

Care Pathways: Guidance on Appraising Sustainability

Surgical Procedure Module



**Sustainable
Healthcare
Coalition**

Second Edition
December 2023



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For and on behalf of
Environmental Resources Management

Approved by: Michael Collins

Signed:



Position: Partner

Date: 06 December 2023

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The first edition (2015) was prepared by Tom Penny, Michael Collins, Andy Whiting and Simon Aumônier

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CHANGES IMPLEMENTED IN SECOND EDITION

Surgical Procedure Module	Change	Page(s)
Surgical procedure module	General updates including replacing out-of-date references, updating branding and small text updates to reflect the newest data	Whole document
Preface to second edition	Preface added	1
2.5 Emission factors	GWPs for anaesthetic gases (info box) added	12
2.7 Example calculation	Info box incorporates additional detail on activity data (eg energy use, anaesthetic gas use) associated with example calculations. No changes to activity data (from 2015) have been made.	16
2.7 Example Calculations	Info box includes updates to calculations, updates to emission factors used, new results are presented including an additional tables of results for a scenario representing the consequence replacing desflurane with sevoflurane. Additional chart has been included for the replacement scenario.	17

This second edition is published as interest in appraising and reducing the impact of care pathways is growing. There is increased prioritisation, and action, on climate change from within the healthcare sector as the NHS, and other health services, develop and implement their net zero commitments. This edition: incorporates updated references; updated surgical procedure calculations and signposts useful calculators, and provides additional supporting information.

Acknowledgement is given to the invaluable input of the following individuals and organisations associated with the first edition:

Sustainable Healthcare Coalition (SHC), formerly Coalition for Sustainable Pharmaceuticals and Medical Devices (CSPM), Leadership Members

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Convening Body and Technical Author

- Environmental Resources Management Limited (ERM): Tom Penny, Michael Collins, Andy Whiting and Simon Aumônier.

This module provides guidance on how to calculate the performance of a representative patient undergoing a surgical procedure against the sustainability metrics. It can be used:

- to direct the appraisal of a specific surgical procedure, through the collection of primary activity data, for a care pathway; or
- as a source of secondary data for surgical procedures to inform a screening assessment of a care pathway; or
- as a source of secondary data for an appraisal of a care pathway where surgical procedures are known not to be material to the overall care pathway.

2.1 DESCRIPTION

A surgical procedure is the investigation or treatment of a condition, disease or injury by qualified persons using invasive measures (eg incision, suture) taking place in an operating room. Typically, it will involve some form of anaesthetic (local, regional or general) and can be elective or unplanned.

A surgical procedure may also be referred to as a surgery or operation. It refers to all inpatient or outpatient surgical procedures conducted in an operating room in an appropriate facility (eg a hospital). An inpatient or outpatient will typically undergo some form of anaesthetic, the surgical procedure is performed, and the patient undergoes post care before discharge, re-entering the inpatient module or use of other services.

Typically, elective surgery will be planned, and the patient requires admission to the hospital for treatment. Unplanned surgery may be carried out in emergency situations, where the patient typically enters the surgical procedure module via an emergency department.

It is recognised that this definition restricts the scope of the module to a qualified team performing a surgical procedure in an operation room. In many instances, this will exclude minor surgical procedures. These scenarios shall be included in a care pathway, but are excluded from this module.

2.2 BOUNDARY SETTING

Boundary setting is an important step to ensure consistency with respect to what should and should not be included in the appraisal of a module. When appraising a surgical procedure, the first step is to map out all of the activities a patient undertakes when using the module. Following this, the services required to provide

these activities shall be determined and finally the resources (eg consumables, energy, etc) identified that are required to provide these services.

To ensure consistency in appraisals, recommended activities, services and resources for a surgical procedure are presented below.

2.2.1 *Activities Undertaken to Provide a Surgical Procedure*

A patient may go through the following steps to have surgery.

