



# Reducing the environmental impact of surgery on a global scale: systematic review and co-prioritization with healthcare workers in 132 countries

National Institute for Health and Care Research Global Health Research Unit on Global Surgery

Correspondence to: Aneel Bhangu, NIHR Global Health Research Unit on Global Surgery, Institute of Applied Health Research, Institute of Translational Medicine Birmingham, Heritage Building, Mindelsohn Way, University of Birmingham, Birmingham B15 2TH, UK (e-mail: a.a.bhangu@bham.ac.uk)

Members of the National Institute for Health and Care Research Global Health Research Unit on Global Surgery are co-authors of this study and are listed under the heading Collaborators.

## Abstract

**Background:** Healthcare cannot achieve net-zero carbon without addressing operating theatres. The aim of this study was to prioritize feasible interventions to reduce the environmental impact of operating theatres.

**Methods:** This study adopted a four-phase Delphi consensus co-prioritization methodology. In phase 1, a systematic review of published interventions and global consultation of perioperative healthcare professionals were used to longlist interventions. In phase 2, iterative thematic analysis consolidated comparable interventions into a shortlist. In phase 3, the shortlist was co-prioritized based on patient and clinician views on acceptability, feasibility, and safety. In phase 4, ranked lists of interventions were presented by their relevance to high-income countries and low-middle-income countries.

**Results:** In phase 1, 43 interventions were identified, which had low uptake in practice according to 3042 professionals globally. In phase 2, a shortlist of 15 intervention domains was generated. In phase 3, interventions were deemed acceptable for more than 90 per cent of patients except for reducing general anaesthesia (84 per cent) and re-sterilization of 'single-use' consumables (86 per cent). In phase 4, the top three shortlisted interventions for high-income countries were: introducing recycling; reducing use of anaesthetic gases; and appropriate clinical waste processing. In phase 4, the top three shortlisted interventions for low-middle-income countries were: introducing reusable surgical devices; reducing use of consumables; and reducing the use of general anaesthesia.

**Conclusion:** This is a step toward environmentally sustainable operating environments with actionable interventions applicable to both high- and low-middle-income countries.

## Introduction

The global climate is rapidly changing, and urgent action is needed to mitigate against the deleterious effects to health. Healthcare contributes 4.9 per cent to the world's carbon emissions<sup>1</sup>, which is more than aviation (1.9–2.4 per cent) or shipping (1.7 per cent)<sup>2–4</sup>. Health systems cannot achieve net zero without addressing operating theatres, which are the most resource-intensive areas of hospitals<sup>5</sup>. To prevent catastrophic global warming, governments around the world have committed to ambitious net-zero goals in all sectors, including healthcare<sup>1</sup>. However, hospitals cannot achieve this without addressing operating theatres.

Trying to change a whole hospital at once is very complex and likely to fail, so operating theatres are the best place to start a journey to net-zero healthcare<sup>6</sup>. They are sheltered environments with few external influences, treat a single patient at once, involve members across a multidisciplinary team, and have a huge environmental impact<sup>7</sup>. If evidence was provided and behaviour changed in operating theatres, learning could be expanded across other hospital areas and along the patient-care pathway, from primary care to postoperative recovery. As surgical services are likely to expand to address

post-coronavirus disease (COVID) backlogs<sup>8</sup>, measures to mitigate against increased environmental impact are a priority.

Candidate interventions need to be scalable across multiple, heterogeneous hospitals, and not be limited to enthusiastic, single-centre advocates. Furthermore, they should be holistic to whole systems across the operating theatre, to prevent siloed approaches<sup>9</sup>. Interventions must not erode the safety and quality of surgical services and should be acceptable to patients<sup>10</sup>. The aim of this co-prioritization process was to generate a ranked list of globally relevant, feasible, and acceptable interventions to reduce the environmental impact of operating theatres.

## Methods

Methodologies were combined to harmonize knowledge gaps and co-prioritize interventions that are feasible and acceptable to stakeholders<sup>11</sup>. This global co-prioritization exercise consisted of four phases:

- Phase 1: a systematic review and global consultation with perioperative healthcare professionals (HCPs) to longlist candidate interventions with evidence of effectiveness.

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- Phase 2: iterative thematic analysis to shortlist these interventions.
- Phase 3: co-prioritization of these shortlisted interventions by key stakeholders, including clinicians and patients, based on feasibility, acceptability, and safety.
- Phase 4: ranking of these interventions into an ordered list of actionable interventions across both high-income countries (HICs) and low-middle-income countries (LMICs).

### Phase 1: systematic review and global consultation survey

A systematic review of the literature was performed according to the PRISMA guidelines to identify studies describing interventions to reduce the environmental impact of operating theatres<sup>12</sup>. As a pragmatic approach in this study, reduced environmental impact was defined as reduction of carbon output (measured with a carbon dioxide equivalent (CO<sub>2</sub>e) calculation) or reduction of plastic waste. A search was performed using MEDLINE, Embase, and Cochrane Library databases, searching for studies published until 3 December 2021. A summary of search terms used for the systematic review are presented in [Table S1](#). Both peer-reviewed full papers and other article types (for example conference abstracts and reports) were eligible. Exclusion criteria were: interventions delivered outside of the operating theatre; and (ii) non-surgical patients (that is endoscopy). Full texts of potentially eligible trials were obtained and independently evaluated for inclusion in the review based on the inclusion criteria. Studies describing surgery for any condition and anaesthesia of any modality were included. References of all included studies were reviewed to ensure relevant studies were included. All studies were independently assessed by two reviewers (Sivesh Kamarajah and Harvinder Mann). When there was disagreement, the senior authors (Aneel Bhangu, James Glasbey, Dmitri Nepogodiev, or Elizabeth Li) assessed the study to reach a consensus. The extracted list of interventions was combined to form the basis of the longlist.

Next, a global consultation survey was conducted with perioperative HCPs (such as surgeons, anaesthetists, theatre practitioners, nurses, and hospital managers) sampled from across the National Institute for Health and Care Research (NIHR) Global Health Unit on Global Surgery network. The consultation survey aimed to explore the current adoption of interventions identified in the systematic review, collate novel, unpublished interventions with early evidence of effectiveness, and identify any barriers to implementing these interventions. The final longlist of interventions were classified into the following categories, as previously described: scope 1: direct emissions; scope 2, emissions from electricity; or scope 3, all other indirect emissions from the supply chain<sup>13</sup>.

### Phase 2: shortlisting of interventions

Individual interventions (transcribed verbatim) underwent three-stage thematic content analysis, consisting of coding, assigning descriptive themes, and then generating summarized interventions across each of the three scopes. Each intervention was double-coded, with analysis performed iteratively by four researchers (Sivesh Kamarajah, James Glasbey, Dmitri Nepogodiev, and Aneel Bhangu) to a point of saturation. As interventions frequently targeted the same carbon-reduction activities, these were combined to reduce redundancy and/or duplication. Differences between specific components of the intervention (for example action, actor, context, target, and

time) were recorded<sup>14</sup>. Consensus on phrasing for the combined intervention domains were agreed across the research team. The results of the thematic analysis were reviewed across two focus-group discussions, including international representation across the perioperative clinical and management teams.

### Phase 3: co-prioritization with clinicians and patients

After shortlisting, a second global consultation was conducted with perioperative HCPs and hospital managers, to explore perceptions of acceptability, feasibility, and safety of candidate interventions from phase 2. In parallel, a Patient Advisory Group (PAG) was established in partnership with Patients and Research Together (PaRT) from Bowel Research UK in line with NIHR Centre for Engagement and Dissemination (CED) recommendations<sup>15</sup>. Diverse representation was proactively sought in accordance with the INCLUDE principles in inclusive research design<sup>16</sup>. The PAG co-developed a patient and public-facing survey using lay language that was disseminated across a broad network of charities and patient groups. The survey targeted those who had had or were currently awaiting surgery. The results of the clinician survey were reviewed by the PAG in an advisory group meeting to further develop emerging themes and inform phase 4 ranking. Members of the PAG were included as equal co-authors in this study's collaborative author group.

### Phase 4: ranking of interventions based on feedback from the Patient Advisory Group, the results of phase 3

Co-prioritization informed ranked lists of interventions based on HCPs' perceptions of feasibility; patient and public co-authors highlighted that patients would be largely unaware of many changes to greener practices in operating theatres, but that they perceived sustainable care to be a marker of a high-quality health system and so ease of implementation was a priority. The ranked lists are presented stratified by country-income group (HIC versus LMIC) of respondents according to World Bank 2019 definitions<sup>17</sup>.

