Unity Insights

Reusable airway devices: Carbon impact and health economic analysis

Final report

January 2025

Contents

Executive summary

Context

Traditionally, airway devices have been designed to be single-use, primarily to eliminate cross-contamination risks and ensure sterility (McGain & McAlister, 2023). This practice, while effective in infection control, results in the disposal of millions of laryngeal blades, laryngeal mask airways (LMAs), and endotracheal tubes (ETTs), annually (Dalton et al., 2024).

The NHS has set targets to achieve net zero carbon emissions by 2040 (NHS England, 2022). Transitioning away from avoidable single-use medical devices is crucial to meet these sustainability goals.

Methodology

To explore the feasibility of ultraviolet light (UVC) sterilisation for laryngeal blades, and vapourised hydrogen peroxide (vH_2O_2) sterilisation for LMAs and ETTs, a carbon impact analysis (CIA) and cost-benefit analysis (CBA) was conducted.

Key results

Carbon impact insights

From an environmental perspective, transitioning from single-use to reused laryngeal blades, LMAs, and ETTs yielded a reduction of 0.40, 0.30, and 0.03 kilograms of carbon dioxide equivalents ($kgCO_2e$) per use, respectively.

Carbon neutrality analysis demonstrated that sterilising laryngeal blades once yields the same carbon impacts as the single-use scenario. From the second and fourth use respectively, sterilising LMAs and ETTs generated carbon efficiencies. This indicates that devices need to be sterilised and re-used only a few times for these sustainability efforts to achieve positive impact.

Health economic insights

Findings from the CBA suggested a mixed economic case for reuse. Laryngeal blades indicate a clear case with a 5-year benefit cost ratio (BCR) of 2.5, LMAs with a lesser but still positive case of 1.2, and ETTs with a negative result of 0.2.

Upon considering annual impacts of reuse across all modelled devices, the 5-year BCR sits just below 1.0 across all scenarios.

Recommendations

- Improve the cost efficiency of vH_2O_2 sterilisation
- Explore alternative sterilisation methods for LMAs and ETTs
- Validate through real-world data
- Broaden life cycle analysis boundary and sustainability metrics

Conclusion

Overall, the reuse of airway devices demonstrated a strong environmental and a mixed economic case for hypothetical implementation in the NHS at a secondary care site, ICB and national level, with significant variation per device to consider. Evaluation findings are subject to clinical effectiveness of the sterilisation processes.

1. Introduction

1.1. Context and background

Airway devices

Airway management refers to maintaining the airway of a patient during surgical procedures, emergency care, and intensive care interventions, typically where a patient may be under general anaesthesia (Medical Devices, 2023). Airway devices, such as laryngeal blades, laryngeal mask airways (LMAs), and endotracheal tubes (ETTs), are used to maintain an open airway during administration of anaesthesia. Laryngeal blades are used to facilitate intubation and visualise the vocal cords by lowering the tongue and pulling forward the epiglottis (Mole Medical, 2023), while LMAs and ETTs are used to ensure breathing is unrestricted during administration of anaesthesia by inserting a tube into the upper (pharynx) and lower airways (trachea), respectively (Aegis Anesthesia, 2024; Simon & Torp, 2024). Traditionally, airway devices have been designed to be single-use, primarily to eliminate cross-contamination risks and ensure sterility (McGain & McAlister, 2023). This practice, while effective in infection control, results in the disposal of millions of devices annually, often by incineration which contributes substantial carbon emissions (Dalton et al., 2024).

Net zero in the NHS

Medical equipment, including airway devices, represents 10% of the NHS's carbon footprint (NHS England, 2022a). The NHS has set targets to achieve net zero carbon emissions by 2040 (NHS England, 2022). Utilising medical supplies more efficiently was identified as one way to reduce emissions; as more than 1.4% of the NHS's supply chain emissions are due to single-use devices (NHS England, 2022). The new government has also stated its commitment towards a circular system by transitioning away from all avoidable single-use medical technology products, instead focusing on reuse, remanufacture and recycling (GOV.UK, 2024). Reducing the environmental impact of medical equipment, including airway devices, through reuse is therefore a key component of the NHS's strategy to meet its sustainability goals.

Reusable solutions

Despite the low cost, convenience, and guidelines that promote procurement of single-use medical devices (Association of Anaesthetists, 2020; Demarré et al., 2023), it is necessary to explore alternatives to current practices to achieve net zero objectives. Laryngeal blades, ETTs, and LMAs could instead be safely sterilised and reused. Specifically, this report investigates the feasibility of reusing BOMImed Optic Blades, i-Gel LMAs, and Portex Endotracheal Cuffed Tubes (Figure 1).

Figure 1: BOMImed Optic Blade, i-Gel LMA, and Portex Endotracheal Cuffed Tube (left to right).

There are two different categories of sterilisation procedures, namely high and low temperature sterilisation. The choice of sterilisation method depends on various factors, most notably the structure and material of the device. While high-temperature methods such as steam sterilisation have traditionally been the only sterilisation option, these methods are only effective for heat-stable devices and require substantial amounts of energy and water (McGain & McAlister, 2023). Here, whether the device has a lumen[1] or not determines which low temperature sterilisation procedure is suitable.

Vapourised hydrogen peroxide (vH_2O_2) sterilisation

Sterilisation using vH_2O_2 is a low-temperature process involving diffusing hydrogen peroxide vapor into a sterilisation chamber to contact all surfaces of the device and penetrate lumens, leading to microbial inactivation (Meleties et al., 2023). Lumened devices such as ETTs and LMAs should first be pre-cleaned manually and in a washer disinfector, before being sterilised in a vH_2O_2 chamber (Figure 2). Here, use of a V-PRO maX vH_2O_2 machine was assumed for modelling purposes. This procedure does require specialised equipment (Miller, 2024), thus must be sterilised at an off-site facility.

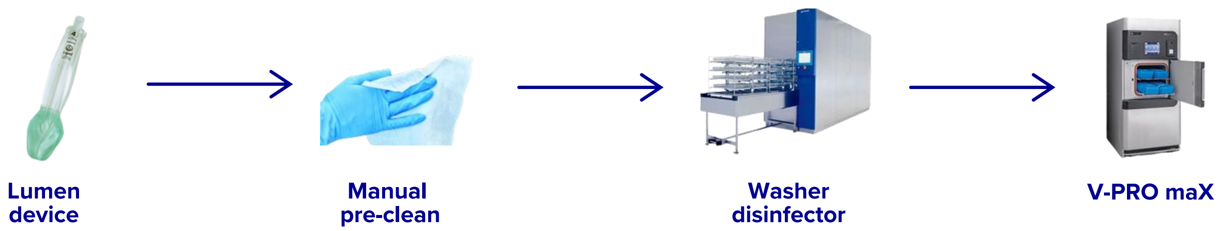

Figure 2: vH_2O_2 process using V-PRO maX.

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[1] A lumened device refers to a device with a hollow cavity, such as a tube.

Ultraviolet-C (UVC) sterilisation

UVC sterilisation is a non-thermal, surface-based sterilisation method that utilises short-wavelength ultraviolet light to inactivate microorganisms (Ramos et al., 2020). This method is particularly attractive due to its short cycle durations, energy efficiency, and lack of chemical residues. It is therefore suitable for flat, non-lumened devices such as laryngeal blades, because they can be fully exposed to UVC light for effective sterilisation. Figure 3 shows a non-lumen device is first manually pre-cleaned before it is then placed inside a UVC sterilisation machine. Here, use of a D25 device was assumed for modelling purposes (UV Smart, 2024).

Figure 3: UVC process using D25.

Transitioning from single-use to reuse of these devices using UVC or vH_2O_2 sterilisation could significantly reduce clinical waste and associated carbon emissions. Investigating these sterilisation procedures is essential to assess their feasibility in reducing environmental impact of airway device management in the NHS (McEvoy & Rowan, 2019; Noh et al., 2020; Ramos et al., 2020), while ensuring patient safety and operational efficiency. It should be noted, however, that further research is being undertaken, and results found in this report are subject to clinical validation.

1.2. Purpose of the current evaluation

Unity Insights was commissioned by Brighton and Sussex Medical School to quantify the carbon impacts of transitioning from single-use to reuse of airway devices; namely, the vH_2O_2 sterilisation of airways (such as ETT and LMAs) and UVC sterilisation of blades. To analyse the environmental and economic impact of this transition, Unity Insights conducted a carbon impact analysis (CIA) and cost-benefit analysis (CBA). Impacts per use were modelled and scaled hypothetically across a secondary care site, wider integrated care system (ICS), and NHS England.

In this report, the reusable devices modelled are in fact identical to the single-use versions of the devices noted above (Figure 1), with ongoing clinical effectiveness studies being conducted to validate assumptions that these can be sterilised and reused in practice.

2. Methodology and scope

2.1. Carbon impact analysis

The intended use of this CIA is to demonstrate the potential reduction in carbon impacts due to the transition from single-use to reuse of airway items using vH_2O_2 or UVC sterilisation. The risk of contamination for reuse is assumed to not be greater than single-use; however, this is subject to the clinical effectiveness of sterilisation techniques currently under investigation. Additionally, the devices modelled (laryngeal blades, LMAs, and ETTs) are designed to be single-use. For the purposes of evaluating the reuse scenario, it is assumed that all devices could be reused 40 times in the CIA model. As this CIA is a comparative analysis, the functional unit was set as per use of each device. This serves to directly compare single-use and reused devices in one common unit.

The methodology employed for this CIA is similar to an environmental impact assessment, as it is a pre-implementation assessment of environmental impacts. This assessment will be used to inform decision-making by identifying potential environmental impacts and providing mitigation recommendations (International Institute for Sustainable Development, 2016); however, the CIA has a narrower scope that evaluates only greenhouse gas emissions that are converted into carbon equivalent impacts.

Clinical assumptions were based on expertise from Brighton and Sussex Medical School and University Hospital Sussex in England, and the temporal scope is limited to the 2024/25 financial year. For a detailed list of materials and weights, methodology around GHG conversion factors and description of calculations used for the CIA, please refer to Table 9 in '*Appendix A: Materials and weights of airway items*', Table 10 in '*Appendix B: Greenhouse gas conversion* factors', and Figure 16 to Figure 22 in '*Appendix C: Carbon impact analysis calculations*'.

Scope

Previous studies have found that most impacts of reusing airway devices were emitted in the utilisation phase (where sterilisation occurs), whereas the impacts of single-use devices were predominantly attributable to the manufacturing and disposal phases (Eckelman et al., 2012; Rizan & Bhutta, 2024). Therefore, it is expected that the largest carbon reductions that may arise from using reusable airway devices instead of single-use devices may be due to reduced production and disposal of single-use devices. As a result, this analysis focussed on the carbon equivalent impacts from the manufacturing phase to the disposal phase to quantify these differences.

The modelled system includes:

- Manufacturing of single-use and reusable airway items
- Transport to use/site
- Utilisation and sterilisation of reusable items

- Transport to off-site sterilisation (vH_2O_2)
- Transport to disposal
- Disposal of single-use items (after each use) and reusable items (end-of-life disposal)

The following process map distinguishes the single-use and reusable airway device lifecycles (Figure 4). The system boundary is indicated by a dashed line, and re-use sterilisation procedures are indicated by a dotted line in the reusable pathway.

