving patients in the development of conceptual diagnostic models i.e. integrating normative experiences into formal understandings of health and the development of products such as prosthetics or drug delivery systems (see Göttgens, 2021 for a detailed overview).

More recently, this has been applied to the actual structures and products of the healthcare systems themselves, examining how *participation* can produce better results (see Lindblom, 2021). In an interesting piece of work Reay and others (2016), the future of hospital infrastructure is imagined by integrating a co-design space providing a platform for patients and other users of the hospital to create objects and voice their opinions about how it should be used, what values it should promote or how it should look. Several outcomes such as the creation of novel wayfinding signage and iconography and new waiting area concepts showed how co-design thinking could be utilised to transformational affect.

Related work by Chamberlain and Partridge (2017) have additionally described the development of a so-called 'frailsafe' approach which seeks to improve measured quality of care for frail and elderly patients by creating a set of tools. The tools are designed to draw attention to the physical markers of frailty such as reliance on medications or risk of falls.

Some other examples have included products designed for prosthetics such as the foam cosemesis explored by Cairns et al (2017). Others have integrated digital app technologies such as the weight management app presented by Curtis et al. (2015) or the sleep improvement technologies developed by Carey-Smith and others (2013), all of which articulate with the NHS in ways which could improve overall patient outcomes.

4. Co-designing interventions

This project utilised a number of design research methods including cultural probes, ethnography, and end-user trials. These methods were used because they are a highly effective and creative means of gathering information from the people that will ultimately use the product, as opposed to others who may only handle it or purchase it within a supply chain (Milton and Rodgers, 2013). The rationale for adopting a co-design approach in this work is that it supports the creative processes of idea generation and product design and development. Moreover, a co-design approach helps improve decision-making whilst promoting cooperation and creativity amongst everyone involved. It has also been stated that co-design improves users' and customers' satisfaction and loyalty over the long-term (Steen et al., 2011; Steen, 2013).

The objectives for phase 1 of this project were to clearly understand current practice, behaviours and interactions with theatre caps and define the requirements for any change. As such, the authors held a series of co-design workshops with NHS Golden Jubilee hospital surgical staff (Figure 2). We created

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a series of design probes to dive deeper into the behaviours, practice, and interactions across and between operating theatre staff.

Figure 2. Co-design workshop with NHS Golden Jubilee hospital staff

The design probes (Figure 3) asked NHS Golden Jubilee hospital surgical staff to articulate what they would like communicated on their theatre cap (e.g., name, role, department, etc.), where they are commonly situated in the operating theatre and who do they communicate with, and how would they like their 'ideal' theatre cap to be fastened - targeting both elements of functionality but also expanding the functional remit of the cap.