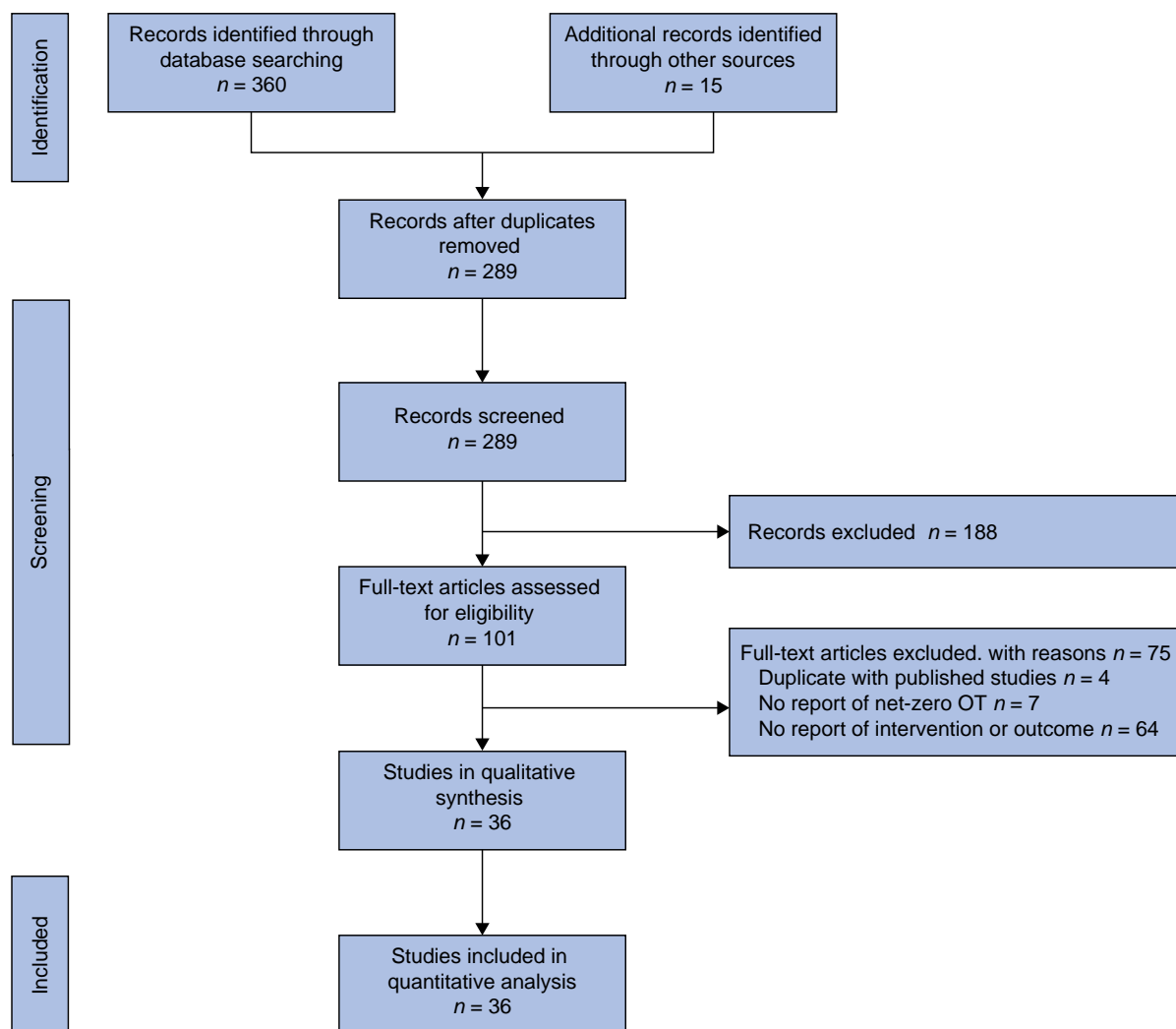
### Ethics

Ethical approval was not required as the global consultation survey gathered fully anonymized expert opinions from our network of research collaborators and co-authors. INVOLVE guidance states ethical approval is not needed for research activities involving patients and the public when they have active involvement, providing opinions and specialist knowledge or advice<sup>18</sup>.

## Results

### Phase 1: systematic review and global consultation survey

The systematic review identified 289 studies, of which 36 ([Table S2](#)) were included after full-text review ([Fig. 1](#)). These reported 43 interventions to reduce the environmental impact of operating theatres. To minimize redundancy, comparable interventions were combined after consensus agreement across the research team ([Table S3](#)). [Table 1](#) shows the 24 agreed interventions generated during this process. The majority of interventions (29/36) were from single-centre studies with no evidence of scaling across multiple departments or hospital networks ([Table S2](#)). None of the studies reported safety implications of these interventions (0/36).



**Fig. 1** PRISMA flow chart of studies included in the systematic review of interventions to reduce the carbon footprint of operating theatres.<sup>19</sup>

A total of 3042 professionals from 117 countries participated in the global consultation (Table S4), of which 36.0 per cent of respondents were from LMICs. Environmental-impact reduction interventions reported in the literature were often not in current practice (median of 24.5 (interquartile range 21.8–35.8) per cent; Table 1). The consultation identified a further 88 unpublished interventions from participants (Table S5). As part of this consultation, HCPs were also asked their opinions on sustainable surgical practices. Of the perioperative professionals, 96.5 per cent were willing to change practice, but only 2.3 per cent felt that there were no barriers to implementation of environmentally beneficial surgical practices in their hospital (Table 2 and Table S6). When exploring barriers to greener operating theatres, there were low rates of sustainable practice plans (17.0 versus 14.4 per cent in LMICs and HICs respectively) and operating theatre sustainability leads (14.1 versus 10.0 per cent), and a lack of information about which green surgery initiatives should be prioritized (78.2 versus 76.0 per cent in LMICs and HICs respectively).

## Phase 2: shortlisting of interventions

During thematic analysis, the longlist was reduced from 112 interventions (24 from the systematic review and 88 from the global consultation) to 15 intervention domains (Fig. 2).

## Phase 3: co-prioritization with clinicians and patients

Co-prioritization was conducted with 5218 perioperative HCPs and hospital managers from 132 countries, of which 2295 of respondents (44.0 per cent) were from LMICs (Table S4). Perioperative professionals considered most of the shortlisted interventions to be safe and feasible, although safety concerns for interventions were generally higher in LMICs (median of 15.8 (range 8.9–40.1) per cent) than HICs (median of 9.1 (range 4.2–29.9) per cent) (Table 3 and Table 4). Interventions raising highest concerns were re-sterilization of ‘single-use’ consumables (40.1 versus 29.9 per cent in LMICs and HICs respectively) and reduction of gases for minimally invasive surgery (21.5 versus 26.0 per cent in LMICs and HICs respectively). Despite being ranked third highest for safety concerns by professionals in LMICs (23.1 per cent; Table 3), introducing surgical devices that can be reused was identified as the most feasible (74.3 per cent). Free-text feedback from LMIC professionals and the international steering group indicated that this was due to pre-existing wide reuse of surgical devices due to financial and resource constraints.

Patient co-prioritization was conducted with 75 patients from the UK only. In general, patient acceptability for patient-facing

**Table 1 Current global practice regarding environmental-impact reduction in operating theatres, organized by scope of the greenhouse gas protocol<sup>13</sup>**

	Overall	HIC	LMIC
<b>Scope 1</b>			
Reducing desflurane use	25.3	31.1	18.6
Removing desflurane from theatre	18.8	19.7	17.9
Reducing nitrous oxide use	32.4	33.4	31.3
Removing nitrous oxide from theatre	23.6	20.8	26.3
Using low flow when using volatile anaesthetics	39.4	40.5	38.2
Mandating total intravenous anaesthesia	13.9	12.1	16.0
<b>Scope 2</b>			
Turning off lights in theatre at night/weekends	61.1	60.6	61.9
Motion-activated lights	14.8	14.3	15.7
Turning down heating/air conditioning at night/weekends	40.5	31.5	52.0
Installing light-emitting diode (LED) lights	31.5	26.1	38.6
Switching off taps between hand washing	64.1	62.4	66.7
<b>Scope 3</b>			
Recycling non-contaminated waste	34.0	38.0	27.5
Reducing plastic syringe use	13.2	12.7	13.9
Reducing unnecessary intravenous fluid use	35.4	30.7	42.1
Reducing unnecessary intravenous drug use	37.3	32.0	44.5
Using reusable surgical gowns	23.3	14.8	36.9
Using reusable surgical drapes	23.1	14.2	37.5
Reducing single-use instruments	23.1	15.7	34.6
Switching blue sterile tray wraps to metal canister trays	23.4	18.4	31.6
Redesigning trays for efficiency	19.4	16.4	24.0
Reducing disposable glove use for simple patient transfers	16.5	11.0	24.9
Using reusable laparoscopy ports	26.8	13.7	45.2
Reserving laparoscopic and robotic surgery	37.0	33.6	42.1
Using reduced packaging	22.7	17.0	30.2

Values are percentages. Scope 1, direct emissions; scope 2, emissions from electricity; and scope 3, all other indirect emissions from the supply chain.<sup>13</sup> HIC, high-income country; LMIC, low-middle-income country.

**Table 2 Barriers to implementing green surgery initiatives identified by perioperative professionals**

	Overall	HIC	LMIC
Lack of information about which green surgery initiatives should be prioritized	77.0	76.0	78.2
Lack of guidance for how to implement green surgery initiatives	75.2	74.0	67.6
Lack of support from hospital management for green surgery initiatives	59.0	60.2	57.5
Lack of engagement by theatre team with green surgery issues	48.4	46.8	50.5
Lack of hospital sustainability lead	76.2	75.5	77.2
Lack of operating theatre sustainability lead	88.4	90.0	95.9
Perceived cost of implementing green surgery initiatives	62.3	60.9	64.1
Lack of time to implement green surgery initiatives	37.6	44.7	28.7
None of the above is a barrier at my hospital	2.3	2.4	2.2

Values are percentages. HIC, high-income country; LMIC, low-middle-income country.

intervention domains was high (median of 93 (interquartile range 90–96) per cent). The only interventions with patient acceptability less than 90 per cent were using local rather than general anaesthetic (84 per cent) and reuse of single-use consumables (86 per cent).