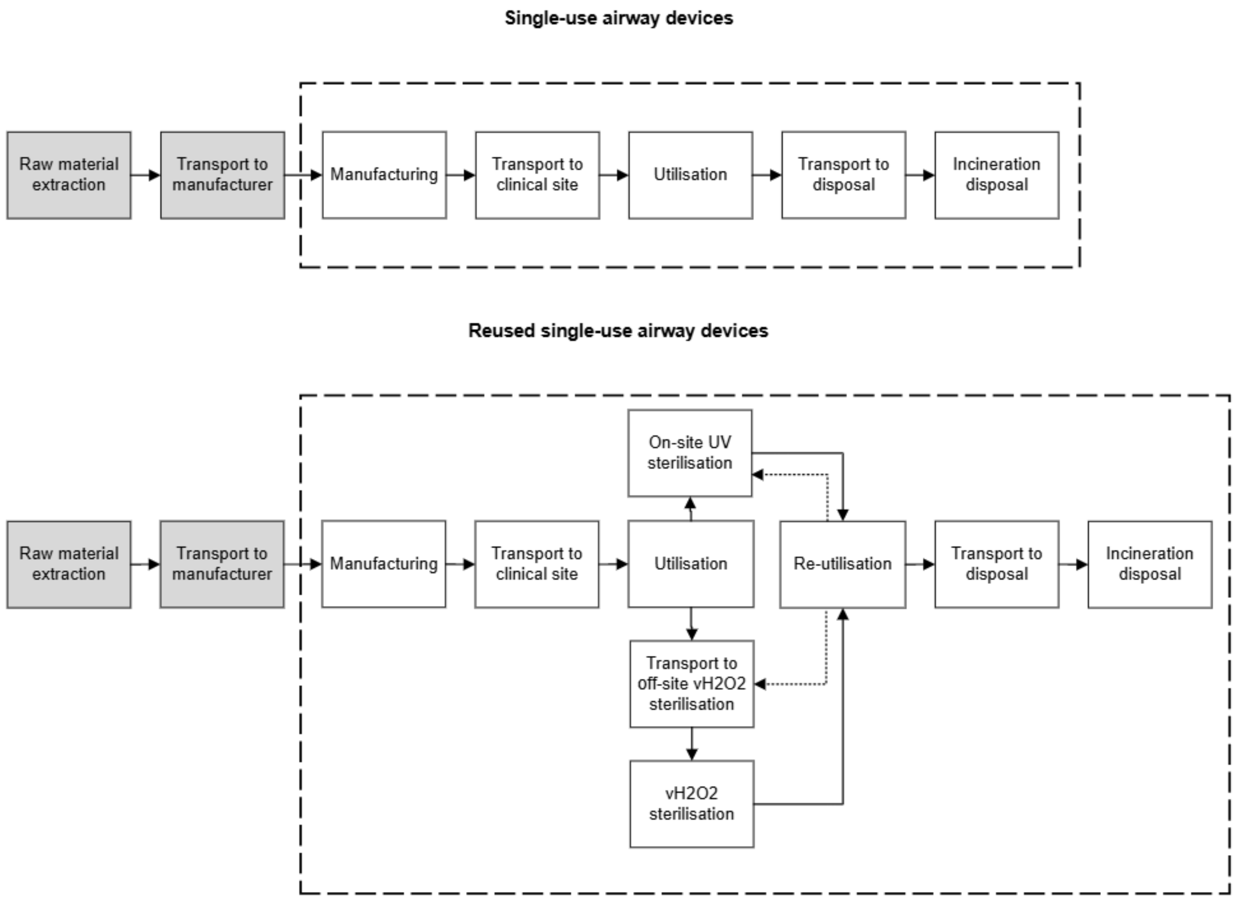

Figure 4: System boundary diagram for single-use and reused airway devices, where dashed and dotted lines indicate the system boundary and sterilisation processes repeating after each re-use, respectively.

Uncertainty analysis

While a full uncertainty and sensitivity analysis has not been conducted as part of this CIA, efforts have been made to account for variability and provide a degree of confidence in the results. An impact range of +- 15% has been applied to the calculated values, generating a range that reflects potential deviations due to underlying assumptions, data quality, and methodological choices.

This approach acknowledges inherent uncertainties in the assessment process, offering stakeholders a more informed perspective of the potential variability in carbon impact outcomes. It is important to note, however, that this correction factor provides an approximation rather than a comprehensive analysis. A full uncertainty and sensitivity analysis, incorporating probabilistic modelling or scenario testing, would provide greater detail and robustness in understanding the range and drivers of variability.

Assumptions

There are three key assumptions that drive the CIA modelling, which arise from conversion factors utilised and sterilisation cycles. For further assumptions, please refer to Table 11 in '*Appendix D: Detailed assumptions list*'.

- GHG conversion factors account for impacts of all raw materials from cradle-to-gate, but not the assembled medical devices specifically. For example, the carbon impact of steel is used as a proxy for laryngeal blades. Although carbon impacts associated with assembly of those materials during the manufacturing phase are not exhaustively modelled, it is assumed that these factors account for most impacts (for example, forming of plastic materials are included; Department for Energy Security and Net Zero, 2023).
- It is assumed that all the manufacturing and sterilisation processes will generate consistent environmental impacts that are unchanged by infrastructure adjustments, local climate, and national energy mix. For example, where steel laryngeal blades are sourced from Pakistan, it is assumed that the GOV.UK (2022) GHG conversion factors represent the emissions generated from the blades, despite different energy mixes between different countries.
- As the carbon impacts associated with sterilisation procedures largely determine the impacts of reused airway devices, the number of devices sterilised in one cycle is impactful. Based on clinical expertise, it is assumed that one device is sterilised per cycle of UVC. In contrast, it is assumed that ten devices (LMAs or ETTs) can be sterilised in one cycle of vH_2O_2, according to the flexible lumened cycle specifications of a V-PRO maX machine.

Carbon equivalents

To disseminate findings, the difference in carbon impacts between the single-use and reused scenarios will be converted from kilograms of carbon dioxide equivalents ($kgCO_2e$) into three carbon equivalents as follows:

- **Carbon equivalent miles by car:** Results will be divided by the greenhouse gas conversion factors per car mile (0.27 $kgCO_2e$; Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy, 2022), thereby estimating the equivalent car miles travelled.
- **Carbon sequestration per tree:** Using the approximate carbon that is sequestered per tree converted into carbon equivalents (50.98 $kgCO_2e$ per tree; United States Environmental Protection Agency, 2015), the emission offset per tree can be estimated.

Results will then be divided by the estimated emission offset per tree, to obtain the equivalent number of trees.

- **Carbon value:** Based on the carbon valuation per $kgCO_2e$ (£0.256 per $kgCO_2e$ in 2024 terms; GOV.UK, 2021), results can be converted into monetary terms. These will then be utilised in the health economic modelling.

2.2. Health economic modelling approach

General approach

The full evaluation has produced an ex-ante (forecasted) appraisal of the prospective impact of the intervention, defined as usage and sterilisation of reusable airway devices (laryngeal blades, LMAs & ETTs) in a secondary care setting. No change to the use cases applied for the devices has been considered, as this is not expected to alter.

The appraisal was conducted in line with *The Green Book* (HM Treasury, 2022) methodology. The HM Treasury guidance is applied throughout the public sector to ensure consistent estimation of costs and benefits in cost-benefit appraisals. In recent years, the framework has been supplemented by several departmental or sectorial *external supplementary guidance* documents (HM Treasury, 2022).

Cost-benefit analysis

General approach

A CBA aims to determine whether the economic value of an intervention can justify the service's costs by estimating the monetary value of the benefits and reviewing the return on investment (ROI; otherwise known as "*social ROI*") based on a static model of the world. Savings were estimated from the perspective of the UK's society as a whole. As with all modelling, it is often difficult to consider and model all possible costs and benefits within the appraisal; however, the service's effects should be considered and outcomes that are most likely to determine the difference between alternative options were included within the appraisal. The net present value (NPV) and benefit cost ratios (BCRs) are important economic summary measures that are derived from such an appraisal and consist of the following formulae:

$$Net\ present\ value = \frac{Net\ cash\ flow}{(1 + Discount\ rate)^{Time\ of\ the\ cash\ flow}}$$

$$Benefit\ cost\ ratio = \frac{Present\ value\ benefits}{Present\ value\ costs}$$

The BCR measures the present value of benefits against the present value of costs. This ratio summarises the overall relationship between relative benefits and costs of the intervention (for example, £X return for every £1 invested). A BCR greater than one indicates that the intervention may deliver a positive NPV (for example, a BCR of two indicates that for every £1 spent, there is an expected return of £2). If the BCR is equal to one, then the present value of the benefits equals that of the costs. Where the BCR is less than one, the value of the costs will outweigh the benefits.

Monetisation

To realise economic outcomes, benefit and cost streams must be monetised. Outcomes were categorised as either direct (NHS related outcomes), indirect (to other public sector organisations), or social outcomes (wider UK society).

Optimism bias

Optimism bias (OB) is defined as "*the tendency for a project's costs and duration to be underestimated and/or benefits to be overestimated*" (Mott MacDonald, 2002), as found by historical UK government reviews on public sector procurement. To account for these '*optimistic*' estimates, the model applies OB correction factors in response to the level of uncertainty in the data or assumptions used within the model. For more information, please see '*Appendix E: Health economic modelling approach continued*'.

The approach taken by Unity Insights is an adaptation of the model created by the Greater Manchester Combined Authority (GMCA) Research Team (HM Treasury et al., 2014). The GMCA model is featured in the supplementary guidance of HM Treasury's *The Green Book* and offers a robust and prudent approach to economic analysis (HM Treasury, 2022). The results outlined in this document include results in which an assumption-specific OB correction has been applied to each benefit and cost stream.

Scenario analysis

Three distinct scenarios have been modelled to comprehensively assess the monetary impact of the Sussex Airway devices project across varying population and implementation scales. These scenarios aim to analyse the estimated monetisable outcomes, to understand the project's potential future impact. The three scenarios are summarised below. In addition, in order to assess the financial affordability of each, a breakdown of scenario 1 by device has been provided, with sensitivity analysis applied.

Please note all scenarios are based on a hypothetical as, at the time of modelling, implementation has not occurred.

- **Scenario 1: Hypothetical secondary care pilot site:** 8 anaesthetic operating rooms
    - Scenario 1a: Breakdown by laryngeal blade
    - Scenario 1b: Breakdown by LMA

- Scenario 1c: Breakdown by ETT

- **Scenario 2: Hypothetical average ICS scale:** 79 anaesthetic operating rooms
- **Scenario 3: National implementation scale:** 3,307 anaesthetic operating rooms

Across all three scenarios, the estimated number of uses per device is derived from NHS England national annual disposal figures and divided by the estimated number of operating rooms for the scenario. A percentage has been applied to consider the proportion of non-single-use laryngeal blades that may be in use.

Scenario 1: Hypothetical secondary care pilot site

- Assessment of the financial impact of implementing reusable single-use airway devices.
- To be scaled based on implementation within a hypothetical hospital site location. This has been modelled in line with Royal Sussex County Hospital, which has eight operating rooms.
- An assumption of one D25 machine for every two operating rooms was confirmed via the clinical expertise of the University of Sussex project team. Therefore, the cost of acquiring four D25 machines (£28,397.32) was modelled. It is assumed all machines required are purchased in year 1 and do not need replacing for the modelled length of time (5-years).

Scenario 2: Hypothetical ICS average level

- The estimated number of operating rooms per ICS was calculated as approximately 79.
- An assumption of one D25 machine for every two operating rooms was confirmed via the clinical expertise of the University of Sussex project team. Therefore, the cost of acquiring 40 D25 instruments (£283,973.20) was modelled. It is assumed all machines required are purchased in year 1.