(Note: *yellow text* refers to sub-modules (activities, procedures, interventions that occur within a module) & *orange text* refers to separate modules to be included in a care pathway)

- **Travel:** the patient travels to the hospital (included under patient travel module).
- **Patient admission:** the patient may be admitted as an inpatient or outpatient to receive the surgical procedure (consider the separate inpatient module) which may be for elective or unplanned reasons.
- **Preparation of patient and operating room:** the operating room is prepared (eg cleaned and equipped) and the patient is briefed or undergoes pre-surgery checks.
- **Anaesthesia:** the patient typically undergoes a form of local, regional or general anaesthetic prior to the surgical procedure.
- **Surgical procedure:** the patient is taken from a ward to the operating room, the patient is anaesthetised, and surgery is performed.
- **Post-anaesthesia care:** the patient may require care to recover from the effects of anaesthesia.
- **Recovery in a hospital ward:** the patient is returned to the ward for monitoring, treatment and further care as an inpatient or outpatient (included under inpatient bed day module or an outpatient module).
- **Discharge, referral or travel:** the patient uses another service, remains an inpatient, is discharged or travels from the hospital after completing their surgical procedure (included under patient travel module).

In order to avoid duplication with other modules and therefore the potential for double-counting within a care pathway, the 'surgical procedure' module only covers those activities that occur related to anaesthesia (pre and post operation) and within an operating room. This surgical procedure module can then be included with an inpatient or outpatient module to develop the care pathway map. It excludes patient travel, referrals for surgery, and bed days. Therefore, the module begins with the patient already at hospital awaiting surgery.

2.2.2 *Services & Facilities Required to Provide a Surgical Procedure*

To provide these activities, the following services and facilities are required.

- **Anaesthesia** in a designated room or in the operating room.
- **Operating rooms**, where the patient may be anaesthetised and the surgical procedure is performed on the patient.
- **Post-anaesthesia care** for the patients recovering from the effects of anaesthesia.
- **Administrative services** and areas to run the operating rooms within a hospital or other facility.

A portion of the hospital shared building and administrative services (eg managing of records, building cleaning) shall be allocated to the surgical procedure provided in the hospital as described in the Allocation section of this module.

Any services and facilities associated with a hospital, but not associated with operating rooms or anaesthesia services, can be excluded from this module (eg occupational health clinics). Capital goods (eg buildings, car parks) can be excluded from the module unless they are known to be material ⁽¹⁾ to performance against the sustainability metrics appraised.

2.2.3 Resources Required to Provide a Surgical Procedure

Based on the list of activities, services and facilities identified above, the following categories of activity data shall be included:

(Note: green text refers to data that shall be included in an appraisal of the module)

- **Facilities**, eg energy, water and waste associated with buildings.
- **Consumables**, eg pharmaceuticals, single use medical devices, anaesthetic gases.
- **Medical gases**, eg nitrous oxide, anaesthetic gases.
- **Equipment**, eg reusable medical equipment, hospital beds, furniture.
- **Travel**, eg staff travel.

The module includes consumables used in preparation for and during surgery. Electricity, fuel and water used by the operating room are included, as is the disposal of consumables and packaging. Impacts of staff are accounted for by including commuting of surgeons, anaesthetist, and nurses. Cleaning and disposal of consumables within the operating room shall be accounted for.

A summary of resources and activities that shall be included in this module is presented below. These may be excluded if they can be shown not to be material to the results. Exclusions should be undertaken by applying the materiality rules in the main document, ie no more than 10% of the total impact may be excluded. A list of additional care pathway modules that may be required to connect to this module to develop the overall care pathway map is also provided. These additional modules are included as examples in order to highlight where this module might fit in to the overall care pathway.

(1) Refer to Section 1.8.4 Materiality and Data Screening in the Care Pathways: Guidance on Appraising Sustainability: Main Document

Include these activity data:

- Consumables used in operating room and (pre & post) anaesthesia services
- Equipment used in operating room and (pre- & post-) anaesthesia services
- Electricity, fuel and water use in operating room and (pre- & post-) anaesthesia services
- Equipment used in hospital shared services
- Electricity, fuel and water used in shared services
- Anaesthetic gases and direct emissions
- Staff travel
- Waste generated
- Cleaning
- Sterilisation
- Administration activities