Patients also highlighted the need for an environmentally friendly operation (97 per cent agreed) if interventions were safe and effective, and 95 per cent felt this was important to their community (Table S7). In terms of the financial implications of implementing these interventions, patients were divided, with 51 per cent supportive of carbon reduction even if it meant higher costs to the health service. Respondents agreed that health services should promote their efforts to reduce the carbon footprint in surgery (75 per cent) and, to a lesser extent, that patients should be empowered to make choices to reduce the carbon footprint of their operation as part of the consent process (70 per cent; Table S7). The PAG enriched this by adding that with concerns around the time of surgery for their own recovery and safety, these factors would take precedent over making more carbon-conscious choices during surgery.

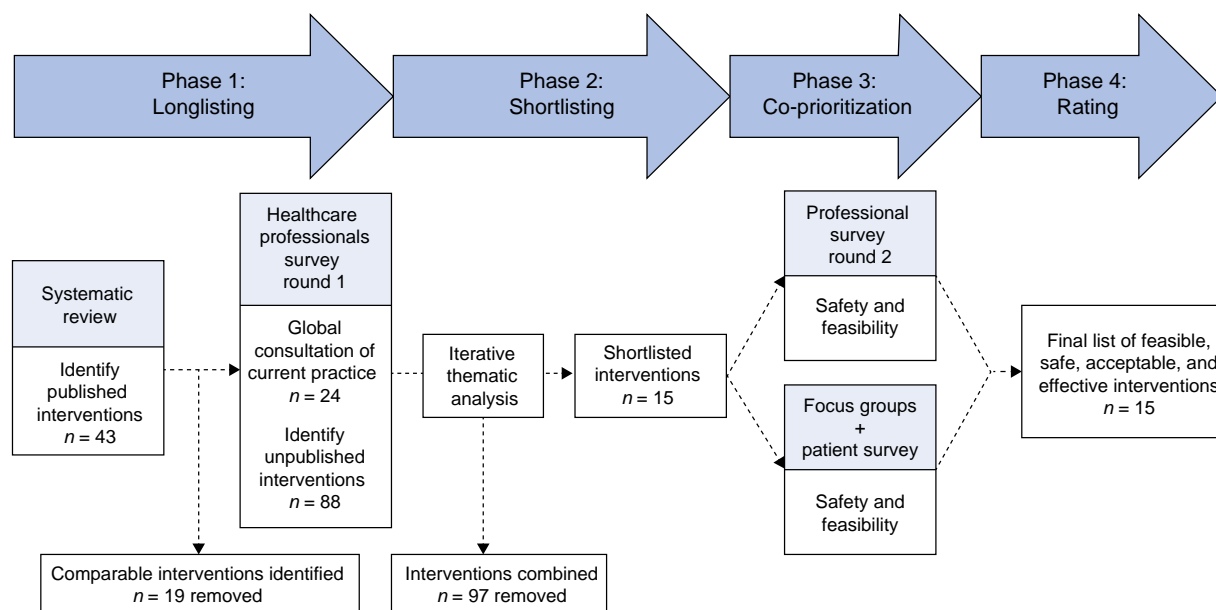
#### Phase 4: ranking of final interventions

The final intervention domains were ranked based on feasibility (Fig. 2), as determined by perioperative professionals from LMICs (Table 3) and HICs (Table 4), with clinician acceptability, safety, and patient acceptability displayed alongside each (Table 5). The top three ranked interventions from LMICs were: introducing reusable surgical devices; reducing use of consumables; and reducing the use of general anaesthesia. The top three ranked interventions from HICs were: introducing recycling; reducing use of anaesthetic gases; and appropriate clinical waste processing.

#### Discussion

This study has identified and ranked a list of interventions that are feasible and immediately actionable for frontline teams and managers to implement within their hospitals. This provides teams around the world a place to start their journey to decarbonizing operating theatres and highlights clear interventions to take forward into future research. This list was divided into two, relevant to both HIC and LMIC settings, to broadly reflect differences in healthcare resourcing. The safety concerns of respondents indicated that further evaluation of some interventions is needed to reassure surgical teams and patients. These were largely around surgical site infections and reusable equipment, and chest infections with changes in anaesthetic practices. Evaluation through well designed, efficient-implementation research is needed to test whether safe and effective measures can be scaled at national and international levels.

Methodologies were combined in this study to try to overcome some of the problems that have limited wide-scale uptake of carbon reduction in operating theatres to date. First, the systematic review identified numerous single-centre studies and opinion pieces, indicating only the very early phases of evidence available. It is very hard for frontline teams to know what to do, and where to start, when reducing their environmental impact. Recent initiatives, such as the UK's Intercollegiate Green Theatre Checklist, are complementary, but contain too many recommendations for immediate implementation (16), and neglect differences in health resourcing, beliefs, and team structures around the world<sup>20</sup>. Second, sustainably reducing carbon in operating theatres is not simple, as teams rotate regularly, and team behaviour needs to be supported by organizational-level change<sup>21</sup>. The systematic review adds to the current literature by identifying barriers and solutions to creating change. This includes a lack of leadership for carbon-reduction initiatives specific to the operating theatre, and a lack of guidance as to which initiatives to prioritize; this is now provided by this manuscript.



**Fig. 2** Co-prioritization of interventions to reduce the carbon and environmental impact of operating theatres

**Table 3** Comparison of perioperative professionals' prioritization voting in low–middle-income countries, ranked by clinicians' perceived feasibility

	Feasibility	Safety concerns	Unintended consequences
Introduce surgical devices that can be reused*	74.3	23.1	23.0
Reduce consumables used*	72.5	16.0	16.9
Reduced general anaesthesia used, increased local/regional anaesthesia†	72.3	8.9	13.4
Reduce energy and water use‡	68.1	15.8	19.4
Increase use of consumables that can be easily recycled*	67.5	14.2	17.5
Ensure appropriate use of clinical waste‡	66.9	12.1	15.2
Introduce reusable surgical gowns and drapes‡	66.8	29.8	29.7
Reduce impact of personal protective equipment (PPE)‡	66.0	22.3	23.8
Reduce the use and wastage of anaesthetic gases‡	65.8	19.4	18.3
Streamline theatre processes‡	64.9	11.0	13.4
Make more use of lightly packaged consumables*	63.0	14.2	16.9
Introduce recycling‡	60.8	13.6	15.5
Introduce re-sterilization and reuse of single-use consumables*	58.0	40.1	39.0
Reduce the impact of surgical fumes§	55.2	12.3	14.4
Reduce the use of gases for minimally invasive surgery¶	48.4	21.5	19.6

Values are percentages. \*Responses from surgeons, theatre nurses, operating department practitioners, and theatre managers/stores only. †Responses from anaesthetists and anaesthetic nurses only. ‡Responses from all participants. §Responses from surgeons and theatre nurses only. ¶Responses from surgeons only.

The strengths of this study include the large network of respondents, from diverse international settings, improving the generalizability of the results. Second, this body of work combines patient and theatre professional views on the interventions to be used in theatre, consulting with a wide range of stakeholders. Public engagement and patient perspectives are essential, given that the benefits of carbon- and waste-reducing interventions are likely to be mainly for the whole community rather than the patient being treated alone<sup>22</sup>. The use of complementary methodologies took the best available evidence, which was found to be widely heterogeneous, and converted it into practical measures suitable for large-scale adoption. This is important, as the next step to create change is to evaluate implementation and scaling across countries and not rely on single-centre enthusiasts.

This study also has limitations, which mainly reflect the very early nature of the literature. The network's judgements on feasibility are relatively subjective and not necessarily borne

through lived experiences (for example installing solar panels for hospital energy). Some interventions that were judged feasible might also require additional, hidden infrastructure changes (for example recycling). This is similar for effectiveness, which reflects an early evidence base and is the best knowledge available until further research emerges. As a result, there was no differentiation between carbon and plastic waste reduction in the ranked co-prioritization lists, and effectiveness estimates were not listed in these tables. Although theatre professionals from LMICs made up 44 per cent of all professionals and managers participating, representation of patients from LMICs was missing from our patient network and is needed in future studies.

This study can be used to point to specific, tangible, next-step research. Where safety concerns were raised, randomized trials with safety outcomes are required, for example evaluating reusable drapes, changes in use of harmful anaesthetic gases, and increase in local anaesthetic repair of inguinal hernia<sup>23</sup>.

**Table 4 Comparison of perioperative professionals' prioritization voting in high-income countries, ranked by clinicians' perceived feasibility**

	Feasibility	Safety concerns	Unintended consequences
Introduce recycling*	76.0	4.2	6.7
Reduce the use and wastage of anaesthetic gases§	71.9	10.1	12.2
Ensure appropriate use of clinical waste*	69.7	4.2	6.0
Reduce consumables used†	68.7	9.1	11.1
Reduce energy and water use*	68.3	8.9	9.9
Reduce the impact of surgical fumes‡	68.2	6.2	8.8
Make more use of lightly packaged consumables†	64.3	6.0	7.8
Increase use of consumables that can be easily recycled‡	60.7	7.5	9.2
Streamline theatre processes*	57.2	6.8	7.8
Reduced general anaesthesia used, increased local/regional anaesthesia§	55.2	10.1	14.9
Introduce surgical devices that can be reused†	53.2	12.6	14.0
Reduce impact of personal protective equipment (PPE)*	53.0	11.7	13.4
Introduce reusable surgical gowns and drapes*	46.2	16.4	18.9
Introduce re-sterilization and reuse of single-use consumables†	33.6	29.9	28.4
Reduce the use of gases for minimally invasive surgery¶	32.2	26.0	22.4

Values are percentages. \*Responses from all participants. †Responses from surgeons, theatre nurses, operating department practitioners, and theatre managers/stores only. ‡Responses from surgeons and theatre nurses only. §Responses from anaesthetists and anaesthetic nurses only. ¶Responses from surgeons only.