Scenario 3: Hypothetical national adoption

- The estimated number of operating rooms nationally was captured from NHS England's QMCO data collection for Q1 2024-25, the figure utilised was 3,307, which excludes the Independent Sector.
- An assumption of one D25 machine for every two operating rooms was confirmed via the clinical expertise of the University of Sussex project team. Therefore, the cost of acquiring 1,654 D25 machines (£11.7m) was modelled. It is assumed all machines required are purchased in year 1.

Benefits

Key benefit streams were identified through discussion with the project team based on hypothetical implementation. The modelled benefit streams are not guaranteed to represent all potential benefits. They have, however, been based on supporting evidence such as public data, clinical input, and reputable literature sources. All benefit streams are listed below in Table 1. A detailed methodology for each benefit stream variable is available in Figure 24 to Figure 29 in '*Appendix F: Benefit and cost streams continued*'.

Table 1: Benefit streams modelled in the current evaluation as part of the health economic modelling component.

Potential outcome	Detail of benefit stream
NHS cash releasing	
Benefit stream 1: Cost difference of reusable steel laryngeal blade use	• Cost per use of single-use steel laryngeal blade • Cost per use of reusable steel laryngeal blade o Inclusive of sterilisation cost • Estimated number of uses per year for each given scenario o Excluding the estimated proportion that are non-single-use devices
Benefit stream 2: Cost difference of reusable LMA use	• Cost per use of single-use LMA • Cost per use of reusable LMA o Inclusive of sterilisation cost • Estimated number of uses per year for each given scenario
Benefit stream 3: Cost difference of reusable ETT use	• Cost per use of single-use ETT • Cost per use of reusable ETT o Inclusive of sterilisation cost • Estimated number of uses per year for each given scenario
Social benefit (non-quality adjusted life years [non-QALY])	
Benefit stream 4: Environmental saving of reusable steel laryngeal blade use	• Estimated modelled benefit per laryngeal blade use in $kgCO_2e$ taken from CIA results • Monetisation of $kgCO_2e$ to pound sterling through conversion

Potential outcome	Detail of benefit stream
Benefit stream 5: Environmental saving of reusable LMA use	• Estimated modelled benefit per LMA use in $kgCO_2e$ taken from CIA results • Monetisation of $kgCO_2e$ to pound sterling through conversion
Benefit stream 6: Environmental saving of reusable ETT use	• Estimated modelled benefit per ETT use in $kgCO_2e$ taken from CIA results • Monetisation of $kgCO_2e$ to pound sterling through conversion

Costs

Cost streams associated with the reusable airway devices project were identified and calculated according to data provided by NHS procurement, the project team, external suppliers (STERIS) and publicly available sources. Each cost stream is listed below in Table 2. A detailed methodology for each cost stream variable is available in Figure 30 to Figure 32 '*Appendix F: Benefit and cost streams continued*'.

Table 2: Cost streams modelled in the current evaluation as part of the health economic modelling component.

Potential cost	Detail of costs
Direct NHS costs	
Cost stream 1: Cost of D25 devices	• The cost of a D25 machine, as provided directly from the supplier, was £7,099.33 (Wassenburg Medical, 2025). This cost included the D25 disinfection unit, D25 trolly, 12 months of warranty and 50 UV verification indicators.
Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning	• The estimated outsourcing cost of hydrogen peroxide cleaning was provided by an undisclosed third-party

Potential cost	Detail of costs
	provider, with the value to be kept confidential due to commercial sensitivity[2]. • This cost provided is inclusive of transport, initial clean, secondary wash and the V-PRO maX cycle for a full load. • The number of devices (LMAs or ETTs) per full load was provided by the University of Sussex project team.
Cost stream 3: Cost of D25 cleaning	The financial cost of cleaning a laryngeal blade after each use: • Electricity usage per D25 cleaning cycle

Limitations

Carbon impact analysis

It should be noted that there are limitations to the CIA pertaining to the scope of analysis and data availability; however, resultant exclusions are expected to contribute less than 15% of total emissions and do not impact the comparative element of the model.

- Some lifecycle phases have not been included in the CIA. Considering that impacts of transport compared with other lifecycle phases are negligible (Rizan & Bhutta, 2024), and there is limited data regarding international supply chains, road transport from manufacturing locations to ports before exporting shipments is excluded. Similarly, transport from ports to supplier warehouses in England (where shipments may be stored before delivery to clinical site) is not accounted for. As a result, impacts of transportation may be underestimated, however, including these will only be further in favour of reusable devices, as both scenarios will have the same total cost divided by uses per device.
- Due to limited data availability in the conversion factors (GOV.UK, 2022), the sterilant of vH_2O_2 used with the V-PRO maX is excluded from the CIA. Although vH_2O_2 is considered a "*green*" sterilant, its production is capital intensive and generates substantial waste (Beckman, 2003), which may underestimate the impacts associated with this sterilisation method.
- Downstream effects related to contamination have not been explored as part of this CIA (Van Wicklin, 2019); however, the clinical feasibility of these sterilisation methos is being

[2] Authenticity verified by Unity Insights.

explored separately. If there is a greater chance of cross contamination between patients using reusable airway devices, this may lead to increased carbon emissions associated with treating infected patients.

Cost benefit analysis

Please note that optimism bias corrections and prudent approaches were applied to all benefit and cost streams in order to reduce the risk of overestimation. The following limitations within the health economic modelling methods utilised were identified:

- Due to the hypothetical nature of the model, usage figures are estimated using NHS England data for single-use disposes per year. To more accurately measure usage, ideally, real-world pilot data would be utilised once available to update figures embedded.
- Expert opinion from the University of Sussex project team, alongside discussions with local suppliers, has been required for the assumed quantity of devices per V-PRO maX cleaning cycle, as well as the number of reuses per device, as listed in Table 11. Similarly to the point above, ideally, these assumptions would be validated by implementation data where possible. Greater optimism bias factors have been applied to provide mitigation here.
- Benefit streams 4 to 6 translate the financial gain from the CIA results of the reusable devices. Therefore, the results are subject to the same limitations, such as the system boundary as detailed within Section 2.1 from the environmental impact assessment.
- The scaling factor assumes that each operating room has an equal usage rate of the airway devices. In practice this will vary by sites and regionally, however, as this model has been built to provide a hypothetical average for each scenario, this does not limit the findings but should be noted if comparing results to a specific site, ICS, or regional picture.

3. Results

3.1. Carbon impact analysis

Laryngeal blades

For laryngeal blades, where 40 reuses are assumed, results indicate that reusing laryngeal blades could lead to a net reduction in carbon impacts, within the range of 0.34 to 0.46 kgCO_2e per use compared to the single-use scenario (Figure 5). Manufacturing contributed approximately 70% of the carbon impacts of single-use blades. The additional impacts associated with UVC sterilisation of reusable blades were small per use (0.0003 kgCO_2e; Figure 5).

	Per use ($kgCO_2e$)				
	Manufacturing	Transport	Sterilisation	Disposal	Total
Single-use blade	0.2894	0.0370	0.0000	0.0863	0.4127
Reused single-use blade	0.0072	0.0009	0.0003	0.0022	0.0106
Net change in $kgCO_2e$ (± 15% impact range)	**-0.2821** -(0.24 - 0.32)	**-0.0361** -(0.03 - 0.04)	**0.0003** (0.00 - 0.00)	**-0.0841** -(0.07 - 0.10)	**-0.4021** -(0.34 - 0.46)

Figure 5: Net change in carbon impacts for reusing laryngeal blades per use compared to single-use. Negative values indicate a net reduction in carbon impacts, whereas positive values indicate a net additional carbon burden.

Laryngeal mask airways

For LMAs, where 40 reuses are assumed, results indicate that reusing the item could lead to a net reduction in carbon impacts, within the range of 0.26 to 0.35 $kgCO_2e$ per use compared to the single-use scenario (Figure 6). Manufacturing contributed approximately 70% of the carbon impacts of single-use LMAs. The impacts associated with vH_2O_2 sterilisation contributed almost 75% of the carbon impacts of reusable LMAs per use.

	Per use ($kgCO_2e$)				
	Manufacturing	Transport	Sterilisation	Disposal	Total
Single-use LMA	0.3748	0.0618	0.0000	0.1101	0.5467
Reused single-use LMA	0.0094	0.0363	0.1401	0.0028	0.1885
Net change in $kgCO_2e$ (± 15% impact range)	**-0.3655** -(0.31 - 0.42)	**-0.0254** -(0.02 - 0.03)	**0.1401** (0.12 - 0.16)	**-0.1073** -(0.09 - 0.12)	**-0.3582** -(0.26 - 0.35)

Figure 6: Net change in carbon impacts for reusing LMAs per use compared to single-use. Negative values indicate a net reduction in carbon impacts, whereas positive values indicate a net additional carbon burden.

Endotracheal tubes

For ETTs, where 40 reuses are assumed, results indicate that reusing the item could lead to a net reduction in carbon impacts, equivalent to 0.03 $kgCO_2e$ per use compared to the single-use scenario (Figure 7). Manufacturing contributed approximately 65% of the carbon impacts of single-use LMAs. The impacts associated with vH_2O_2 sterilisation contributed almost 88% of the carbon impacts of reusable LMAs per use.

	Per use ($kgCO_2e$)				
	Manufacturing	Transport	Sterilisation	Disposal	Total
Single-use ETT	0.1279	0.0185	0.0000	0.0496	0.1959
Reused single-use ETT	0.0032	0.0161	0.1401	0.0012	0.1606
Net change in $kgCO_2e$ (± 15% impact range)	**-0.1247** -(0.11 - 0.14)	**-0.0023** -(0.00 - 0.00)	**0.1401** (0.12 - 0.16)	**-0.0483** -(0.04 - 0.06)	**-0.0353** -(0.03 - 0.03)

Figure 7: Net change in carbon impacts for reusing ETTs per use compared to single-use. Negative values indicate a net reduction in carbon impacts, whereas positive values indicate a net additional carbon burden.

Carbon equivalents

Figure 8 shows the net change in carbon impacts due to transitioning from single-use to re-use for each airway device over a one-year period, by scaling the carbon impacts per use by the number of devices used per year. The carbon value of the transition for laryngeal blades, LMAs, and ETTs yields £298k, £1.4m, and £40k, respectively.

Annual impacts (equivalents per year)	Laryngeal blades	LMAs	ETTs
Net change in $kgCO_2e$	-1,165,978	-6,447,166	-186,991
Carbon value	£298,490	£1,650,474	£47,870
Number of trees	22,873	126,473	3,668
Miles by car	320,236	1,770,714	51,357

Figure 8: Annual difference expressed in carbon value, number of trees, and miles travelled by car per year for laryngeal blades, LMAs, and ETTs.

In terms of car miles, the carbon reduction achieved by reusing laryngeal blades, LMAs, and ETTs is equivalent to 320k, 1.5m, and 44k miles travelled, respectively. At the lowest estimate for ETTs, this translates into driving across Great Britain from Land's End to John O'Groats and back 26 times (McDougal, 2020).

Carbon neutrality analysis

By comparing the cumulative impacts of single-use and reused devices, it is possible to determine how many times a device must be sterilised and reused for the carbon impact per item to achieve carbon neutrality[3]. This analysis provides insight into the minimum number of re-uses that yield a reduction in carbon impacts compared to the single-use scenario. Figure 8 illustrates that, from the first use, sterilising laryngeal blades contributes the same impacts as if the item were used once and disposed of (0.41 $kgCO_2e$). Thereafter, each time the laryngeal blade is sterilised with UVC and reused, the impacts per use are lower than the single-use comparator (0.83 $kgCO_2e$ versus 0.41 $kgCO_2e$; Figure 8).