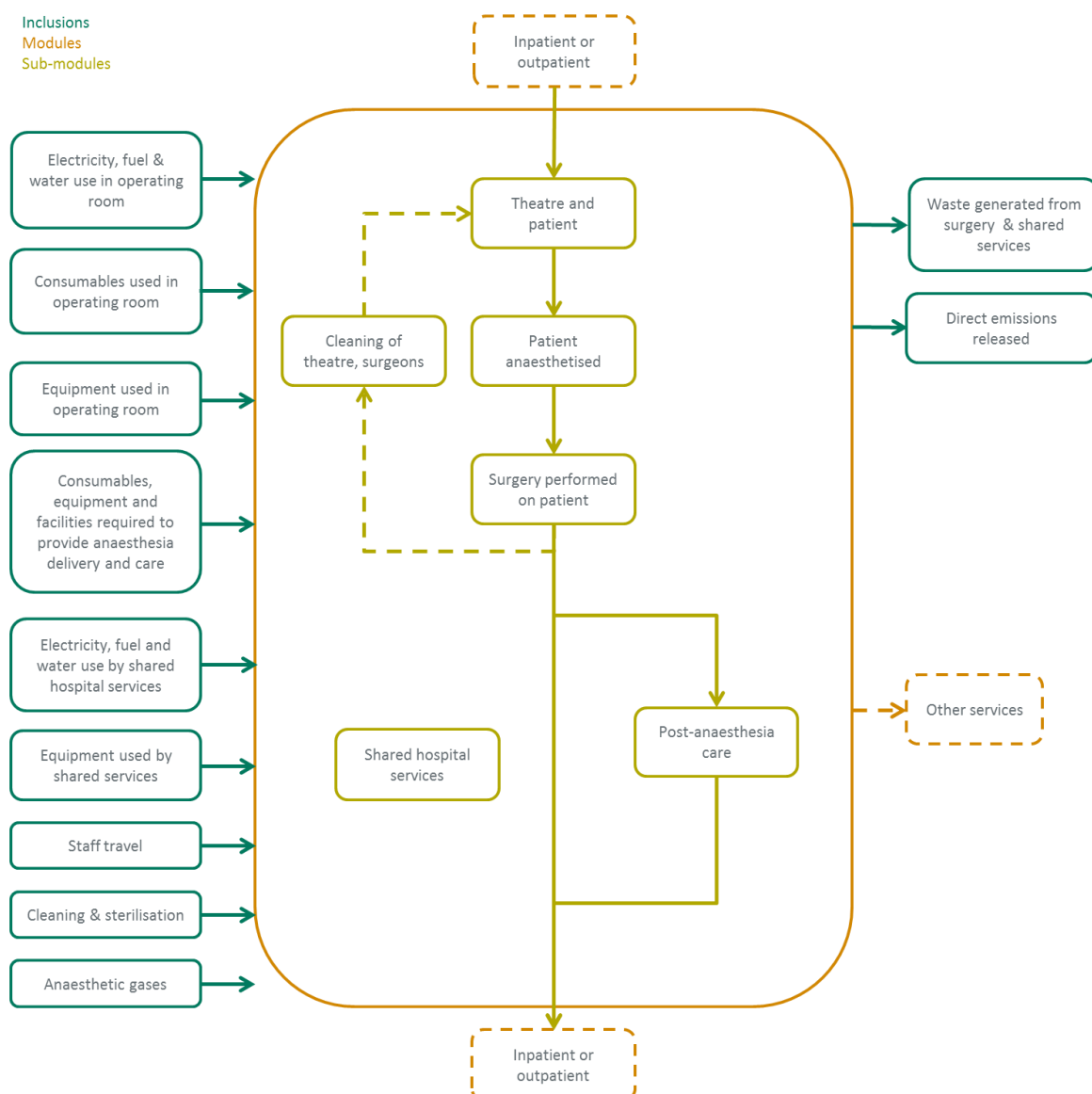
Exclude these activity data:

- Capital goods (eg buildings, car parks)
- Surgeon training
- Other staff training
- Health authorities, financial services
- Surgeon & other staff non-protective clothing and food consumption

Additional modules that may be required, but that are excluded from this module:

- Patient travel
- Inpatient bed day
- Emergency department
- Other services provided after admission

Figure 2.1 **Surgical Procedure Example Process Map**



2.3 UNIT OF ANALYSIS

A unit of analysis is identified as a common ‘reference flow’ or ‘basis for comparison’ to allow for the module to be included in a care pathway appraisal or to be used to compare different scenarios of the same module (eg surgical procedures in different regions or the significance of changes made to an existing surgical procedure).

A patient in a defined age range, attending an operating room for a specific type of surgical procedure of defined length in a geographical area.

The unit of analysis is a set number of patients attending an operating room for surgery. This allows for the patient’s journey through the care pathway to be analysed. It is important to make clear the magnitude of care, including the age and condition of the patient.

- eg an adult patient attending an operating room for hip replacement surgery in the UK.