**Table 5 Summary of patient and clinician voting during co-prioritization at the end of phase 4, ranked by feasibility overall (low–middle-income countries and high-income countries)**

Stakeholder	Clinicians			Patients	
	Prioritized interventions	Feasibility	Safety	Lay language summary	Acceptability*
Shortlisted intervention		Safety concerns	Unintended consequences		
Reduce consumables used†	70.4	12.1	13.7	Using less disposable ('throwaway') equipment, for example by only opening items when needed rather than 'just in case'	95
Introduce recycling‡	69.3	8.3	10.6	Increasing recycling of the paper, plastics, and metals used in theatre	96
Reduce the use and wastage of anaesthetic gases§	69.2	14.2	14.9	Using strategies to reduce the use of greenhouse gases by the anaesthetist when you are put to sleep for your operation (Not patient facing)	91
Ensure appropriate processing of clinical waste‡	68.5	7.7	10.0		–
Reduce energy and water use‡	68.2	11.9	14.1	Reducing heating, lighting, and water usage in empty operating theatres (Not patient facing)	99
Make more use of lightly packaged consumables†	63.7	9.6	11.8		–
Increase use of consumables that can be easily recycled‡	63.7	10.4	12.9	(Not patient facing)	–
Reduced general anaesthesia used, increased local/regional anaesthesia§	62.7	9.6	14.2	Where possible, using local anaesthetic rather than general anaesthetic for an operation	84
Reduce the impact of surgical fumes¶	62.5	8.9	11.3	Capturing and safely removing any fumes created during surgery	97
Introduce surgical devices that can be reused†	62.5	17.2	18.0	Choosing surgical equipment that can be sterilized and safely reused in more than one operation (Not patient facing)	95
Streamline theatre processes‡	60.6	8.6	10.3		–
Reduce impact of personal protective equipment (PPE)‡	58.7	16.4	18.0	(Not patient facing)	–
Introduce reusable surgical gowns and drapes‡	55.3	22.3	23.7	Using personal protective equipment that can be washed and sterilized to safely reuse across multiple operations	92
Introduce re-sterilization and reuse of single-use consumables†	44.3	34.4	33.1	Sterilizing and safely reusing equipment that is marketed as 'single-use' by manufacturers	86
Reduce the use of gases for minimally invasive surgery#	39.3	24.0	21.2	Safely reducing the use of greenhouse gases during keyhole surgery	92

Values are percentages. \*Proportion of patients reporting 'very comfortable', 'comfortable', or 'neutral' about the acceptability of this intervention. †Responses from surgeons, theatre nurses, operating department practitioners, and theatre managers/stores only. ‡Responses from all participants. §Responses from anaesthetists and anaesthetic nurses only. ¶Responses from surgeons and theatre nurses only. #Responses from surgeons only. –, not applicable.

Where measures are likely to be both safe and effective, quality-improvement approaches can help to scale changes in energy supply and use, changes in recycling, and changes to

instrument use, and identify the best models to scale this learning around the world. Qualitative methods will be required to create data-driven approaches to behaviour change and engaging senior

management (complex intervention research), the role of leaderships, and the best way to train and sustain diverse teams in carbon reduction<sup>24–26</sup>.

## Collaborators

### The National Institute for Health and Care Research Global Health Research Unit on Global Surgery

Adewale Adisa; Michael Bahrami-Hessari; Aneel Bhangu; Christina George; Dhruv Ghosh; James Glasbey; Parvez Haque; J. C. Allen Ingabire; Sivesh Kathir Kamarajah; Laura Kudrma; Virginia Ledda; Elizabeth Li; Robert Lillywhite; Rohin Mittal; Dmitri Nepogodiev; Faustin Ntirenganya; Maria Picciochi; Joana Filipa Ferreira Simões; L. Booth; R. Elliot; A. S. Kennerton; K. L. Pettigrove; L. Pinney; H. Richard; R. Tottman; P. Wheatstone; John W. D. Wolfenden; A. Smith; A. Emad Sayed; Aakansha Giri Goswami; Aamer Malik; Aaron Lawson Mclean; Abbas Hassan; Abd Jabar Nazimi; Abdallah Aladna; Abdalrahman Abdelgawad; Abdel Saed; Abdelfatah Abdelmageed; Abdelilah Ghannam; Abdalrahman Mahmoud; Abdul Alvi; Abdulaziz Ismail; Abdulhafiz Adesunkanmi; Abdulla Ebrahim; Abdullah Al-Mallah; Abdullah Alqallaf; Abdullah Durrani; Abdullah Gabr; Abdullahi Musa Kirfi; Abdulmalik Altaf; Abdulmjeed Almutairi; Abdurrahman J. Sabbagh; Abdulrazak Ajiya; Abdurrahman Haddud; Abed Alfattah Mahmoud Alnsour; Abhinav Singh; Abhishek Mittal; Abigail Semple; Abiodun Adeniran; Abraham Negussie; Abraham Oladimeji; Abubakar Bala Muhammad; Abubaker Yassin; Abuzer Gungor; Achille Tarsitano; Adaiha Soibiharry; Adam Dyas; Adam Frankel; Adam Peckham-Cooper; Adam Truss; Adamu Issaka; Adel Mohamed Ads; Adeleke Akeem Aderogba; Ademola Adeyeye; Adesoji Ademuyiwa; Adham Sleem; Adrian Papa; Adriana Cordova; Adu Appiah-Kubi; Adullah Meead; Aeris Jane D. Nacion; Afieharo Michael; Agustin Albani Forneris; Agustin Duro; Agustin Rodriguez Gonzalez; Ahmad Altouny; Ahmad Ghazal; Ahmad Khalifa; Ahmad Ozair; Ahmad Quzli; Ahmad Haddad; Ahmad Faizal Othman; Ahmad Shuib Yahaya; Ahmed Elsherbiny; Ahmed Nazer; Ahmed Tarek; Ahmed Abu-Zaid; Ahmed Al-Nusairi; Ahmed Azab; Ahmed Elagili; Ahmed Elkazaz; Ahmed Kedwany; Ahmed Mohammed Nuhu; Ahmed Sakr; Ahmed Shehta; Ahmed Shirazi; Ahmed Mohamed Ibrahim Mohamed; Ahmed Elshawadfy Sherif; Ahmed K. Awad; Ahmed M. Abbas; Ahmed Saber Abdelrahman; Ahmed Siddique Ammar; Ahmed Y. Azzam; Ahmet Burak Ciftci; Ahmet Cem Dural; Ahmet Necati Sanli; Aida Cristina Rahy-Martín; Aida Rosita Tantri; Aimal Khan; Aiman Al-Touny; Aiman Tariq; Aimen Gmati; Ainhua Costas-Chavarri; Aino Auerkari; Aitor Landaluce-Olavarria; Ajay Puri; Ajay Radhakrishnan; Akaninyene Esemé Ubom; Akhilesh Pradhan; Akif Turna; Akinfolarin Adepiti; Akira Kuriyama; Al-Faraaz Kassam; Ala Hassouneh; Alaa El-Hussuna; Alaa Habeebullah; Alaa Mohamed Ads; Alaa Mousli; Alan Biloslavo; Alan Hoang; Alan Kirk; Alasdair Santini; Alba Vazquez Melero; Albaro José Nieto Calvache; Albert Baduell; Albert Chan; Alberto Abrate; Alberto Balduzzi; Alberto Cabañero Sánchez; Alberto Navarrete-Peón; Alberto Porcu; Alberto Brolese; Alberto G. Barranquero; Alberto Maria Saibene; Albushra Altayeb Adam; Aldo Vagge; Alejandra Jara Maquilón; Alejandro Leon-Andrino; Aleksandar Sekulić; Aleksandar Trifunovski; Aleksandro Mako; Alemayehu Ginbo Bedada; Alessandro Broglia; Alessandro Coppola; Alessandro Giani; Alessandro Grandi; Alessandro Iacomino; Alessandro Moro; Alessia D'amico; Alessia Malagnino; Alethea Tang; Alex Doyle; Alex Alfieri; Alex Haynes; Alex Wilkins; Alexander Baldwin; Alexander Heriot; Alexander Laird;