Figure 9 illustrates that from the second re-use, sterilising LMAs using vH_2O_2 sterilisation contributes less impacts than using two single-use devices (1.09 $kgCO_2e$ versus 0.90 $kgCO_2e$). Sterilising an ETT yields achieves carbon neutrality from the fifth re-use (0.98 $kgCO_2e$ versus 0.97 $kgCO_2e$; Figure 8).

[3] Carbon neutrality is defined as where the emissions from using UVC or vH_2O_2 sterilisation to reuse devices are at least equal to baseline emissions (single-use).

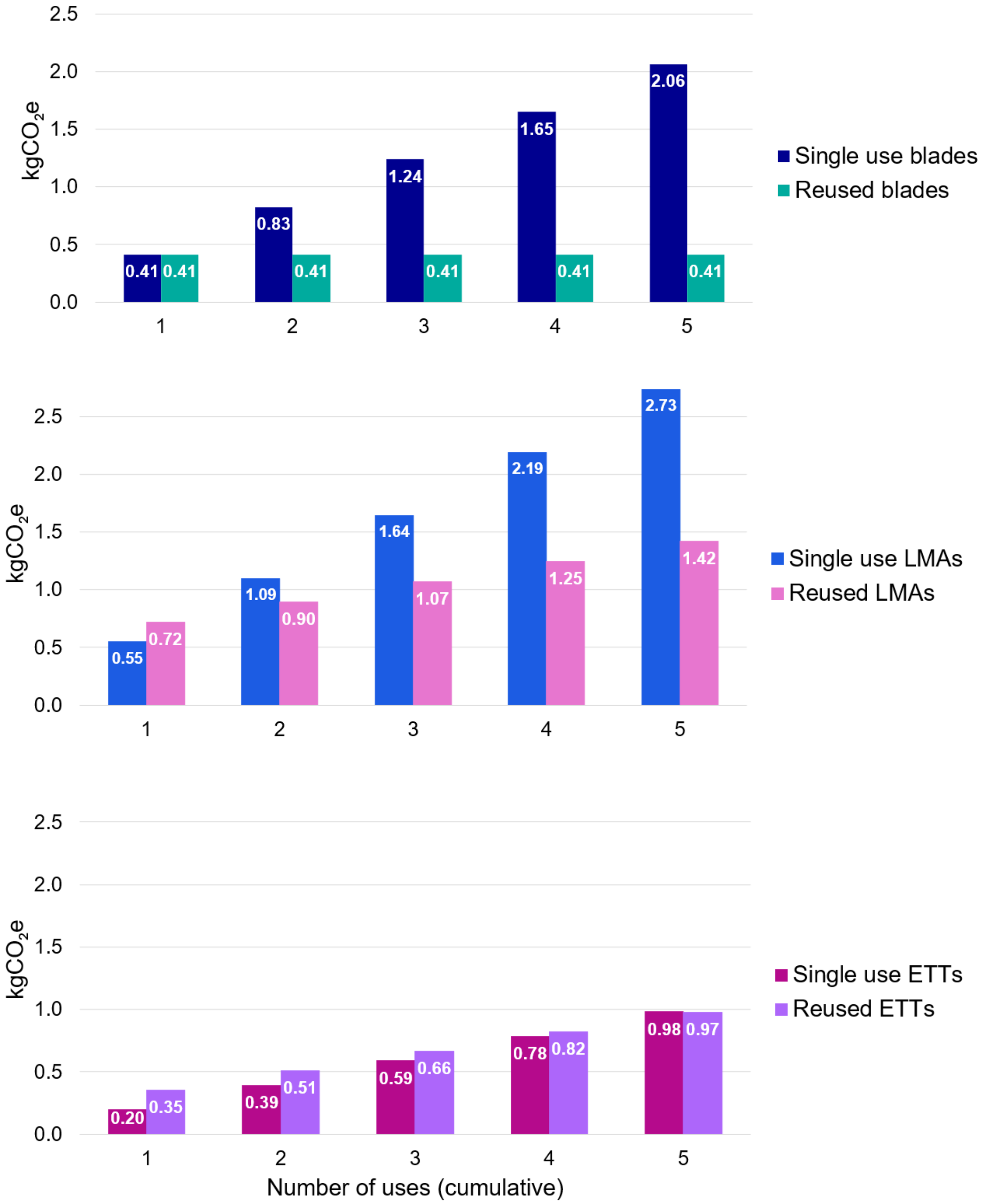

Figure 9: Comparison of cumulative carbon impacts for single-use and reused blades, LMAS, and ETTs per number of uses.

3.2. Health economic modelling

This section contains findings from the health economic modelling. For more information throughout, please see '*Appendix E: Health economic modelling approach continued*' and '*Appendix F: Benefit and cost streams continued*' for further details.

Scenario 1: Hypothetical secondary care pilot site

This section presents the scenario 1 results. The model provides estimates of the costs and benefits under each scenario over the duration of the pilot. For this scenario, a breakdown by each device has been provided, as can be seen in Table 3, Table 4, and Table 5. Table 6 depicts the collective results for scenario 1.

1a. Laryngeal blade breakdown

Table 3: Scenario 1 - laryngeal blade breakdown, economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

Laryngeal blades (£, net present value in 2024 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 1: Cost difference of reusable steel laryngeal blade use	£16k	£16k	£15k	£15k	£15k	**£77k**
Benefit stream 4: Environmental saving of reusable laryngeal blades use	£1k	£1k	£1k	£1k	£1k	**£3k**
Total benefits	**£17k**	**£16k**	**£16k**	**£16k**	**£15k**	**£80k**
Costs						
Cost stream 1: Cost of D25 devices	£33k	-	-	-	-	**£33k**
Cost stream 3: Cost of D25 cleaning	<£1k	<£1k	<£1k	<£1k	<£1k	**<£0k**

Laryngeal blades (£, net present value in 2024 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Total costs	**£33k**	**<£1k**	**<£1k**	**<£1k**	**<£1k**	**£33k**
Net present value						
Total NPV	**-£16k**	**£16k**	**£16k**	**£16k**	**£15k**	**£47k**
BCR	**0.5**					**2.5**

**The figures above may not sum as they have been rounded to the nearest £1k pounds.*

Sensitivity results

Figure 10 depicts the 5-year NPV sensitivity analysis using @RISK software to represent the most likely outcomes alongside the potential range of results at 90% confidence intervals (CI), based on 10,000 simulations for scenario 1a. The 5-year NPV sensitivity analysis for scenario 1a identified a likely result of £47k (90% CI between £41k and £54k; range = £13k).

The tornado chart in Figure 11 illustrates the individual impact of the greatest three inputs on the overall 5-year NPV.

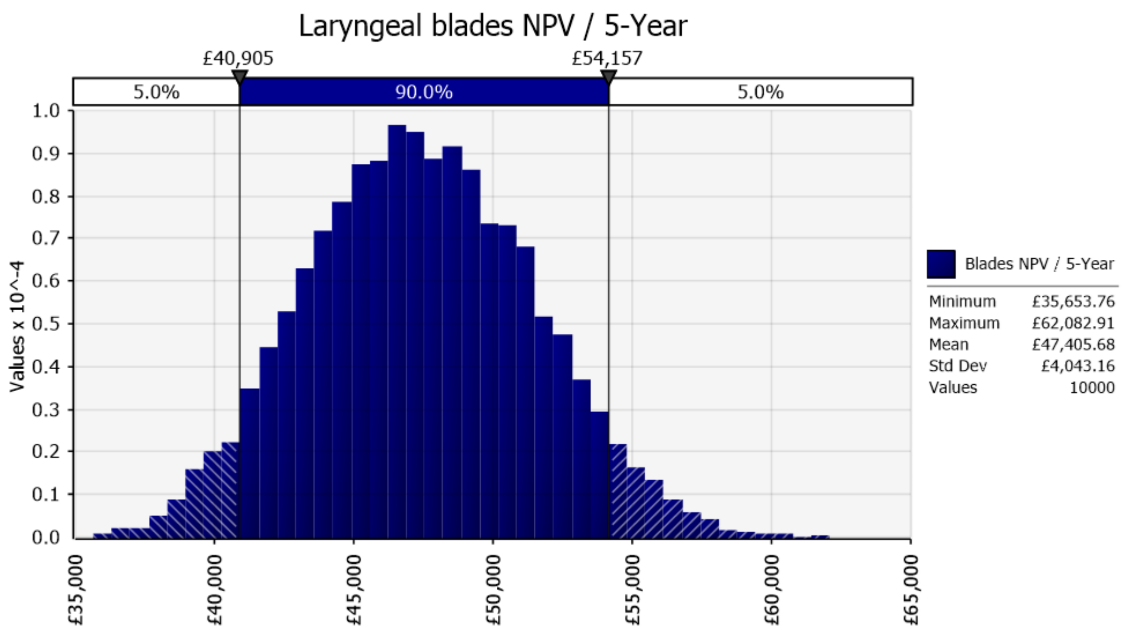

Figure 10: Histogram of sensitivity results following the Monte Carlo simulation showing the net impact of scenario 1a.

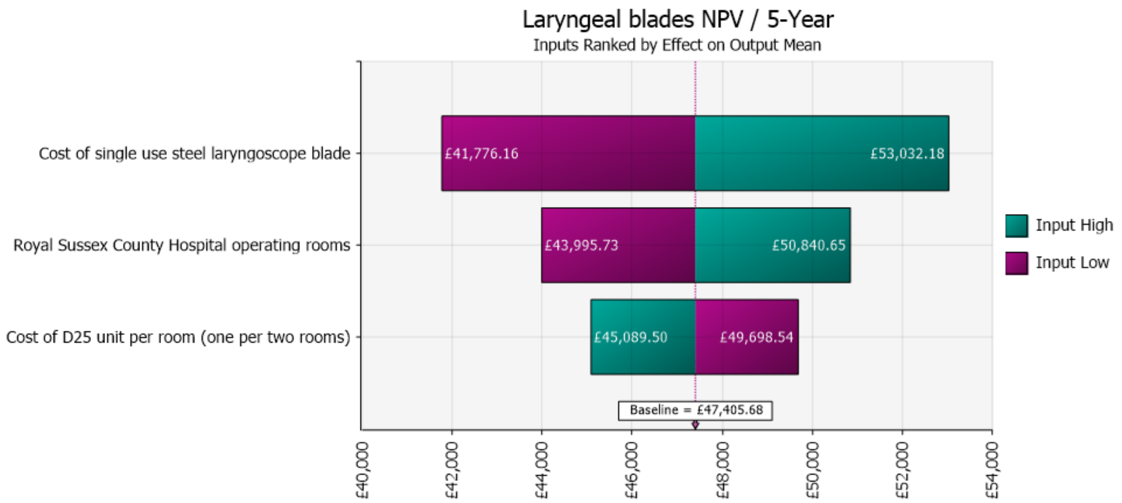

Figure 11: Tornado chart depicting key factors which influence the overall net impact of scenario 1a.

Summary

Results indicate a BCR below one for the first year modelled (0.5) due to the initial sunk cost of purchasing the D25 machines. Year 2 onwards is estimated to generate a positive NPV of £15k to £16k a year, with an overall BCR of 2.5 after five years.