The consumption of resources may be dependent upon both the nature of the surgical procedure and the time taken to provide it. For example, the resources to clean the operating room will be required in completing a single surgical procedure irrespective of length, but the electricity consumed by medical equipment will vary, based on length of the surgical procedure. Depending on the nature of the appraisal, it may also be necessary to include the time taken to provide the specific surgical procedure.

- eg an adult patient attending an operating room for 2 hours of hip replacement surgery in the UK.

2.4 ACTIVITY DATA

Activity data are the quantified measures of activity relevant to the module being appraised.

Surgical procedure module activity data include the following:

- **Reference data**, such as floor area and throughput of the operating room split by services and types of patient.
- **Facilities data** (eg energy, water and waste) of the operating room split by services and patient type where possible.
- **Consumables, medical gases and equipment** used in each of the sub-modules defined for a surgical procedure attributed to patient type and condition where possible.
- **Consumable and equipment** used in shared services of surgical procedure administration and the hospital.
- **Travel of staff** required to provide the inpatient service and all shared hospital services.

Primary activity data shall be collected to appraise the module if they are found to be material to the care pathway.

To determine if primary activity data are required, the data in *Section 2.7* can be used to inform a screening assessment of a care pathway. If the activity is found not to be material in the screening study, primary data, although preferable, are not required and the case study data can be used to represent the surgical procedure within the care pathway.

2.4.1 Primary Data

Where required, primary activity data specific to the surgical procedure being appraised shall be included. These data are likely to be sourced from a representative sample of hospital departments involved in the appraisal.

If a surgical procedure for a specific condition is being appraised, data shall be collected to represent a patient undergoing a surgical procedure for that condition. When collecting data for a surgical procedure, it is important to note which data are fixed or are time dependent, based on length of the procedure. Activity data requirements include the following.

- **Consumables for the operating room:** the type and quantity of all consumables required to provide surgery in the operating room. These data should be for a fixed period or defined length of time and for the specific condition that is being appraised.
- **Equipment for the operating room:** the type, quantity, lifetime and number of uses of equipment required to provide surgery in the operating room. These data should be for a fixed period or defined length of time and the specific condition that is being appraised.
- **Consumables, anaesthetic gases and equipment used in anaesthesia care (administering and post-care):** the type, quantity, lifetime and number of uses of equipment and type and quantity of consumables and anaesthetic gases required to administer anaesthetic and post-anaesthesia care for the patient for a fixed period or defined length of time for the surgical procedure.
- **Facilities for the surgical procedure:** quantity of electricity, fuels, water and types of waste generated from the surgical procedure for the specific condition. If possible, these data should be based upon the equipment required to provide the service or alternatively allocated based on floor area and sub-metering, split by operating room, anaesthesia services and other activities.
- **Consumables and equipment for administrative services:** the type, quantity, lifetime and number of uses of equipment and type and quantity of consumables relevant to the administrative services required to operate the rooms required for the surgical procedure and the hospital services allocated to the surgical procedure.
- **Administrative services facilities:** quantity of electricity, fuels, mains water and types of waste generated associated with the administrative services required to operate the rooms necessary for the surgical procedure and the hospital services allocated to the surgical procedure.
- **Staff travel:** staff surveys to calculate the modes and distances travelled by staff attributable to surgery, post-anaesthesia care and hospital services.

These data are the minimum required to conduct a surgical procedure appraisal. Additional activities, services and resources may be identified when mapping the specific surgical procedure and these shall be included, noting that they are in addition to the minimum requirements set out in this guidance.

In some instances, it may not be possible to attribute consumables, equipment or facilities data directly to the surgical procedure. In these instances, they shall be allocated to the procedure using the reference data collected (eg length of surgery time, floor area, and patient throughput). Allocation is described further in *Section 2.6*.

If the 'bottom up' data described above are not available, then financial data and cost allocation may be used as a proxy in order to quantify consumables, equipment, facilities and travel data for a surgical procedure.

2.4.2 Secondary Data

For activities identified in the process map that are outside the direct control of the organisation, suitable secondary data sources can be used. Secondary data are particularly useful where activities or modules are not deemed to be material to the study through a screening exercise or materiality assessment. Primary data collection is still preferred and should be used if it is possible reasonably to collect it. Examples of secondary data sources can be found in the case study section, *Section 2.7* and from literature eg HealthcareLCA⁽²⁾.