Alexander Lazarides; Alexander O'connor; Alexander Trulson; Alexander Christopher Rokohl; Alexandra Caziuc; Alexandra Triantafyllou; Alexandre Anesi; Alexandrina Nikova; Alexandros Andrianakis; Alexandros Charalabopoulos; Alexandros Tsolakidis; Alexandru Chirca; Alexis P. Arnaud; Alexis Rafael Narvaez-Rojas; Alfie Kavalakat; Alfio Spina; Alfonso Recordare; Alfredo Annicchiarico; Alfredo Conti; Alhassan Datti Mohammed; Ali Kocatas; Ali Almhimid; Ali Arnaout; Ali Fahmy; Ali Mangi; Ali Modabber; Ali Bilal Ulas; Ali Yasen Y. Mohamedahmed; Alice Frontali; Alice Moynihan; Alif Yunus; Aline Ahmad; Alistair J Kent; Almu'atasim Khamees; Aloy Okechukwu Ugwu; Alparslan Turan; Alsnosy Abdullah Khalefa Mohammed; Alvaro Navarro-Barrios; Alvaro Yebes; Álvaro Francisco Lopes De Sousa; Amabelle Moreno; Aman Sethi; Amanda Caroline Dawson; Amani Alsayd Abdulsalam Othman; Amanjot Kaur; Amanuel Wolde; Amedeo Antonelli; Amedeo Scifo; Ameen Alhamad; Amelia Davis; Amer Alderazi; Amer Harky; Amina Mohammed-Durosolorun; Amina Seguya; Amina Okhakhu; Amine Chamakhi; Amine Sebai; Amine Souadka; Amir Asla; Amit Agrawal; Amit Persad; Amit Gupta; Amr Elgazar; Amruta Kulkarni; Amy Coates; Ana Ciscar Bellés; Ana Danic Hadzibegovic; Ana Jotic; Ana Kowark; Ana Martins; Ana Mejia Pineda; Ana Peral; Ana Sánchez Gollarte; Ana Senent-Boza; Ana Isabel Avellaneda Camarena; Ana M. Castaño-Leon; Ana Maria Minaya Bravo; Ana María Gimeno Moro; Ana-Maria Musina; Ana-María Tapia-Herrero; Anai Kothari; Anand Gupta; Anand Raja; Anas Aljaiuossi; Anas Taha; Anass Mohammed Majbar; Anastasia Prodromidou; Anastasios Kanatas; Anaya Gupte; Andee Dzulkarnaen Zakaria; Andrea Balla; Andrea Barberis; Andrea Bondurri; Andrea Bottari; Andrea Costantino; Andrea Figus; Andrea Lauretta; Andrea Mingoli; Andrea Romanzi; Andrea Sagnotta; Andrea Scacchi; Andrea Picchetto; Andrea Estefania Cueto Valadez; Andrea-Pierre Luzzi; Andreas Älgå; Andreas Fontalis; Andreas Hecker; Andreas K Demetriades; Andreea-Madalina Serban; Andrei Bogdan Văcărașu; Andrej Cokan; Andres Isaza-Restrepo; Andrew Beamish; Andrew Schache; Andrew Stevenson; Andrew Yiu; Andrew J. Cockbain; Andrey Litvin; Ane Abad-Motos; Angel Becerra; Ángel Cilleruelo Ramos; Angela Chiaradia; Angela Dell; Angela Romano; Angelo Pascale; Angelo Alessandro Marra; Angelos Dimas; Angelos Kolias; Anis Cerovac; Anish Koneru; Anisse Tidjane; Anita Eseenam Agbeko; Ankur Bajaj; Ankush Gosain; Anna Allan; Anna Carreras-Castañer; Anna D'amore; Anna Dare; Anna Maffioli; Anna Palepa; Anna Paspala; Anna Konney; Anna Nunzia Della Gatta; Anne-Cecile Ezanno; Anneza Yiallourou; Anthony Kinnair; Anthony Rayner; Anthony Kevin Scafa; Antoinette Bediako Bowan; Antonella Veglia; Antonino Russo; Antonino Maniaci; Antonio Castaldi; Antonio Gil-Moreno; Antonio Maffuz-Aziz; Antonio Meola; Antonio Nenna; Antonio Perez Ferrer; Antonio Ramos Bonilla; Antonio Ramos-De La Medina; Antonio Rodriguez Infante; Antonio Santoro; Antonio Simone Laganà; Antony Bateman; Antony Louis Rex Michael; Anwaar Abozid; Anwar Sadat Seidu; Aoife Lowery; Apichat Tantraworasin; Aqsa Rasheed; Arcangelo Picciariello; Arda Isik; Areeba Saif; Arfa Anjum; Argyrios Ioannidis; Ariel Abeldaño; Arif Hussain; Arjun Nathan; Arkady Bedzhanyan; Arkaitz Perfecto; Armando De Virgilio; Armando Galvan; Armin Sahlitzki; Arne Böttcher; Arrigo Pellacani; Arthur Gatti; Arturan Ibrahimli; Arun Menon; Arun Sahni; Aruyaru Stanley Mwenda; Asad Choudhry; Asanka Jayawardane; Ashish Gupta; Ashok Ramasamy; Ashrarur Rahman Mitul; Ashvind Bawa; Ashwani Nugur; Ashwin Rammohan; Ashwin Sachdeva; Asif Mehraj; Asif Yildirim; Asma Alqaseer; Asmaa Radwan; Asser Sallam;

Athanasios Syllaios; Athanasios Tampakis; Athari Alwael; Athina Samara; Atila Eroglu; Atiqur Rahman; Atila Ulkucu; Atila Zaránd; Audrius Dulskas; Augustine Tawiah; Augusto Zani; Aurelia Vas; Ausra Lukosiute-Urboniene; Auwal Adamu; Avinash Aujayeb; Awais Amjad Malik; Ayberk İplikçi; Ayesha Mahmud; Aylin Pelin Cil; Ayomide Makanjuola; Ayoub Akwaisah; Aysuna Galandarova; Ayten Saracoglu; Azel Regan; Aziz Mutlu Barlas; Baba Alhaji Bin Alhassan; Badr Mostafa; Baha Ben Hamida; Bahar Canbay Torun; Bahiyah Abdullah; Balasingam Balagobi; Balazs Banky; Baljit Singh; Bamidele Alegbeleye; Banu Yigit; Baraa Nabil Hajjaj; Barbara Burgos-Blasco; Barbara Seeliger; Barnabas Alayande; Barrag Alhazmi; Bassey Enodien; Beatrice Torre; Beatriz Gómez Pérez; Beatriz Villota Tamayo; Beatriz De Andrés-Asenjo; Begoña Quintana-Villamandos; Behiç Girgin; Behrad Barmayehvar; Bekzat Beisenov; Ben Creavin; Ben Dunne; Ben Marson; Ben Waterson; Benjamin Martin; Benjamin Zucker; Benjamin Ngie Xiong Wong; Berk Baris Ozmen; Bernard Hammond; Bernard Mbwele; Bernardo Núñez; Bert Dhondt; Besma Gafsi; Bethan Mcleish; Bettina Lieske; Bhavesh Tailor; Biagia La Pira; Biagio Picardi; Biagio Zampogna; Biagio Casagrande; Bianca Maria Festa; Bijnya Panda; Bilal Kirmani; Bilal Sulaiman; Binay Gurung; Bincy Zacharia; Birgit Bette; Birhanu Ayana; Bisera Nikolovska; Blanca Capdevila Vilaró; Blanca De Vega Sánchez; Bm Zeeshan Hameed; Bogdan Diaconescu; Bojan Kovacevic; Boris Bumber; Boris Sakakushev; Boris Tadic; Bouhani Malek; Bourhan Alrayes; Bradley Thomas; Branislav Gális; Brendan Gallagher; Brett Knowles; Brian Cunningham; Brian Daley; Brijesh Mishra; Bruce Ashford; Brunella Maria Pirozzi; Bruno Berselli; Bruno Martinez-Leo; Bruno Sensi; Bruno Nardo; Burak Celik; Burak Giray; Burçin Abud; Bushray Almiqlash; C S Pramesh; Cagatay Taskiran; Caio Antonio De Campos Prado; Calogero Cipolla; Calvin Kumar; Camilla English; Camilla Riccetti; Camilla Vanni; Camille Brassat; Candice Downey; Caoimhe Duffy; Carina Chwat; Carina Cutmore; Carl Sars; Carlo Ratto; Carlo Alberto Pacilio; Carlos De La Infesta García; Carlos Guijarro Moreno; Carlos Magalhães; Carlos Prada; Carlos Shiraiishi Zapata; Carlotta Senni; Carolina Dutra Queiroz Flumignan; Carolina Martinez-Perez; Carolina Lugo Duarte; Carolina Soledad Romero Garcia; Caroline Anderson; Caroline Hing; Carolyn Cullinane; Caterina Cina; Catheriner Zabkiewicz; Catrin Sohrabi; Cem Emir Guldogan; Cezar Ciubotaru; Chaitya Desai; Chandrajit Raut; Charles Demetriou; Charles Handford; Charles Okpani; Charudutt Paranjape; Cherry Koh; Chetan Khatri; Chetan Parmar; Chi Wei Mok; Chiara Caricato; Chiara Marafante; Chidiebere Peter Echieh; Chih Ying Tan; Chon Sum Ong; Christel Conso; Christiaan Jardinez; Christian Konrads; Christian Warner; Christian Chigozie Makwe; Christin Henein; Christina Fleming; Christina L Roland; Christine Maurus; Christine Nitschke; Christof Mittermair; Christoph Mallmann; Christophe Andro; Christopher Harmston; Christopher Kuppler; Christopher Lotz; Christopher Nahm; Christopher Rowe; Christopher Ryalino; Christopher Wallis; Christopher Paul Millward; Christos Anthoulakis; Christos Apostolou; Christos Chouliaras; Christos Kalfountzos; Christos Kaselas; Christos Vosinakis; Chukwuma Okereke; Chung Shen Chean; Ciaran Barlow; Cihad Tatar; Cillian Clancy; Cillian Forde; Claire Sharpin; Claire Mccarthy; Claire Nestor; Claire Warden; Clara Castro Ávila; Clara Massaguer; Clarissa Ern Hui Fang; Claudia Pinto Martins; Claudio Guerci; Claudio Mauriello; Clemens Holzmeister; Clemens Miller; Clemens Weber; Clemens Georg Wiesinger; Cleo Kenington; Colin Noel; Colin Sue-Chue-Lam; Collins Adumah; Colm Neary; Comert Sen; Conall Fitzgerald; Constantine Ezeme;