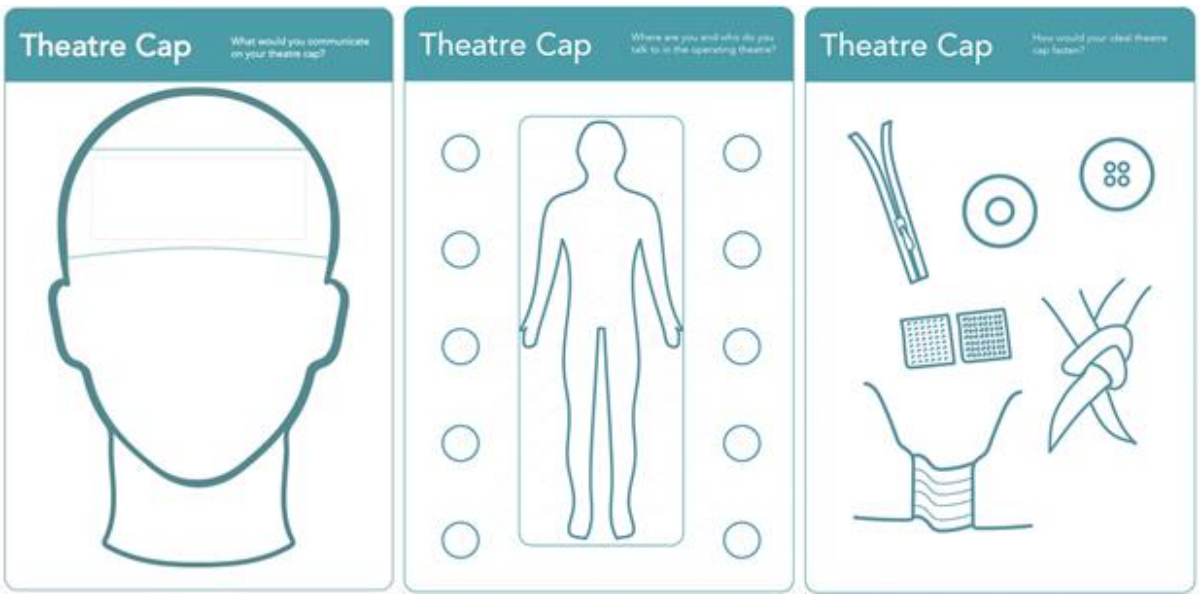

Figure 3. Design probe for co-design workshop

Phase 1 of this work has also involved the authors posing a number of specific questions relating to the implementation of reusable theatre caps with NHS Golden Jubilee hospital surgical staff. The questions include the following:

- *What barriers are there for you in using reusable theatre caps?*
- *What material would you like your theatre cap made from?*
- *What would you like to communicate on your theatre cap?*
- *How many theatre caps (on average) do you use each day?*
- *Anything else you would like to say about theatre caps?*

4.1. Co-design results

Initial results from the co-design workshops and the design probes reveal a number of key insights (Figure 4 and Figure 5). Analysing the feedback from the design probes highlights a number of issues

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related to ergonomics, comfort, and material quality. In terms of feedback on the ergonomics of theatre caps, the respondents stated that the current theatre caps hurt their ears and that the sizes are either too large or too small. In terms of material qualities, the respondents commented that they break all the time and that the theatre caps are very plain in appearance and boring. The respondents made clear that they would prefer to wear surgical theatre caps that are made from a 'comfortable' material and from material that is less 'sweaty'. The respondents also stated that they would like a theatre cap that is easy to put on and fast to remove. One of the most revealing points identified from the design probe is the potential number of people and roles present in a typical operating theatre. The design probe reveals as many as 19 different roles present, which evidences the very real risk of miscommunication and misidentification in the operating theatre environment.

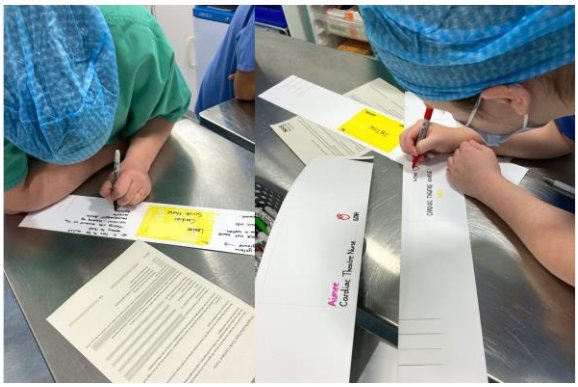

Figure 4. Co-design workshop outcomes

Further to this, a probe was also developed in order to explore how a scrub cap might expand its traditional and current functional role. As shown in Figure 5 below, several insights have been gained that can be utilised to improve the current design of the caps with respect to the key functional and systemic space in which the caps are used. Crucially, a number of findings relate to the manufacturing material being poor quality or uncomfortable, to quote two responses: 'they break all the time' and 'they hurt our ears'. In essence, these complaints point to clear possible design interventions. Additionally, the communication framework was examined and the placement of staff within a theatre is a key area that can be explored for improvement. For instance, the use of symbols, colours or iconography (currently not used) may help improve the workflow within surgical contexts. Furthermore, the functionality and comfort of the fastenings were examined with many citing the lack of adjustability as a key issue with the current design and favouring systems with an implicit conformity around the user's head such as elasticated bands.