Sensitivity analysis indicates a positive range of results at the 90% CI, with the key influencing factors being the single-use cost of the laryngeal blades, followed by the number of operating rooms (which dictates the quantity of devices), and finally the cost of the D25 machine.

1b. LMA breakdown

Table 4: Scenario 1 - LMA breakdown, economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

LMAs (£, net present value in 2024 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 2: Cost difference of reusable LMA use	£234k	£227k	£220k	£214k	£208k	**£1,102k**

LMAs (£, net present value in 2024 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefit stream 5: Environmental saving of reusable LMA use	£1k	£1k	£1k	£1k	£1k	**£6k**
Total benefits	**£235k**	**£228k**	**£221k**	**£215k**	**£209k**	**£1,109k**
Costs						
Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning	£204k	£198k	£192k	£186k	£181k	**£961k**
Total costs	**£204k**	**£198k**	**£192k**	**£186k**	**£181k**	**£961k**
Net present value						
Total NPV	**£31k**	**£30k**	**£30k**	**£29k**	**£28k**	**£148k**
BCR	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**

**The figures above may not sum as they have been rounded to the nearest £1m pounds.*

Sensitivity results

Figure 12 depicts the 5-year NPV sensitivity analysis using @RISK software to represent the most likely outcomes alongside the potential range of results at a 90% CI, based on 10,000 simulations for scenario 1b. The 5-year NPV sensitivity analysis for scenario 1b identified a likely result of -£148k (90% CI between £47k and £249k; range = £202k).

The tornado chart in Figure 13 illustrates the individual impact of the greatest three inputs on the overall 5-year NPV.

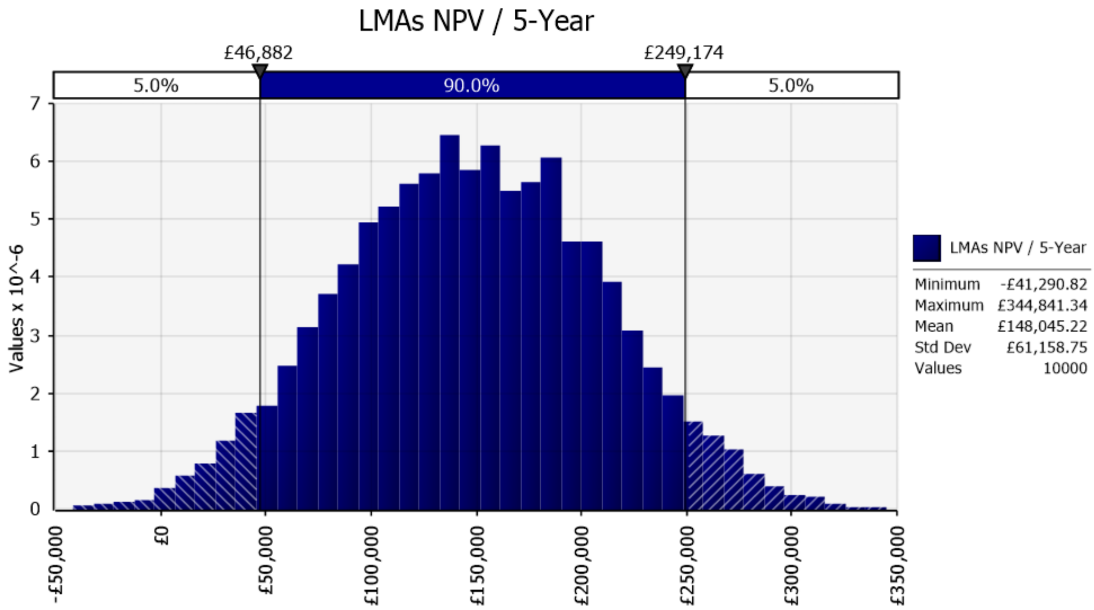

Figure 12: Histogram of sensitivity results following the Monte Carlo simulation showing the net impact of scenario 1b.

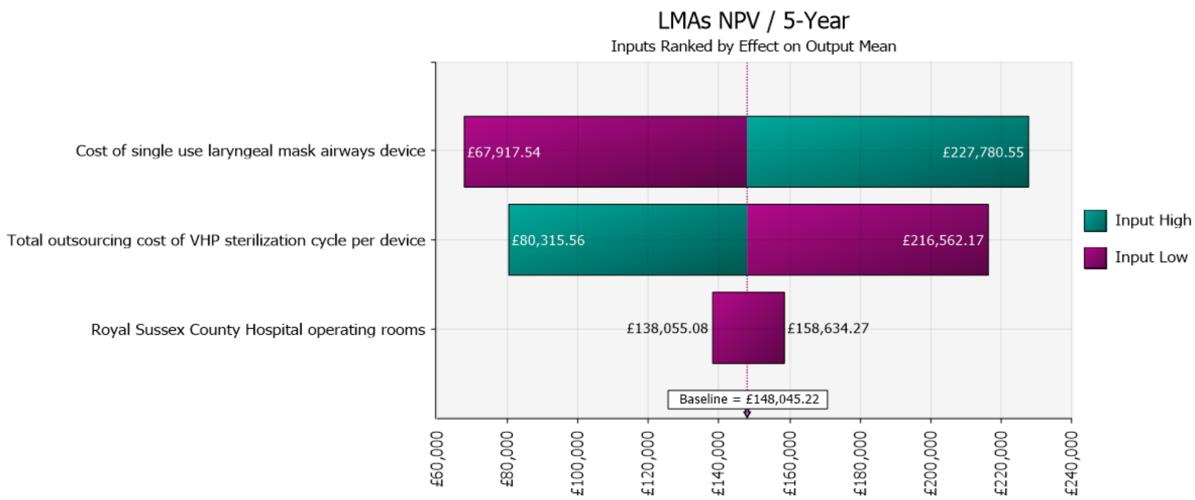

Figure 13: Tornado chart depicting key factors which influence the overall net impact of scenario 1b.

Summary

Results indicate a positive BCR (greater than one) for all years modelled (1.2), as the benefits and costs are linearly correlated. A yearly positive NPV of £28k to £31k is seen with an overall BCR of 1.2 after five years.

Sensitivity analysis indicates a positive range of results at the 90% CI, although negative at the minimum. Similarly to 1a. results, the primary influencing factor was the single-use cost of the

LMA, however, due to the significantly higher cost per sterilisation, the second most influential factor on the result is the cost of vH_2O_2 sterilisation.

1c. ETT breakdown

Table 5: Scenario 1 - ETT breakdown, economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

ETTs (£, net present value in 2024 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 3: Cost difference of reusable ETT use	£11k	£10k	£10k	£10k	£9k	**£50k**
Benefit stream 6: Environmental saving of reusable ETT use	-£1k	-£1k	-£1k	-£1k	-£1k	**-£3k**
Total benefits	**£10k**	**£10k**	**£9k**	**£9k**	**£9k**	**£46k**
Costs						
Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning	£60k	£58k	£56k	£55k	£53k	**£283k**
Total costs	**£60k**	**£58k**	**£56k**	**£55k**	**£53k**	**£283k**
Net present value						
Total NPV	**-£50k**	**-£49k**	**-£47k**	**-£46k**	**-£45k**	**-£236k**
BCR	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**

**The figures above may not sum as they have been rounded to the nearest £1k pounds.*

<u>Sensitivity results</u>

Figure 14 depicts the 5-year NPV sensitivity analysis using @RISK software to represent the most likely outcomes alongside the potential range of results at a 90% CI, based on 10,000 simulations for scenario 1b. The 5-year NPV sensitivity analysis for scenario 1b identified a likely result of -£237k (90% CI between -£262k and -£212k; range = £50k).

The tornado chart in Figure 15 illustrates the individual impact of the greatest three inputs on the overall 5-year NPV.

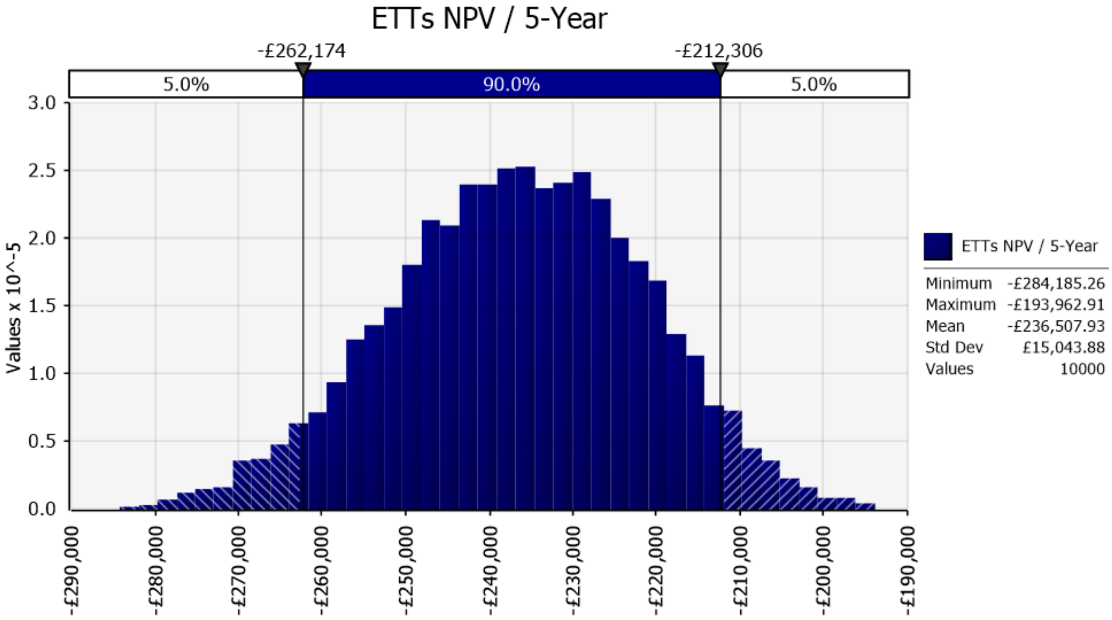

Figure 14: Histogram of sensitivity results following the Monte Carlo simulation showing the net impact of scenario 1c.

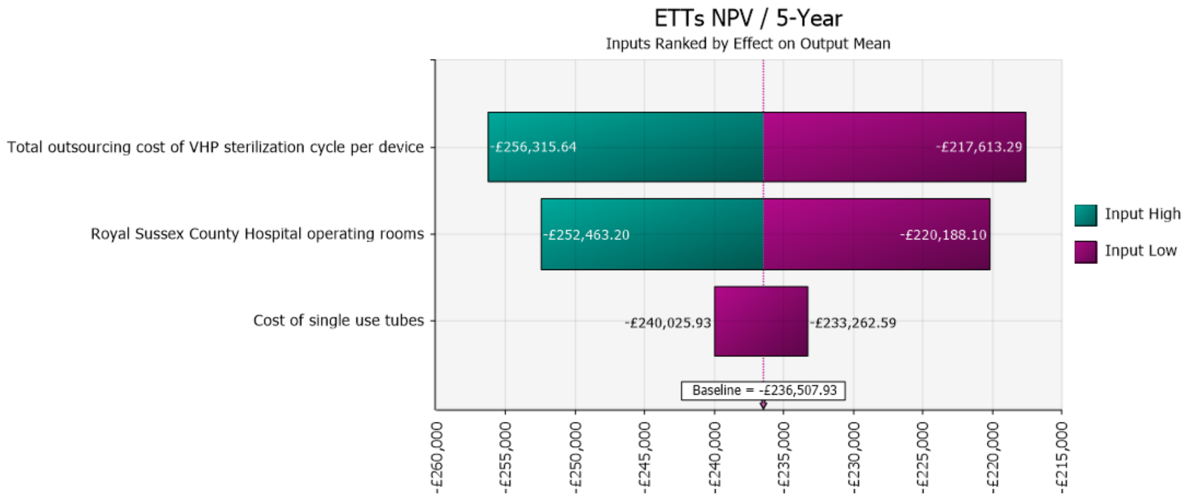

Figure 15: Tornado chart depicting key factors which influence the overall net impact of scenario 1c.