Constantinos Nastos; Cristian Mesina; Cristina Bombardini; Cristina Torregrosa; Cristina Puentes Valdespino; Cristine Pathirannehalage Don; Dakshitha Wickramasinghe; Damiano Milanesi; Daniel Armijos; Daniel Asiiimwe; Daniel Beswick; Daniel Clerc; Daniel Cox; Daniel Doherty; Daniel Fernández Martínez; Daniel Garay Lechuga; Daniel Gero; Daniel Gil-Sala; Daniel Lindegger; Daniel Reim; Daniel Shaerf; Daniel Shmukler; Daniela Branzan; Daniela Filipescu; Daniela Rega; Daniele Bernardi; Daniele Bissacco; Daniele Fusario; Daniele Morezzi; Danielle Sabella; Danijela Mrazovac Zimak; Danilo Vinci; Danjuma Sale; Danyal Zaman Khan; Daniel Thereska; Dario Andreotti; Dario Tartaglia; Darling Ramatu Abdulai; Dattatreya Mukherjee; Daunia Verdi; David Idowu; David John; David Johnson; David Moro-Valdezate; David Naumann; David Omar; David Proud; David Roberts; David Santos Guzmán; David Watson; David Julià Bergkvist; David Benjamin Lumenta; Davide Ferrari; Davide Rizzo; Dawit Degarege; Dayan Fanery Campino Castillo; Deborah Douglas; Deborah Wright; Deedar Nanjiani; Dejan Bratus; Demet Altun; Denise Sievers; Dennis Vaysburg; Devvrat Katechia; Dhruva Ghosh; Diallo Abdoul Azize; Diana Rodrigues; Diana Alejandra Pantoja Pachajoa; Dickon Hayne; Didier Mutter; Diego Raimondo; Diego Eskinazi; Diego Sasia; Diletta Corallino; Dillip Muduly; Dilraj Grewal; Dimitar Hadzhiev; Dimitra Peristeri; Dimitri Pournaras; Dimitri Aristotle Raptis; Dimitrios Angelou; Dimitrios Haidopoulos; Dimitrios Magouliotis; Dimitrios Moris; Dimitrios Schizas; Dimitrios Symeonidis; Dimitrios Tsironis; Dimitrios Korkolis; Dimitris Tatsis; Dinesh Thekkinkattil; Dirk Rolf Bulian; Diwakar Pandey; Dogan Vatansever; Dominic Parker; Dominik Wiedemann; Dominika Borselle; Domiziana Pedini; Donald Schweitzer; Donatas Venskutonis; Job Otokwala; Kabir Musa Adamu; Parvathy Pk; Mebanshanbor Garod; Amera Ali Dakheel Ellafi; Dragana Zivkovic; Drago Jelovac; Duminda Wijesundera; Duncan Mcpherson; Éanna Ryan; Ebere Ugwu; Ebikela Ivie Baidoo; Ebrahim Shaddad; Ecem Memişoğlu; Eddy P. Lincango Naranjo; Edgar Brodtkin; Edoardo Segalini; Edoardo Viglietta; Eduard Hendriks; Eduard-Alexandru Bonci; Eduarda Sá-Marta; Eduardo Nieto Ortega; Eduardo Garcia-Loarte Gomez; Edwaldo Edner Joviliano; Edward Clune; Edward Horwell; Edward Mains; Edward Vasarhelyi; Edward J. Caruana; Edward J. Nevins; Edwin Mwintiereh Ta-Ang Yenli; Efratratia Baili; Eftychios Listoridis; Eghosa Morgan; Ehab Shiban; Ejaz Latif; Ekaterini Christina Tampaki; Ekene Ezenwa; Ekpemi Irune; Elaine Borg; Elamin Eisa; Eleftherios Gialamas; Elena Parvez; Elena Theophilidou; Elena Adelina Toma; Eleni Arnaoutoglou; Elgun Samadov; Elie Kantor; Elif Akbas Ulman; Elif Colak; Elisa Cassinotti; Elisa Bannone; Elise Sarjanoja; Elizabeth Yates; Elizabeth Vincent; Elizabeth Weng Yan Lun; Elmedina Cerovac; Elmes Saoussene Dif; Elmustafa Alkhalifa; Elorm Daketsey; Elsayed A. Fayad; Eman Sheikh; Emanuele Pontecorvi; Emanuele Cammarata; Emanuele La Corte; Emanuele Rausa; Emeka Danielson Odai; Emilia Guasch; Emiliano Cano-Trigueros; Emilie Uldry; Emilio Peña Ros; Emily Matthews; Emin Erhan Donmez; Emmanouil Giorgakis; Emmanouil Kapetanakis; Emmanouil Stamatakis; Emmanuel Bua; Emmanuel Schneck; Emmanuel Aadereyir Nachele; Emmanuel Owusu Ofori; Emrah Akin; Emre Gönüllü; Emre Furkan Kirkan; Enes Çelik; Enoch Wong; Enrico Capozzi; Enrico Pinotti; Enrique Colás-Ruiz; Enrique González; Enver Fekaj; Ephraim Ohazurike; Ephrem Kebede; Ergin Erginöz; Erik Efrain Sosa Duran; Erin Scott; Erman Aytac; Erminia Albanese; Ernes John Castro; Eslam Albayadi; Eslam Kriem; Esra Siddig; Esraa Otfy; Essam Eldien Abuobaida Banaga Hag El Tayeb; Estelle How Hong; Esther Saguil; Etienne Belzile; Eugene Tuyishime;



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Mekki Hassan; Menan Elsadek; Mengistu G. Mengesha; Mercedes Estaire Gómez; Merihan A. Elbadawy; Meron Pitcher; Mert Tanal; Merve Tokocin; Merve Ergenc; Meryem Nur Çelik; Metaxia Bareka; Mevlut Recep Pekcici; Micaela Cappuccio; Michael Dasa; Michael Dewan; Michael El Boghdady; Michael Ezeanochie; Michael Greenhalgh; Michael Jenkinson; Michael Kelly; Michael Spartalis; Michael Zyskowski; Michaël Racine; Michael De Cillia; Michael Jen Jie Chu; Michael R. Mallmann; Michael Z. L. Zhu; Michail Klimovskij; Michail Vailas; Michał Kisielewski; Michel Adamina; Michela Campanelli; Michele Carvello; Michele Ammendola; Michele Manigrasso; Michele Scopelliti; Michelle White; Michelle L. Collins; Mickael Chevallay; Miguel Fróis Borges; Miguel Mayo-Yáñez; Miguel Rocha Melo; Miguel Ruiz-Marín; Miguel Angel Freiria Eiras; Miguel F. Cunha; Mihaela Pertea; Mihail Slavchev; Mihnea Davidescu; Mikel Prieto; Mikhail Agapov; Milad Gahwagi; Milagros Carrasco Prats; Milan Rudic; Milena Senica Verbic; Milosz Kostusiak; Mircea Gabriel Stoleriu; Miriam Abellan Lucas; Mirko Barone; Misbahu Ahmad; Misganaw Alemu Adimass Alemu; Mishal Fatima; Mitsuru Ida; Mo Sahu; Mo'nes Muhaisen; Moacyr Salem; Moataz Maher Emara; Mobolaji Oludara; Mohadeseh Sotudeh; Mohamad B. Kassab; Mohamed Abdelkhalek; Mohamed Alsoni; Mohamed Anwar; Mohamed El-Kassas; Mohamed Elbahnasawy; Mohamed Eldabaa; Mohamed Rabie; Mohamed Abdelghafor Hassanin; Mohamed Adhnan Thaha; Mohamed Shafi Mahboob Ali; Mohammad Alhamid; Mohammad Badr Almoshantaf; Mohammad Reza Keramati; Mohammed Bafaquh; Mohammed Abuzaid; Mohammed Al-Shehari; Mohammed Alharthi; Mohammed Alkahlan; Mohammed Alwash; Mohammed Alyousef; Mohammed Amir; Mohammed Basendowah; Mohammed Deputy; Mohammed Jibreel; Mohammed Shadrul Alam; Mohammed Alsharif; Mohammed Duah Issahalg; Mohammed Eltahier Abdalla Omer; Mohammed Kabir Abubakar; Mohd Rusdi Draman; Moheyaldien Ahmed Elamin Elnour; Momin Eltayeb; Monica Noguez Castillo; Monir Jawad; Monish Raut; Montassar Ghalleb; Morihiro Katsura; Moritz Lebe; Mostafa Abbas; Mostafa Abdelrahman; Mostafa Shalaby; Muhamed Farhan-Alanie; Muhammad Farooq; Muhammad Musadaq; Muhammad Arshad; Muhammad Ayyub Anjum; Muhammad Usman; Muhammad Amjad Chaudhary; Muhammad Asif Raza; Muhammad Fairuz Shah Abd Karim; Muhammad Hamid Chaudhary; Muhammad Haris Janjua; Muhammad Imran Khokhar; Muhammad Isfandyar Khan Malik; Muhammad Taqi Pirzada; Muhammad Umar Younis; Muhammad Elhadi; Muhammed Salih Suer; Muhammed Ergenc; Muhannud Binnawara; Muhawenimana Emmanuel; Mujeeb Abbasi; Mukhammad David Naimzada; Mukhtar Kulimbet; Munenori Kusunoki; Muneza Eugene; Munish Chauhan; Muntaser Abu Shokor; Murad Aljiffry; Murat Kalin; Musbahu Kurawa; Müserref Beril Dincer; Musliu Adetola Tolani; Mustafa Soytaş; Mustapha Yakubu; Mustapha Ibrahim Usman; Muiywa Aremu; Mykola Paranyak; Nabila Talat; Nabila Kausar; Nagendra Dudi-Venkata; Nagham Bazzi; Najat Ben Hasan; Naomi Natasha Van Wyk; Naseebah Shaban; Naser Almgla; Naser Yousefzadeh Kandevari; Nasser Alzerwi; Natalia Alvarez; Natalia Motas; Natalia Andrea Rivera Rincón; Natalie Blencowe; Natalie Simon; Natasha Aghtarafi; Navdeep Kaur Ghuman; Naveen Sharma; Naveen Wijekoon; Navin Kumar; Naya Hassan; Ndubuisi Onyemaechi; Nebojša Prijović; Necdet Özçay; Neha Goel; Neil Segaren; Neil Sharma; Nektaria Kalyva; Nelson Morales Palacios; Nestor Fabian Pedraza Alonso; Ngozi Onyeagwara; Niccolò Petrucciani; Niccolò Daddi; Nicholas Lightfoot; Nicholas Power; Nicholas Segaren; Nichole Starr; Nici