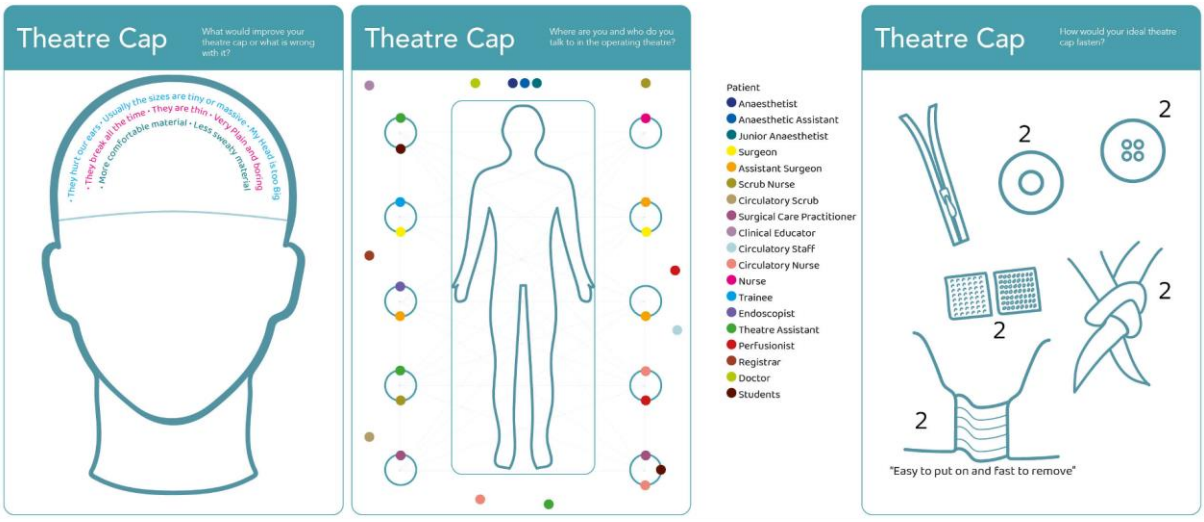

Figure 5. Theatre cap probe responses

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To solidify further the results gained from the co-design workshop and the design probe responses, the authors asked a wide range of NHS Golden Jubilee hospital surgical staff to articulate any barriers they perceive in using reusable theatre caps. Also, what material they would like their 'ideal' theatre cap to be made from. We also asked the surgical staff what they would like to communicate on the front of their reusable theatre cap and anything else they would like to say, more generally, about theatre caps using post-it notes (Figure 6).

Figure 6. Post-it Note comments from NHS Golden Jubilee surgical staff

A number of key recommendations from the NHS Golden Jubilee surgical staff included the following:

1. *The reusable theatre cap should be manufactured using materials that are lint-free, breathable, hair-friendly, easily washed, soft to touch, and comfortable to wear.*
2. *The reusable theatre cap should communicate the individual's first name only, job role, department speciality, and should appear 'friendly'.*
3. *The reusable theatre cap should have a 'friendly' and 'welcoming' appearance and offer a range of colours.*

The NHS Golden Jubilee surgical staff also raised a few issues in the future design and development of the reusable theatre cap notably how they will be laundered, the costs involved, and issues relating to infection control. These issues ultimately relate to how we can approach the problem more systemically and implement realistic behavioural change that might have a positive impact on waste reduction and overall sustainability metrics.

4.2. Discussion

There are many questions still unanswered in relation to healthcare garments and how they can best be manufactured and (re)utilised. This design probe and co-design exercise goes some way to exploring the design-value that can be gain by doing them.

We can consider how the workshop can be looked at within the wider scope of design research and product development. Many design researchers are involved in the sustainable design of interventions (products, services and systems) that positively impact on the environment, health and healthcare, promote dignity, and enhance quality of life, and action change in a range of settings (Rodgers, 2021; Winton & Rodgers, 2020)). Addressing issues in the health ecosystem requires not just an assemblage of projects and practices, but a more ambitious approach that reflects on the past and imagines the future. This co-design workshop showed how a solution space can grow from the focused assessment of a well-understood problem and related set of products. While the use of co-design is not without its critics,