2.5 EMISSION FACTORS

Once primary activity data or secondary activity data have been collected, they shall be combined with the appropriate emission factors in order to calculate the sustainability metrics of the module.

Sources of emission factors are available in *Annex C* of the Main Document and should be used where specific emission factors are not available. An example of a specific emission factor is the GHG emissions associated with the manufacture of a specific type of surgical mask.

⁽²⁾ <https://healthcarelca.com/>

Anaesthetic Gases Global Warming Potential

Anaesthetic and analgesic gases as a result of their relatively high global warming potentials, low metabolism and venting to atmosphere contribute 2% to the NHS' carbon footprint.

Gas	Identifier	GWP100 (AR5) kg CO ₂ eq per kg	GWP100 (AR6) kg CO ₂ eq per kg
Desflurane	HFE-236ea2	1790	2590
Isoflurane	HCFE-235da2	491	539
Sevoflurane	HFE-347mmz1	216	195
Nitrous oxide	N ₂ O	265	273
Nitrous oxide w/ Oxygen (50/50)	Entonox	153*	158*

*GWP estimated based on 50% by vol & 57.9% by mass N₂O

Sources:

Delivering a 'Net Zero' National Health Service - July 2022

AR5: Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestad, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Table 8.A.1)

AR6: Smith, C., Z.R.J. Nicholls, K. Armour, W. Collins, P. Forster, M. Meinshausen, M.D. Palmer, and M. Watanabe, 2021: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity Supplementary Material. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. (Table 7.SM.7)

If 'bottom up' activity data cannot be collected (eg quantities of types of consumables) then financial data may be used and combined with environmental extended input output (EEIO) analysis databases in order to calculate values for the sustainability metrics. Use of EEIO is considered to introduce greater uncertainty and so using emission factors and primary activity data is preferable.

2.6 MODULE CALCULATION STEPS

Steps to appraise the module include the following.

1. Map the activities and services associated with the module.
2. Complete a materiality assessment using the module case study in order to understand the significance of the activity data and the module to the pathway (if relevant).
3. If significant, identify sources from which to collect the required activity data. If not significant, use appropriate secondary or case study data and adapt to the specific scenario.
4. Collect the required activity data appropriate to the module scenario.
5. Identify how activity data can be allocated the unit of analysis (see Allocation section below). Identify the nature of consumption for each activity data (ie whether consumption of the resource is fixed per surgical procedure or time dependent).
6. Identify secondary data sources either in *Annex C* of the Main Document or specific to the activity data collected.
7. Perform allocation where necessary and combine the activity data and emission factors.
8. Interpret the findings and follow the guidelines in *Section 3* of the main document for reporting.

2.6.1 Allocation

In the first instance, one should seek to avoid allocation. However, this is often impracticable. Activity data collected for the module may need to be allocated to the particular module and to the unit of analysis.

It is important in a surgical procedure to differentiate between resources and emissions that are consumed or generated by conducting a surgery irrespective of time (eg cleaning chemicals) and those that are dependent upon the length of time of the surgery (eg anaesthetic gases). For fixed dependent data, allocation shall be performed on the basis of the number of surgeries that the data represent (eg patient throughput). For time-dependent data, allocation shall be performed on the basis of the total hours of surgery that the data represent.

This process is described below in order of priority.

- **Consumables and equipment used for the surgical procedure.**
 - i. Collect activity data specific to the unit of analysis in the first instance.
 - ii. Identify consumables and equipment used during the surgical procedure specific to the condition. Identify the relationship to consumption (eg fixed per surgery or time dependent). For fixed data, divide by the total number of patients undergoing surgery for the specific condition. For time-dependent data, divide by the total hours of surgery for the specific condition.
 - iii. If this is not possible, collect activity data on consumables and equipment used in surgery at hospital and divide by the total throughput of all patients having surgery for the defined time period for fixed data or by the total number of hours of surgery provided for time dependent data.