Summary

Results indicate a BCR below one for all years modelled (0.2), as the benefits and costs are linearly correlated. A yearly negative NPV of -£45k to -£50k is seen with an overall BCR of 0.2 after five years.

Sensitivity analysis indicates a negative range of results at the 90% CI, and at the maximum. The primary influencing factor was cost of vH_2O_2 sterilisation, this time followed by the cost of the device, due to ETTs being the cheapest of the devices modelled.

1. *Combined result*

Table 6: Scenario 1 economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

Royal Sussex County Hospital (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 1: Cost difference of reusable steel laryngeal blade use	£16k	£16k	£16k	£15k	£15k	**£78k**
Benefit stream 2: Cost difference of reusable LMA use	£234k	£230k	£223k	£217k	£210k	**£1,114k**
Benefit stream 3: Cost difference of reusable ETT use	£11k	£10k	£10k	£10k	£9k	**£50k**
Benefit stream 4: Environmental saving of reusable steel laryngeal blade use	£1k	£1k	£1k	£1k	£1k	**£3k**
Benefit stream 5: Environmental saving of reusable LMA use	£1k	£1k	£1k	£1k	£1k	**£7k**

Royal Sussex County Hospital (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefit stream 6: Environmental saving of reusable ETT use	-£1k	-£1k	£0k	£0k	£0k	**-£2k**
Total benefits	**£262k**	**£258k**	**£250k**	**£243k**	**£236k**	**£1,249k**
Costs						
Cost stream 1: Cost of D25 devices	£33k	-	-	-	-	**£33k**
Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning	£264k	£260k	£252k	£244k	£237k	**£1,257k**
Cost stream 3: Cost of D25 cleaning	<£1k	<£1k	<£1k	<£1k	<£1k	**<£1k**
Total costs	**£296k**	**£260k**	**£252k**	**£244k**	**£237k**	**£1,290k**
Net present value						
Total NPV	**-£34k**	**-£2k**	**-£1k**	**-£1k**	**-£1k**	**-£40k**
BCR	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

**The figures above may not sum as they have been rounded to the nearest £1k pounds.*

Summary

Scenario 1 results indicate a 5-year BCR of one, with an NPV of -£40k. The primary benefit is the cost difference of reusable LMA usage, with the corresponding highest cost being off-site vH_2O_2 sterilisation.

Scenario 2: Hypothetical wider ICS level

This section presents the scenario 2 results. The model provides estimates of the costs and benefits under each scenario over the duration of the pilot. Table 7 depicts the results for scenario 2.

Table 7: Scenario 2 economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

Average ICS scale (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 1: Cost difference of reusable steel laryngeal blade use	£161k	£159k	£154k	£149k	£145k	**£769k**
Benefit stream 2: Cost difference of reusable LMA use	£2,302k	£2,265k	£2,197k	£2,131k	£2,071k	**£10,965k**
Benefit stream 3: Cost difference of reusable ETT use	£104k	£102k	£99k	£96k	£93k	**£493k**
Benefit stream 4: Environmental saving of reusable steel laryngeal blade use	£6k	£6k	£6k	£6k	£5k	**£29k**
Benefit stream 5: Environmental saving of reusable LMA use	£14k	£14k	£13k	£13k	£12k	**£65k**
Benefit stream 6: Environmental saving of reusable ETT use	-£5k	-£5k	-£5k	-£5k	-£5k	**-£24k**

Average ICS scale (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Total benefits	**£2,581k**	**£2,540k**	**£2,464k**	**£2,390k**	**£2,322k**	**£12,298k**
Costs						
Cost stream 1: Cost of D25 devices	£354k	-	-	-	-	**£354k**
Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning	£2,597k	£2,556k	£2,479k	£2,404k	£2,336k	**£12,371k**
Cost stream 3: Cost of D25 cleaning	<£1k	<£1k	<£1k	<£1k	<£1k	**<£1k**
Total costs	**£2,950k**	**£2,556k**	**£2,479k**	**£2,404k**	**£2,336k**	**£12,725k**
Net present value						
Total NPV	**-£369k**	**-£15k**	**-£15k**	**-£14k**	**-£14k**	**-£427k**
BCR	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

**The figures above may not sum as they have been rounded to the nearest £1k pounds.*

<u>Summary</u>

Scenario 2 results indicate a 5-year BCR of one, with an NPV of -£427k. The primary benefit is the cost difference of reusable LMA usage, with the corresponding highest cost being off-site vH_2O_2 sterilisation.

Scenario 3: Hypothetical national adoption

This section presents the scenario 3 results. The model provides estimates of the costs and benefits under each scenario over the duration of the pilot. Table 8 depicts the results for scenario 3.

Table 8: Scenario 3 economic modelling results. Please note that the figures below have been rounded to the nearest GBP for presentation and as such, totals may not sum. These values have a GDP deflator and discounting applied.

National scale (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
Benefits						
Benefit stream 1: Cost difference of reusable steel laryngeal blade use	£6.8m	£6.7m	£6.5m	£6.3m	£6.1m	**£32.3m**
Benefit stream 2: Cost difference of reusable LMA use	£96.7m	£95.1m	£92.3m	£89.5m	£87.0m	**£460.5m**
Benefit stream 3: Cost difference of reusable ETT use	£4.3m	£4.3m	£4.2m	£4.0m	£3.9m	**£20.7m**
Benefit stream 4: Environmental saving of reusable steel laryngeal blade use	£0.3m	£0.2m	£0.2m	£0.2m	£0.2m	**£1.2m**
Benefit stream 5: Environmental saving of reusable LMA use	£0.6m	£0.6m	£0.5m	£0.5m	£0.5m	**£2.7m**
Benefit stream 6: Environmental saving of reusable ETT use	-£0.2m	-£0.2m	-£0.2m	-£0.2m	-£0.2m	**-£1.0m**
Total benefits	**£108.4m**	**£106.7m**	**£103.5m**	**£100.4m**	**£97.5m**	**£516.5m**
Costs						
Cost stream 1: Cost of D25 devices	£14.8m	-	-	-	-	**£14.8m**
Cost stream 2: Cost of off-site hydrogen	£109.1m	£107.3m	£104.1m	£101.0m	£98.1m	**£519.6m**

National scale (£, net present value in 2023 figures)	2024/25	2025/26	2026/27	2027/28	2028/29	5 years (2024/25 to 2028/29)
peroxide (V-PRO maX) cleaning						
Cost stream 3: Cost of D25 cleaning	<£0.1m	<£0.1m	<£0.1m	<£0.1m	<£0.1m	**<£0.1m**
Total costs	**£123.9m**	**£107.3m**	**£104.1m**	**£101.0m**	**£98.1m**	**£534.4m**
Net present value						
Total NPV	**-£15.5m**	**-£0.6m**	**-£0.6m**	**-£0.6m**	**-£0.6m**	**-£17.9m**
BCR	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

**The figures above may not sum as they have been rounded to the nearest £1m pounds.*

Summary

Scenario 3 results indicate a 5-year BCR of one, with an NPV of -£17.9m. The primary benefit is the cost difference of reusable LMA usage, with the corresponding highest cost being off-site vH_2O_2 sterilisation.

4. Discussion

4.1. Carbon impact analysis

- Laryngeal blade reuse (UVC sterilisation): **$kgCO_2e$ reduction per use = 0.40**
- LMA reuse (vH2O2 sterilisation): **$kgCO_2e$ reduction per use = 0.30**
- ETT reuse (vH2O2 sterilisation): **$kgCO_2e$ reduction per use = 0.03**

Reducing the environmental impact of medical devices, particularly single-use items, has gained increasing attention as the NHS strives to reduce their carbon footprint, in line with their net zero commitments. This CIA compared the carbon impacts (kgCO_2e) per use of single-use compared to reusing airway devices, where it is assumed that those devices may be reused 40 times each. The results indicate that the viability of reusing a traditionally single-use airway device depends predominantly on the net environmental impact, after evaluating the impacts of manufacturing and disposal against those arising from sterilisation.

From an environmental perspective, the difference in carbon impacts between single-use and reused laryngeal blades, LMAs, and ETTs is 0.40 kgCO_2e, 0.30 kgCO_2e, and 0.03 kgCO_2e per use, respectively (Figure 6, Figure 7, Figure 7). Here, positive values indicate a net reduction of carbon impacts from reusing devices, indicating that reusing all devices yields carbon efficiency gains within the modelled parameters.

As net carbon reductions scale with each reuse, conducting a carbon neutrality analysis where the number of re-uses is varied, provided further insights. From the first, second, and fifth re-use, less carbon impacts were generated by reuse compared to single-use for laryngeal blades, LMAs, and ETTs, respectively (Figure 9). This indicates that, where clinically feasible, the carbon efficiency of each device may be improved by altering this factor.

Results are supported by (Rizan & Bhutta, 2024), which found that the environmental impacts of reusable items typically depend on the utilisation phase, where sterilisation occurs. Specifically, the number of uses and sterilisation procedure directly impacts whether reuse yields environmental reductions compared to single-use. Maximising loading capacity of sterilisation cycles and reusing products more often may generate environmental reductions (Rizan & Bhutta, 2024). This was also supported by Demarré et al. (2023), which identified optimising sterilisation processes as an area of concern to minimise the environmental impact and resultant impacts on human health.

Achieving net carbon reductions through reuse depends on carbon accounting and operational factors. As this carbon impact analysis was developed pre-implementation, all results are subject to the findings of ongoing clinical effectiveness studies investigating the feasibility and appropriateness of vH_2O_2 and UVC to sterilise traditionally single-use airway devices. Reuse may be limited by device durability, potential contamination risks, and institutional infrastructure that dictates sterilisation capacity.

4.2. Economic impact

- Laryngeal blade reuse (UVC sterilisation): **5-year BCR = 2.5**
- LMA reuse (vH_2O_2 sterilisation): **5-year BCR = 1.2**
- ETT reuse (vH_2O_2 sterilisation): **5-year BCR = 0.2**
- Scenario 1 to 3 (reuse of all devices): **5-year BCR = 1**

Findings from the CBA suggest a mixed economic case for implementing the reuse of the airway devices identified. Overall, when considering all devices being reused and sterilised through the processes detailed, the 5-year BCR is just below 1.0 across all scenarios, indicating a minor negative return on investment. Despite this, reviewing the results by item demonstrates the economic viability of each. These results suggest that the case is positive and strongest for the laryngeal blade, with a BCR of 2.5, followed by the LMA at 1.2 and lastly the ETT, which is below one, and so estimated to create an overall economic cost to the healthcare system through reuse.