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with some citing its implicit biases and tendencies towards idealism and problem simplification (see von Busch & Palmås, 2023), here we showed how exploring concepts of personalisation and communication systems could have a positive impact. In essence there is a sense of *value* that is fostered where medical staff have a position within a team hierarchy that can be clearly understood. This in turn leads to a culture of care for the garments whereby the theatre cap is conceptually viewed not as a disposable item but part of a personal uniform or identity that can and should be looked after, echoing arguments made in the theories of uniforms (see Craik, 2003). If the uniform becomes an object of personal care, that is cleaned routinely by the individual user, this has the potential to massively reduce the waste generated by disposable garments and the requirements of industrial cleaning. Similar concepts using the personalisation of garments to increase their sustainability have been explored by Maldini et al (2019), Black & Eckhert (2010) and by Chapman (2012) with his interesting concept of 'emotionally durable design'. There is clear evidence that a personal and emotional connection with items of clothing, increase their overall lifespan.

This is however not the end of the story. The design and delivery of care services play a vital role in improving health outcomes but these services face several challenges, including the increasing burden of chronic conditions, environmental sustainability, and health inequalities. Consequently, the role of design-led research in health and social care contexts has changed in recent years, shifting from a focus largely on economic growth towards one of wider social and environmental issues that highlights a more design-led systemic approach. Therefore, there is a moral precedent to align to 'high-level' targets (e.g., Net Zero, UNSDGs and the futures focused UN Resilience Frontier Pathways) to be translated into actionable measures for design-led interventions in the health ecosystem and be rapidly applied in order to accelerate green transitions. Health-care activities protect and restore health and save lives but The Organisation for Economic Co-operation and Development (OECD) estimates that up to 20% of our healthcare resource could be being wasted. Research such as that presented highlights the possibilities within this space - where some are practical and grounded targeting this waste, others are speculative and may only be possible in radically different economic and social arrangements.

While these explorations have been based in practical prototyping, other work has examined personalised and sustainable care from an advanced manufacturing and generative design perspective (Urquhart et al., 2022) or arrangements involving digital twins (Urquhart et al., 2022b), ideas that seek to use the advanced powers of computing to alleviate these complex problems. Other perspectives such as the architectural design and waste management of hospitals require complex and potentially radical design re-imaginings (Lattanzio, 2022). Or food production within healthcare - an area that intersects heavily with waste, care, sustainability, nutrition and ethics (Naithani, 2008).

These co-design adjacent methods may become a routine part of healthcare in decades to come and tease a speculative future in which healthcare is viewed within the wider systemic ambit of society, culture and crucially, the environment.

5. Conclusions

This paper presents a number of insights into the co-design and development of a reusable theatre cap for NHS Scotland staff. We have shown through co-design methods that several design interventions would increase the overall sustainability of theatre caps and improve aspects of functionality including having a printed name and iconography relating to teams and roles. To summarise, the research aims to:

- *Empower design-led research to respond to nationally significant green transition challenges in innovative, design-led collaborative ways.*
- *Embed circularity and sustainability across product, service, strategy and policy design in relation to the identified challenges.*
- *Realise measurable, green transition-supportive change across sectors and publics.*
- *Catalyse and foster opportunities for social, cultural, environmental, and economic impact of design research-led interventions.*
- *Enable and support a greater diversity of voices and perspectives in the design of green-transition supportive-interventions, including users, publics and underserved communities.*
- *Create opportunities to build capacity and capability in design research for green transition.*

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- *Promote the role of design and making across health and social care, and foster new opportunities for innovation in designing green transitions.*

This co-design workshop provided insights into how design can be utilised to provide meaningful solutions to complex problems and shows how user buy-in can significantly enhance the outcomes. The exploration of the communication matrix between the theatre staff is an interesting outcome for instance that revealed that the misidentification of roles is a common issue that the minimal redesign of ubiquitously worn garments may solve.

There are some limitations to the work presented here as it does not directly examine the sustainability impact in terms of metric of energy or material use and it is unclear to what extent reuse in this context would significantly impact net-zero targets. Nonetheless, the work presented here is a starting point for meaningful and lasting change with can both improve our delivery of care within the NHS and create a more sustainable world through the rich tools of design.

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