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Raul Guevara; Ravi Agarwal; Ravi Vissapragada; Rawan A.rahman Alharmi; Raza Sayyed; Rebecca Browning; Rebecca Critchley; Rebecca Mallick; Rehab Alarabi; Reinaldo Isaacs Beron; Reinhold Függer; Rema Othman; Rema Saad; Remedios Revilla Amores; Renan Carlo Colombari; Renata Curic Radivojević; Renato Patrone; René Novyzedlák; René Manuel Palacios Huatuco; Reto Baertschiger; Rhea Liang; Rhys Luckwell; Ricardo Escrevente; Ricardo Fernandes Rezende; Ricardo Pedrini Cruz; Riccardo Lenzi; Riccardo Rosati; Richard Donovan; Richard Egan; Richard Morris; Richard Page; Richard Seglenieks; Richard Unsworth; Richard Wilkin; Richard Je Skipworth; Richard Justin Davies; Rifat Bezirci; Rishi Talwar; Rizwan Azami; Rob Bohmer; Robert Crichton; Robert Fruscio; Robert Hooker; Robert Jach; Robert Parker; Robert Pillerstorff; Robert Sinnerton; Robert Stabler; Robert Michael O'connell; Roberta Ragozzino; Roberta Tutino; Roberta Angelico; Roberto Cammarata; Roberto Colasanti; Roberto Macchiavello; Roberto Peltrini; Roberto Pirrello; Roberto Vaschetti; Robinson Esteves Pires; Rocco Papalia; Rodrigo Arrangoiz; Roel Hompes; Rohin Mittal; Rokeya Salah; Romina Pinto; Ronald Flumignan; Rory Callan; Rory Cuthbert; Rory Dennis; Rosa Scaramuzzo; Rosa Montero Macías; Rosa Sánchez; Rosemary Ogu; Rosnelifaizur Ramely; Rossella Sgarzani; Roszalina Ramli; Roxane Hillier; Ruben Thumbadoo; Rucira Ooi; Rukiyat Abdus-Salam; Ruqaya Masri; Russell Hodgson; Ryan Mathew; Ryckie Wade; Sabatino D'archi; Sabina Khan; Sabrina Ngaserin; Sachin Kale; Sadiq Hassan; Safa Merghani; Safia Benamar; Sagir Muhammad; Saif Badran; Saifaleslam Elsahli; Saimir Heta; Salah Hammouche; Saleh Baesa; Salvatore Paiella; Samaher Taj Eldeen Hassan Taj Eldeen; Samara Arkani; Samarth Mittal; Sameer Hirji; Sameer Tebha; Sameh Emile; Samer Dbouk; Samik Kumar Bandyopadhyay; Saminu Muhammad; Samson Olori; Samuel Amoako Asirifi; Samuel Hailu; Samuel Ling; Samuel Newman; Samuel Ross; Samuel Wanjara; Sandip Kumar; Sanjeeva Seneviratne; Sara Tamburello; Sara Busto Suarez; Sara Ingallinella; Sara Irshaidat; Sara Konswa; Sara Mambrilla; Sara Nasser; Sara Parini; Sara Pitoni; Sara Ornaghi; Sara Castanheira Rodrigues; Sarah Abdelmohsen; Sarah Aitken; Sarah Tian; Sarit Badiani; Sarwat Ahmad; Sarya Swed; Sathish Muthu; Sathya Lakpriya; Saud Alzahrani; Saulius Mikalauskas; Savita Lasrado; Savni Satoskar; Sayesha Bawa; Saygin Altiner; Sean Garcia; Sean Stevens; Sebahattin Demir; Sebastian Ken-Amoah; Sebastian Tranca; Sebastian Ziemann; Selmy Awad; Semra Demirli Atici; Sentilnathan Subramaniam; Serap Erel; Serena Jiang; Sergey Efetov; Sergey Efremov; Sergey Katorkin; Sergio Chávez Valladares; Sergio Marcos Contreras; Serhat Meriç; Serkan Zenger; Seyer Safi; Sezai Leventoğlu; Shady Elsalhawy; Shafaque Shaikh; Shahila Sheik; Shahnoor Islam; Shahzad Shamim; Shahzad Hussain Waqar; Shahzaib Ahmad; Shahzaib Farid; Shaikh Sanjid Seraj; Shalini Sundarraju; Sharad Karandikar; Sharan Sambhwani; Sharat Chopra; Sharfuddin Chowdhury; Sharon Laura; Sharwany Ahmed; Shaun Wason; Shawn Jia Hwang Tan; Sheila Fraser; Shekinah Williams; Sherief Ghozy; Sherif Abdelmawgoud; Sherif Shehata; Shilpa Sharma; Shima Ahmed; Shima A. Al-Touny; Shireen Ramzanali; Shireen Anne Nah; Shirley Jansen; Shiv Rajan; Shiva Dindyal; Shivang Amin; Shoab Ahmad; Shoukrie I. M. Shoukrie; Shoura Karar; Shraddha Patkar; Shuaib Abdulsalam; Shuxun Lin; Siddhi Hegde; Silvia Fiorelli; Silvia Quaresima; Silvia Villacé Redondo; Silvia Palmisano; Silvia Ruggiero; Simon Balogun; Simon Cais; Simon Cole; Simon Federer; Simon Le Roux; Simona Ippoliti; Simona Meneghini; Simona Viola; Simone Manfredelli; Simone Novello; Sivakumar Ganamadha; Smain Nabil Mesli; Smruti Kale;