Exploring the results of reusing the laryngeal blade, the cost of sterilisation using the D25 machine is clearly cost-effective. This is due to the cost per use, after 40 reuses and sterilisations, being dramatically lower than the purchase price after one use. Results estimated that during the second year of reusing laryngeal blades, the cost of purchasing the D25 machines will have been recouped, with subsequent years creating a cost-saving system efficiency. Results for the LMAs and ETTs indicate a significantly higher cost per device to sterilise using the vH_2O_2 method, however, due to the cost of purchasing LMAs (modelled at £7.20 per device), reuse of these devices is expected to create a positive return on investment. This is not the case with regard to the ETTs, where the price per item to purchase is lower than the modelled cost of sterilisation, therefore, the economic case for reusing these devices is not supported.

Unsurprisingly, the key variables identified through the sensitivity analysis influencing results are the cost of the single-use device and cost of sterilisation. Assuming the price per device is likely to be fixed, this indicates that variables forming the cost of sterilisation per device should be optimised to improve the economic case for reuse. These factors include the number of devices per sterilisation cycle and the number of reuses possible per device.

Scenarios one, two and three had minimal variation in BCRs across scenarios and years, due to the linear relationship of the operating room scaling by usage of each device. The notable difference in approach across each scenario is for the first year (2024/25), whereby the initial cost of purchasing the D25 machines is modelled. This demonstrated the initial sunk cost leading to a lower result, although analysis of the laryngeal blades in scenario 1a. estimates that this cost is recouped within the second year.

Reviewing the benefits by benefit stream type, it is clear, and as expected, that the greatest benefits modelled are through the change is purchasing costs created through reuse, rather than the environmental benefits translated into a financial social gain. These are true cash-releasing benefits, which positively impact NHS budgets. Taking the first year for Scenario 1, results identify that benefit streams 1 to 3 account for 99.6% of the total benefits. Total costs modelled were primarily accrued by the offsite vH_2O_2 sterilisation method, this accounted for 89.2% of the total cost for scenario 1, year 1. Therefore, to impact the economic viability of the LMA and ETT devices being reused, the cost per device to be cleaned through this method should be reviewed.

Overall, these findings demonstrate an evident positive economic case for implementation of reusable laryngeal blades using the UVC sterilisation method, a lesser but still positive case for the LMA devices, and a contrary case for ETTs under the current model assumptions and sterilisation method.

5. Recommendations

Improve the cost efficiency of vapourised hydrogen peroxide sterilisation

As raised within Section 4.2, the most influential factor determining the economic case is the cost per device sterilisation, relative to the original single-use device cost. To improve the financial case for the LMA and ETT devices, the focus should be on methods to reduce the cost of this process. Discussions with providers to optimise the quantity of devices per cleaning cycle, collection and transportation to off-site locations, or being able to bring the sterilisation process in-house may change the results modelled.

Explore other sterilisation methods for LMAs and ETTs

Although this evaluation only reviewed the vH_2O_2 sterilisation method for the LMA and ETT devices, other sterilisation methods, such as different radiation options, could be explored. This would require clinical evidence to ensure the accountability of the method from a clinical effectiveness and patient welfare perspective, but results could provide different outcomes that support both the environmental and financial implication of reusing these devices.

Validate modelled laryngeal blade results through real-world data

Due to the current stage of the project, usage data has been generalised based on a national scale, with hypothetical scenarios. The robustness of results could be enhanced through real-world implementation at a site level. This would not only allow for updating of assumptions but also provide an opportunity to collect data on implementation processes, such as clinical perspectives on effectiveness and acceptability which do not form part of the scope of this evaluation piece.

Broaden life cycle analysis boundary and sustainability metrics

This evaluation scope was formed accounting for data and budget availability, hence decisions were made with the project team to limit the system boundary and focus on carbon impact, as detailed within Section 2.1. To further understand the impact to the environment from reusing the airway devices, producing a full life cycle analysis in line with international standards (International Organization for Standardization, 2022) is recommended. This would account for raw material extraction and transport to manufacturing, as well as identification of additional sustainability metrics, such as water use, pollution, and waste generation. Further, it is recommended that a full sensitivity and uncertainty analysis be incorporated to identify key determinants and account for the expected range of potential impacts.

6. Conclusion

To conclude, the results identified through the evaluation suggest that each device needs to be considered separately, as results differ across the perspectives included within the evaluation (environmental and financial). Overall, both the environmental and economic case for implementation of the reusable laryngeal blade is positive. As it is assumed that each device can be reused up to 40 times effectively in the clinical setting with a sterilisation after each use, these results support the case for implementation, with a recommendation to collect real-world implementation data to update and validate assumptions utilised.

Similarly, regarding the LMAs, carbon efficiencies associated with reusing these devices is positive and a slight positive return on investment estimated in the economic case. Currently, this also supports the case for implementation, however, financially there is further opportunity to improve results, particularly through avenues to minimise the sterilisation cost per device from vH_2O_2.

Reuse of ETTs is also modelled to yield carbon efficiency gains, in terms of $kgCO_2e$ produced per use, yet the health economic model estimates a low BCR. This is due to the cost of sterilisation per device being significantly greater than the original cost per single-use device. This combination of findings creates a challenging decision for implementation from a commissioner perspective, further emphasising the focus on future methods to minimise the sterilisation cost per device for ETTs, which may require a different method to vH_2O_2.

Overall, the reusable airway devices demonstrated a strong environmental and a mixed economic case for hypothetical implementation in the NHS at a secondary care site, ICB level and nationally, with significant variation per device to consider. Evaluation findings must be validated through identifying the impact of clinical effectiveness on the sterilisation process to ensure the feasibility of the reuse assumptions applied without impacting patient safety.

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8. Appendices

8.1. Appendix A: Materials and weights of airway items

Table 9: Detailed materials and associated weights for each airway item.

Item	Material	Weight (g)	Source
Laryngeal blade	Chromium steel	66.00	Sherman et al. (2018)
	Packaging film	1.60	Sherman et al. (2018)
	Fiber optic glass	3.00	Sherman et al. (2018)
	Kraft paper	4.30	Sherman et al. (2018)
	Corrugated board box	16.00	Sherman et al. (2018)
	Total weight	**90.90**	
LMA	Styrene ethylene butadiene styrene	83.00	Expert opinion
	Packaging: Polypropylene	14.85	Expert opinion
	Packaging: Paper	18.15	Expert opinion
	Total weight	**116.00**	
ETT	PVC	19.25	Medical World (2025)
	Packaging: Polypropylene	14.85	Expert opinion
	Packaging: Paper	18.15	Expert opinion
	Total weight	**52.25**	

8.2. Appendix B: Greenhouse gas conversion factors

Table 10: Greenhouse gas conversion factors for primary material production.

Category	Conversion factor	Kilograms of CO_2e ($kgCO_2e$) per tonne
Manufacturing $kgCO_2e$ conversion factors	Metal construction	4,005.14
	Average plastic film	2,560.26
	Glass	1,402.77
	Paper and board: paper	910.48
	Paper and board: board	801.52
	Plastic: Polystyrene	3,764.04
	Plastics: Polypropylene	3,090.82
	Plastic: Polyvinyl chloride	3,399.18
	Other: Clothing	2,2310.00
Transport $kgCO_2e$ conversion factors	Shipping emission factor (Average container ship; transportation of one tonne over one kilometre)	0.02
	Transport emissions (Average [up to 3.5 tonnes] van; transportation of one tonne over one kilometre)	0.58
Electricity $kgCO_2e$ conversion factors	Electricity in the UK ($kgCO_2e$ per kWh)	0.21
Disposal $kgCO_2e$ conversion factors	High temperature incineration (incl. direct and indirect)	949.00

8.3. Appendix C: Carbon impact analysis calculations

Calculations

Carbon impacts from the manufacturing to end-of-life disposal lifecycle phases are modelled based on the methodology detailed below.

Manufacturing

To account for the carbon impact of the production of the materials used to manufacture airway devices, each material and its associated weight were multiplied by their relevant primary material production greenhouse gas conversion factors (GHG conversion factors; please refer to Table 10 in '*Appendix B: Greenhouse gas conversion factors*' for full list of factors). For example, the chromium steel in laryngeal blades was multiplied by the metal construction greenhouse gas conversion factor. Thereafter, all carbon dioxide equivalents of each material component of each item are summed together to obtain the total impacts associated with manufacturing (Figure 16).

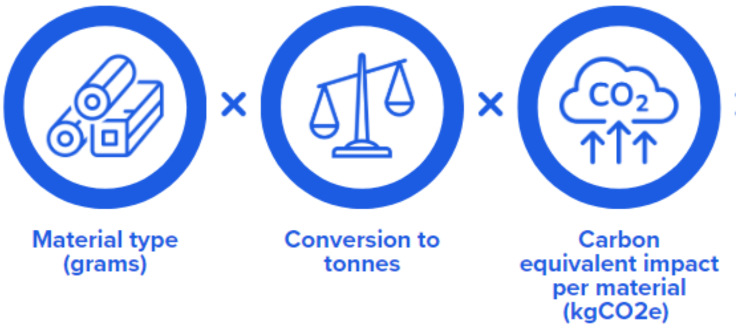

Figure 16: Calculation of carbon impacts for manufacturing per each material.

Item specifications were based on literature sources and confirmed by clinical site experts. For further detailed information, please refer to Table 9 in '*Appendix A: Materials and weights of airway items*'.

Transport

Transport was split into three categories, namely (i) transport from manufacturing location to clinical site, (ii) transport from clinical site to off-site sterilisation (where applicable for LMAs and ETTs sterilised with vH_2O_2), and (iii) transport from clinical site to off-site disposal.

Transport to clinical site

To calculate the transport to the clinical site (Figure 17), the total weight of each item was multiplied by:

- Carbon equivalent of the shipping distance from manufacturing location to the relevant port in England.
- Carbon equivalent of the roundtrip distance travelled by truck from the relevant port to the clinical site.

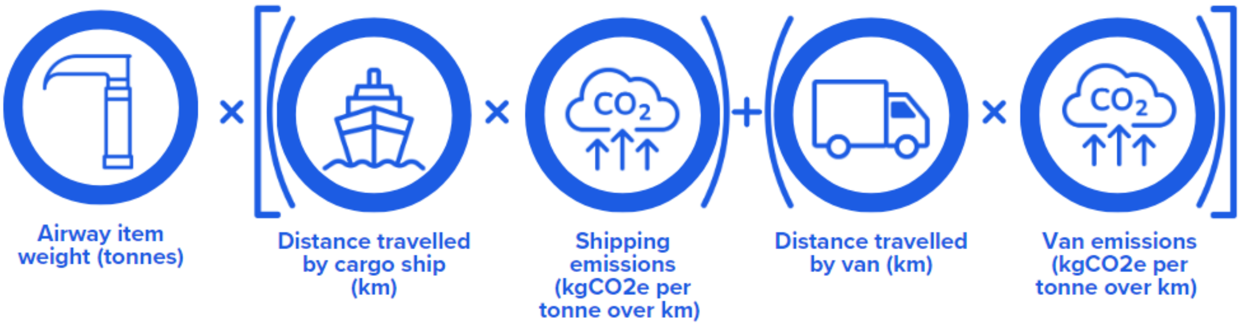

Figure 17: Calculation of carbon impacts for transport to clinical site per airway item.

Transport to disposal

The total weight of each item was multiplied by the average roundtrip from a clinical site to disposal location (Rizan et al., 2021).

Transport to off-site sterilisation

For LMA and ETTs that are sterilised off-site using vH_2O_2, there was an additional transport element to account for the transport to the sterilisation facility. Both transport to disposal and off-site sterilisation will be calculated as in Figure 18.

Figure 18: Calculation of carbon impacts for transport to disposal and off-site sterilisation (where applicable).