- **Facilities data for the surgical procedure.**
 - i. Where possible, identify the facilities data (eg electricity) directly attributable to the surgical procedure for a patient with a specific condition (eg by considering equipment use).
 - ii. Identify facilities data by sub-module (eg operating room, post-anaesthesia care) for the surgical procedure and use a technical expert (or use cost allocation processes) to estimate the percentage to be allocated to surgical procedures. For fixed data, divide by number of patients undergoing surgery for the specific condition. For time-dependent data, divide by the total hours of surgery for the specific condition.
 - iii. Identify facilities data for the relevant department. Identify the floor space of the relevant rooms in the hospital and allocate on this basis, before dividing by the total number of patients undergoing surgery or the total number of hours of surgery completed.
- **Consumables, anaesthetic gases and equipment used during anaesthetic services (administering and post-care).**
 - i. Collect activity data specific to the unit of analysis in the first instance.
 - ii. Where possible, identify consumables, anaesthetic gases and equipment used throughout administering anaesthetic and post-anaesthesia care that are directly attributable to the patient being considered.
 - iii. Identify all consumables, anaesthetic gases and equipment used by services required to provide administration of anaesthetic and post-anaesthesia care and allocate across total patient throughput for anaesthetic services in the defined time period.
- **Facilities data used during anaesthetic services (administering and post-care).**
 - i. Where possible, identify the facilities data (eg electricity) directly attributable to the anaesthetic services for a patient with a specific condition (eg by considering equipment use).
 - ii. Identify facilities data by sub-module (eg operating room, post-anaesthesia care) for the surgical procedure and use a technical expert (or use cost allocation processes) to estimate the proportion to be allocated to anaesthetic services.
 - iii. Identify facilities data for the relevant department. Identify the floor space of the relevant rooms in the hospital and allocate on this basis, before dividing by the total number of patients receiving anaesthetic services.
- **Consumables and equipment used for shared hospital services and surgery administrative services.**
 - i. Where possible, identify consumables and equipment used throughout the shared services that are directly attributable to a surgical procedure.

- ii. Identify all consumables and equipment used by services required to provide a surgical procedure and allocate across the total patient throughput of the hospital over the defined time period.
- Facilities data for shared hospital services and surgery administrative services.
 - i. Where possible, attribute shared facilities data directly to the surgical procedure.
 - ii. Identify total facilities data for the hospital and allocate to the total patient throughput of the hospital.

2.7 *EXAMPLE CALCULATIONS*

An example of calculating GHG emissions is shown below.

The materiality of data should be considered when collecting and appraising data for the module. Materiality refers to the estimated significance of data to the module being appraised. It is recommended that no more than 10% of data contributing any impact appraised be excluded (eg 10% contribution to GHG emissions of the module). Further guidance on estimating significance can be found in the main document and annexes ⁽³⁾. Users may apply a different cut-off percentage (other than 10%) if justified and this shall be reported along with the results of the appraisal.

For a GHG appraisal, additional effort should be taken when appraising the following categories as these are anticipated to be the most significant contributors:

- consumables (eg single use medical devices used);
- medical gases; and
- energy (eg electricity used directly by the module).

Other hotspots may be identified when conducting an appraisal and all resources and emissions within the boundaries of the module should be considered for significance before excluding any data point.

(3) Refer to Section 1.8.4 Materiality and Data Screening in the Care Pathways: Guidance on Appraising Sustainability: Main Document

Module Surgical Procedure
Unit of analysis An average hour of surgical procedure in an operating room.

Included activities

- ✓ Consumables used in operating room and (pre & post) anaesthesia
- ✓ Equipment used in operating room and (pre- & post-) anaesthesia services
- ✓ Electricity, fuel and water use in operating room and (pre- & post-) anaesthesia services
- ✓ Electricity, fuel and water used in shared services
- ✓ Anaesthetic gases and direct emissions
- ✓ Staff travel
- ✓ Waste generated
- ✓ Cleaning (assumed captured in data)
- ✓ Sterilisation (assumed captured in data)

Excluded activities

- × Pharmaceuticals administered during patient treatment
- × Implants, prosthesis, blood or other items surgery specific items
- × Capital goods (eg buildings, car parks)
- × Surgeon training
- × Other staff training
- × Health authorities, financial services

Surgical procedure selected calculations

Per hour	Quantity/per hour of surgery	Emission Factor AR5 kgCO ₂ e/unit	Result kgCO ₂ e	Notes
Electricity (kWh)	11	0.275	3.0	Emission factor includes well to tank and transmission and distribution
Natural Gas (kWh)	41.8	0.210	8.8	Emission factor includes well to tank and
Mains water (m ³)	0.155	0.177	0.0274	
Sevoflurane (litres)	0.0108	546	5.9	Release + manufacture
Desflurane (litres)*	0.0061	2808	17.1	Release + Manufacture
Isoflurane (litres)	0.00052	877	0.5	Release + Manufacture
Nitrous Oxide (litres)	18.5	0.504	9.3	Release + Manufacture
Carbon Dioxide (litres)	6.44	0.003	0.02	Release + Manufacture
Waste - bottom up (kg)	1.62	0.865	1.4	Estimated based on consumables use and assuming 100% clinical waste incineration
Waste top down (kg)	0.405	0.461	0.2	Hospital waste allocated to surgical procedures based on staff numbers and assuming equal split between landfill, recycling and hazardous