Sobhana Iftekhar Tani; Sobia Malik; Sofia Anastasiadou; Sofia Boligo; Sofia Esposito; Sofia Valanci; Sofia Xenaki; Sofija Pejkova; Soham Bandyopadhyay; Sokol Trungu; Somprakas Basu; Sondas Alkhatib; Sonia Pérez-Bertólez; Sonia Lopez Flores; Sophie Donoghue; Sorinel Lunca; Soyombo Orsoo; Spyridon Potamianos; Sreekar Devarakonda; Sreelakshmi Suresh; Stefanie M. Croghan; Stefano Turi; Stefano Capella; Stefano Lucchini; Stefano Magnone; Stefano Salizzoni; Stefano Scabini; Stefano Scaringi; Stefano Piero Bernardo Cioffi; Steffen Seyfried; Stephan Degener; Stephanie Potten; Stephanie Taha-Mehlitz; Stephen Ali; Stephen Angamuthu; Stephen Mcaleer; Stephen Richard Knight; Stuart White; Styliani Mantziari; Stylianos Kykalos; Su Kah Goh; Subhadip Pal Chowdhury; Sufyan Ibrahim; Suha Elzwai; Sujesh Bansal; Sujit Tripathy; Sultan Amrayev; Sumadi Lukman Anwar; Sumit Banerjee; Sumit Thakar; Summaya Saeed; Sunil Kumar Venkatappa; Sunit Das; Suphakarn Techapongsatorn; Surya Kumar Dube; Susan Lee; Susana González-Suárez; Susana Henriques; Suzana Konjevoda; Suzanne Gisbertz; Sybil Lizanne Bravo; Syed Mannan; Syed Imran Bukhari; Syed Nabeel Zafar; Sylvia Batista; Synn Lynn Chin; Tahera Arif; Taiwo Akeem Lawal; Talar Vartanoglu Aktokmakyan; Tamara Osborn; Tamas Szakmany; Tamás Sztipits; Tania Triantafyllou; Tania Abigail Cueto Valadez; Tanveer Singh; Tanwir Khaliq; Tapan Patel; Tarig Fadalla; Tarik Jichi; Tarik Sammour; Tariq Al-Shaiji; Taryn Naggs; Tatjana Barišić; Taxiarchis Nikolouzakis; Tayfun Bisgin; Teresa Perra; Tefik Kivilcim Uprak; Themistoklis Dagklis; Theodore Liakakos; Theodoros Sidiropoulos; Theophilus Justus Kofi Adjese; Theresa Dölker; Thida Oung; Thomas Aherne; Thomas Diehl; Thomas Pinkney; Thomas Raymond; Thomas Rhombert; Thomas Schmitz-Rixen; Thumuluru Kavitha Madhuri; Tibor Karl Lohmann; Tien Yeoh; Tilemachos Zaimis; Tim Bright; Tim O. Vilz; Tim R. Glowka; Timothy Board; Timothy Hardcastle; Tina Cohnert; Tina Tomić Mahečić; Tinka George William; Tobias Klatter; Tom Abbott; Tom Watcyn-Jones; Tome Mendes; Tomislav Kulis; Tomislav Sečan; Tommaso Campagnaro; Tommaso Frisoni; Tommaso Simoncini; Tommaso Violante; Toms Janis Safranovs; Toni Risteski; Tony Pang; Tosin Akinyemi; Tsanko Yotsov; Tsegazeab Laeke; Tsukasa Kochiyama; Tunde T. Sholadoye; Tural Alekberli; Uchechukwu Ezomike; Ugo Giustizieri; Ugo Grossi; Ülkü Ceren Köksoy; Ulrich Bork; Ulrich Kisser; Ulrich Ronellenfitsch; Umar Saeed; Umberto Bracale; Umesh Jayarajah; Umme Habiba Abdul Rauf; Uros Bumbasirevic; Ursula María Jarod Ferrer; Usama Ahmed; Usman Mohammed Bello; Uzair Jogiat; Uzma Sadia; Vagif Galandarov; Vairavan Narayanan; Valentin Calu; Valentina Bianchi; Valeria Ciniero; Valeria Tonini; Vania Silvestri; Vardhini Vijay; Varun Dewan; Varut Lohsiriwat; Vasanthika Thuduvage; Vasileios Mousafeiris; Vedran Dragicic; Veerasamy Sasireka; Veljko Santric; Venkata Ramana Murthy Kusuma; Venkata Satish Kolli; Veronica Alonso; Veronica De Simone; Veronica Picotti; Verónica Martín Martínez; Vicky Panduro-Correa; Victor Kakotkin; Victor Pinto Angulo; Victor Turrado-Rodríguez; Vijay Krishnamoorthy; Vin Shen Ban; Vinay Shah; Vincenza Maiola; Vincenzo Giordano; Vincenzo La Vaccara; Vincenzo Lizzi; Vincenzo Papagni; Vincenzo Schiavone; Vinojan Satchithanantham; Virginia Garcia-Virto; Virginia Jimenez; Vishal Kumar; Vishal Shelat; Vivek Bhat; Vivek Sodhai; Vivien Graziadei; Vladislav Kutuzov; Vladislav Stoyanov; Vlasios Okseloglou; Vojko Flis; Wael Atif Fadl Elhassan; Wah Yang; Wai Cheong Soon; Wail Tashkandi; Waleed Al-Khyatt; Waleed Mabood; Walid Bijou; Wasantha Wijenayake; Wasim D; Wiktor Krawczyk; William Atkins; William Bolton; William White; Wim Ceelen; Xanthoula Vagena; Yaacov Gozal; Yabasin Iddrisu Baba;

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## Supplementary material

Supplementary material is available at BJS online.

## Data availability

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary material.

## References

- Karliner J, Slotterback S, Boyd R, Ashby N, Steele K. *Health Care's Climate Footprint: How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action*. [https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint\\_092319.pdf](https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf) (accessed 15 January 2022)
- Ritchie H. *Sector by Sector: Where do Global Greenhouse Gas Emissions Come From?* <https://ourworldindata.org/ghg-emissions-by-sector> (accessed 15 January 2022)
- Edenhofer O, Pichs-Madruga R, Sokona Y, Minx JC, Farahani E, Kadner S et al. *Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc\\_wg3\\_ar5\\_frontmatter.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_frontmatter.pdf) (accessed 15 January 2022)
- Graver B, Zhang B, Rutherford D. *CO<sub>2</sub> Emissions From Commercial Aviation, 2018*. [https://theicct.org/sites/default/files/publications/ICCT\\_CO2-commercl-aviation-2018\\_20190918.pdf](https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf) (accessed 20 January 2022)
- MacNeill AJ, Lillywhite R, Brown CJ. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. *Lancet Planet Health* 2017;**1**: e381–e388
- Bhangu A, Frankling C, Glasbey JC, Kamarajah SK, Li E, Nepogodiev D et al. Net zero surgery: proof of concept and uncertainties. *Bull R College Surg Engl* 2022;**104**:326–331
- Wormer BA, Augenstein VA, Carpenter CL, Burton PV, Yokeley WT, Prabhu AS et al. The green operating room: simple changes to reduce cost and our carbon footprint. *Am Surg* 2013;**79**:666–671
- COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg* 2020;**107**:1440–1449
- White SM, Shelton CL, Gelb AW, Lawson C, McGain F, Muret J et al. Principles of environmentally-sustainable anaesthesia: a global consensus statement from the World Federation of Societies of Anaesthesiologists. *Anaesthesia* 2022;**77**:201–212
- Qin RX, Velin L, Yates EF, El Omrani O, McLeod E, Tudravu J et al. Building sustainable and resilient surgical systems: a narrative review of opportunities to integrate climate change into national surgical planning in the Western Pacific region. *Lancet Reg Health West Pac* 2022;**22**:100407
- National Institute for Health Research Global Health Research Unit on Global Surgery. Prioritizing research for patients requiring surgery in low- and middle-income countries. *Br J Surg* 2019;**106**:e113–e120
- Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;**339**:b2700
- Bhatia P, Cummis C, Brown A, Drauker L, Rich D, Lahd H. *Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard*. Washington DC: World Resources Institute and World Business Council for Sustainable Development. <https://lca-net.com/files/Comparison-of-the-GHG-protocol-with-the-ISO-14040-series.pdf> (accessed 3 March 2022)
- Presseau J, McCleary N, Lorencatto F, Patey AM, Grimshaw JM, Francis JJ. Action, actor, context, target, time (AACTT): a framework for specifying behaviour. *Implement Sci* 2019;**14**: 102
- National Institute for Health and Care Research. *PPI (Patient and Public Involvement) Resources for Applicants to NIHR Research Programmes*. <https://www.nihr.ac.uk/documents/ppi-patient-and-public-involvement-resources-for-applicants-to-nihr-research-programmes/23437> (accessed 13 February 2022)
- National Institute for Health and Care Research. *Improving Inclusion of Under-Served Groups in Clinical Research: Guidance From INCLUDE Project*. [www.nihr.ac.uk/documents/improving-inclusion-of-under-served-groups-in-clinical-research-guidance-from-include-project/25435](http://www.nihr.ac.uk/documents/improving-inclusion-of-under-served-groups-in-clinical-research-guidance-from-include-project/25435) (accessed 20 February 2022)
- The World Bank Group. *World Bank Country and Lending Groups, 2019* (accessed 20 January 2022)
- NHS National Patient Safety Agency. *INVOLVE: Promoting Public Involvement in NHS, Public Health and Social Care Research*. <https://www.invo.org.uk/wp-content/uploads/2011/12/INVOLVEfinalStatement310309.pdf> (accessed 2 March 2022)
- Page MJ, Moher D, Bossuyt PM et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ* 2021:n160. <http://dx.doi.org/10.1136/bmj.n160>
- Beatty J, Shelton C, Rizan C, Robb H. *Intercollegiate Green Theatre Checklist*. <https://www.rcsed.ac.uk/media/1331733/green-theatre-compendium-of-evidence-rcsed-161022.pdf> (accessed 4 April 2022)
- Davis M, Coan P. Organizational change. In: Barling J, Robertson J (eds), *The Psychology of Green Organizations*. Oxford: Oxford University Press, 2015, 244–274
- Putnis N, Neilson M. Environmental sustainability and quality care: not one without the other. *Int J Qual Health Care* 2022;**34**: mzac066
- Yeung J, Jhanji S. VITAL - Volatile vs Total Intravenous Anaesthesia for Major Non-Cardiac Surgery. <https://warwick.ac.uk/fac/sci/med/research/ctu/trials/vital/>

24. Curry LA, Ayedun AA, Cherlin EJ, Allen NH, Linnander EL. Leadership development in complex health systems: a qualitative study. *BMJ Open* 2020;**10**:e035797
25. Stephens TJ, Peden CJ, Pearse RM, Shaw SE, Abbott TEF, Jones EL et al. Improving care at scale: process evaluation of a multi-component quality improvement intervention to reduce mortality after emergency abdominal surgery (EPOCH trial). *Implement Sci* 2018;**13**:142
26. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. *BMJ* 2021;**374**:n2061