*Desflurane use is close to being eliminated across NHS trusts. If the use of desflurane was replaced with sevoflurane, assuming a ratio of 3.6:1 (desflurane:sevoflurane, [https://www.bjanaesthesia.org.uk/article/S0007-0912\(17\)36743-0/fulltext](https://www.bjanaesthesia.org.uk/article/S0007-0912(17)36743-0/fulltext)) the impact change would be a decrease of 16 kgCO₂e per hour of surgery

Module Surgical Procedure
Unit of analysis An average hour of surgical procedure in an operating room.

Assumptions Sub metered electricity data was made available by a representative department. Electricity for shared services and facilities (kitchens, hospital administration etc) was allocated based on staff numbers. Hospital fuel usage was allocated to the module based on staff numbers. Staff travel was estimated using National Travel survey data for commuting. The average length of a surgical procedure was 66 minutes. Purchasing data for operating theatres was collected and divided by total number of surgical procedures. Results have been normalised to 1 hour.

- Data sources**
- Annual data for operating theatres. Dr Frank Swinton, Airedale General Hospital NHS Foundation Trust, 2014
 - Average distance travelled by purpose and mode: England, 2021, National Travel Survey, Department for Transport statistics
 - Estates Return Information Collection (ERIC) database maintained by the Health and Social Care Information Centre <http://www.hscic.gov.uk/>
 - UK Government conversion factors for company reporting of greenhouse gas emissions 2023 <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023>
 - ecoinvent 3.9 Life Cycle Assessment database <https://ecoinvent.org/>
 - SimaPro LCA software <https://simapro.com/>
 - Xiaocheng Hu, JM Tom Pierce, Tim Taylor, Karyn Morrissey, The carbon footprint of general anaesthetics: a case study in the UK. Resources, Conservation and Recycling, Volume 167, 2021, 105411, ISSN 0921-3449, <https://doi.org/10.1016/j.resconrec.2021.105411>

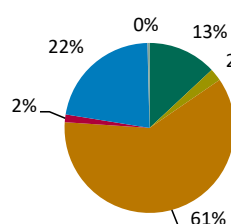
Surgical procedure results (per hour)

Per hour	GHG Emissions (kg CO ₂ e)	Fresh water use - direct (m ³)	Fresh water use - indirect (m ³)	Fresh water use - total (m ³)	Hazardous waste (kg)	Non-hazardous waste (kg)	Total waste (kg)
Consumables	7.1	x	38.20	38.20	x	x	x
Equipment	1.3	x	9.32	9.32	x	x	x
Medical gases	33.0	x	1.48	1.48	x	x	x
Medical gases*	17.0	x	1.50	1.50	x	x	x
Travel	0.8	x	1.73	1.73	x	x	x
Energy	11.8	x	13.38	13.38	x	x	x
Water	0.0	0.15	0.51	0.66	x	x	x
Waste**	0.2	x	0.30	0.30	x	x	0.41
Total	54.4	0.15	64.3	64.5	x	x	0.41
Total*	38.4	0.15	64.1	64.3	x	x	0.41

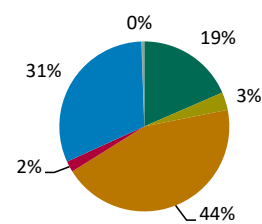
* Desflurane replaced with sevoflurane on a 3.6:1 desflurane to sevoflurane basis

** waste data not possible to disaggregate between hazardous and non-hazardous

Contribution analysis GHG emissions (baseline)



Contribution analysis GHG emissions (desflurane substituted)



For further information or to provide feedback please visit: <https://shcoalition.org/>

This document is the second edition prepared by Michael Collins, Simon Aumônier, Saori Galley and Aoife Calnan.

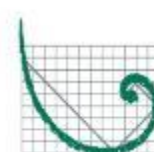
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