Sterilisation

UVC on-site sterilisation

To calculate the carbon impact of UVC sterilisation of laryngeal blades using the D25 machine, the energy required for one sterilisation cycle (UV Smart, 2024) was multiplied by the carbon conversion for electricity (Figure 19; GOV.UK, 2022).

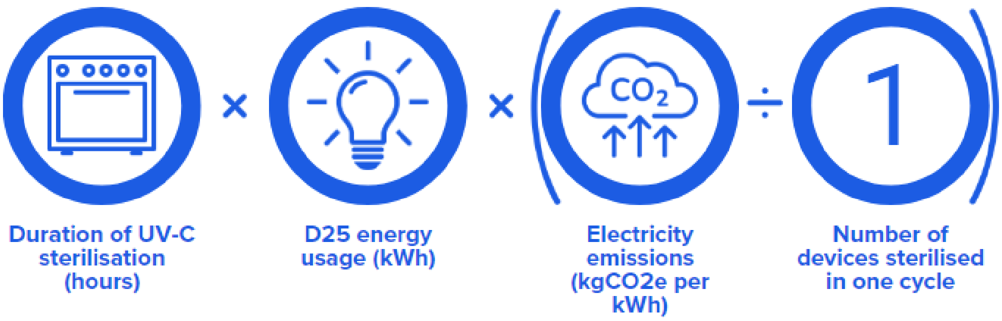

Figure 19: Calculation of carbon impacts for UVC sterilisation per item.

vH_2O_2 off-site sterilisation

The process of vH_2O_2 sterilisation involves three distinct phases that each generate carbon impacts. These phases are (i) manual pre-cleaning, (ii) washer disinfection, and (iii) sterilisation using the v-PRO Max machine (Figure 2). To account for the manual pre-cleaning, carbon impacts were estimated for the equipment used. The methodology employed here was to account for the manufacturing and end-of-life disposal of the precleaning brush and cloth by multiplying the weight (divided by the expected number of uses) by the GHG conversion factors for manufacturing and incineration, respectively (Figure 20).

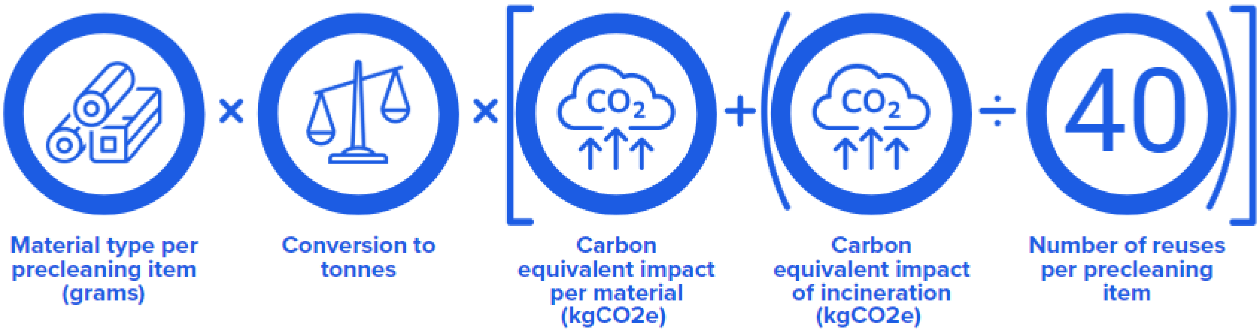

Figure 20: Calculation of carbon impacts for precleaning phase of vH_2O_2 sterilisation.

Carbon impacts due to the washer disinfection and v-PRO Max sterilisation process were calculated using the energy consumption and durations. Thereafter, impacts were proportioned according to the number of devices per cycle (Figure 21).

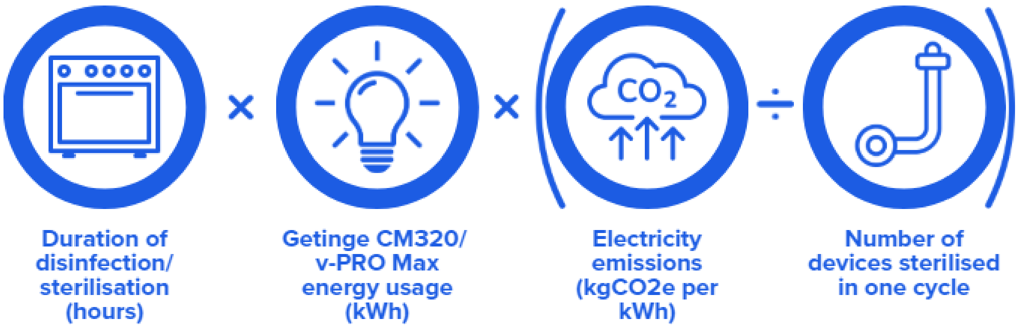

Figure 21: Calculation of carbon impacts for washer disinfector and v-PRO Max sterilisation phase of vH_2O_2 sterilisation.

Disposal

The total weight of airway items were multiplied by the conversion factor for high temperature incineration (Rizan et al., 2021) to obtain the carbon impact of disposal for each airway item, as shown in Figure 22.

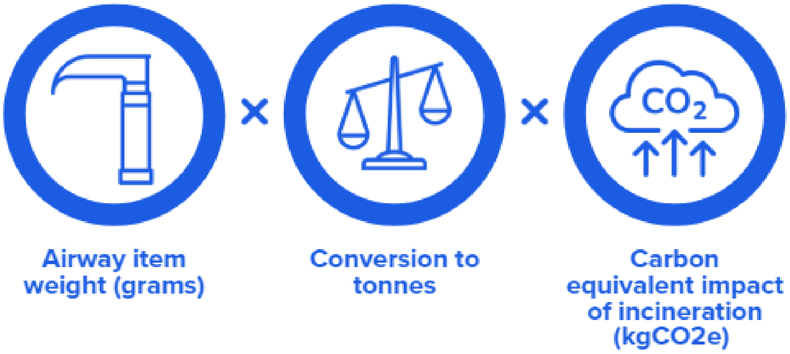

Figure 22: Calculation of carbon impacts for disposal per airway item.

8.4. Appendix D: Detailed assumptions list

Manufacturing

- It is assumed that single-use and reused single-use airway items consist of identical materials.
- Based on the clinical expertise from the University Hospitals Sussex project team, it is assumed that laryngeal blades, LMAs, and ETTs are manufactured in Pakistan, Lithuania, and Mexico, respectively.
- Where packaging details were not available for LMAs, it was estimated that the proportion of materials was identical to the packaging modelled by Eckelman et al. (2012; 5.16g polypropylene and 6.38g of paper). As a result, the total weight of packaging (33g) was assumed to consist of 45% polypropylene and 55% paper.
- Similar assumptions were used to model packaging for ETTs, as the identical packaging materials and weights (14.85g polypropylene and 18.15g paper) were used.
- The handles typically used with laryngeal blades are estimated by clinical experts to be reused more than 1,000 times; thus, impacts are negligible and excluded from the analysis.
- Based on clinical judgement, it is assumed that iGel LMAs are entirely made of styrene ethylene butadiene styrene (SEBS), where the mass of the item without is 83 grams.
- Based on clinical expertise, ETTs were modelled according to the midpoint between the most commonly used sizes in adults (based on size 7 and size 8 Portex Endotracheal Cuffed Tubes; midpoint is 19.25g between 16.5g and 22g, respectively).
- Due to limited GHG conversion factors available (Department for Energy Security and Net Zero, 2023), it is assumed that SEBS and chromium steel can be appropriately proxied by carbon impacts of polystyrene and metal construction, respectively.
- It is assumed that there is no waste generated during the manufacturing process.

Transport

- The selection of port that receives international supplier shipments in England was based on route estimations provided by Ports.com (2025) and Fluent Cargo (2025). Accordingly, it is assumed that the port location in England may change depending on where the shipment originated.
- It is assumed that all transportation distances from shipment ports to clinical sites, and from clinical sites to sterilisation and disposal, are return trips. For modelling purposes, it was assumed that the clinical site location was Brighton and Sussex Medical School.
- Transportation for sea and road freight is modelled based on emission factors for an average container ship and an average van, respectively.

- It is assumed that an average distance of 58 miles is representative of the distance travelled from modelled clinical sites and disposal location (Rizan et al., 2021).

Sterilisation

- It is assumed that the midpoint of 398 volts for the V-PRO maX machine represents average energy consumption, which is then multiplied by 10 amps to obtain energy consumption in watts (3,980 watts; W).
- It is assumed that each item is manually wiped with a reusable plastic brush and cotton cloth of 0.078 kg and 0.006 kg before being disposed after 40 re-uses. Thereafter, it is assumed that each item is disposed under high temperature incineration.
- As the scope of this CIA is limited to the use of airway items, the sterilisation of the reusable plastic brush and cotton cloth are excluded.

Table 11: Detailed assumptions list.

Description	Amount	Unit	Source
UVC assumptions			
D25 duration	25	Seconds	UV-Smart D25 plus brochure
Number of devices per D25 sterilisation	1	Device	Expert judgement
Energy consumption of D25 for one use	220	Watts	UV-Smart D25 plus brochure
vH_2O_2 assumptions			
Roundtrip from clinical site to vH_2O_2 sterilisation (STERIS, Leicester)	324	Miles	Calculated
Weight of pre-clean brush	0.078	Kg	Expert judgement
Weight of pre-clean cloth	0.006	Kg	Expert judgement

Description	Amount	Unit	Source
Number of times brush and cloth may be reused for pre-cleaning	40	Reuses	Unvalidated assumption
Energy consumption of V-PRO maX for one cycle	2.2	kWh	Expert judgement (STERIS)
Voltage of V-PRO maX	398	V	Expert opinion
Amps of V-PRO maX	10	A	Expert opinion
Energy consumption of V-PRO maX per second	3,980	Watts	Calculated
Voltage of CM320	206	V	Getinge Group (n.d.)
Amps of CM320	63	A	Getinge Group (n.d.)
Energy consumption of Getinge CM320 per second	12,978	Watts	Calculated
Number of devices per V-PRO maX sterilisation	10	Devices	Expert opinion
Number of devices per washer disinfector	25	Devices	Expert opinion
Duration of V-PRO maX flexible cycle	35	Minutes	STERIS V-PRO maX product specification chart
Duration of washer disinfector cycle	45	Minutes	Expert opinion
Transport			
Distance from Pakistan, Karachi Port to London, England port (Thames port)	6,924	Nautical miles	Ports.com (2024)

Description	Amount	Unit	Source
Distance from Thames port to clinical site	79.5	Miles	Google Maps (2024c)
Distance from Klaipeda port, Lithuania to Immingham port, England	1,569	Km	Fluent Cargo (2024a)
Distance from Immingham port to clinical site	245	Miles	Google Maps (2024a)
Distance from Altamira port, Mexico to London Gateway Port	10,330	Km	Fluent Cargo (2024b)
Distance from London Gateway port to clinical site	72	Miles	Google Maps (2024b)
Distance from site to disposal (mean roundtrip)	58	Miles	Rizan et al. (2021)
Reuses			
Assumed number of blades reuses	40	Reuses	Expert judgement
Assumed number of LMA reuses	40	Reuses	Expert judgement
Assumed number of ETT reuses	40	Reuses	Expert judgement
Carbon equivalence factors			
Environmental impact per car mile ($kgCO_2e$)	0.2746	$kgCO_2e$	GOV.UK (2022)
Emission offset per tree ($kgCO_2e$)	30.65	Lb	United States Environmental

Description	Amount	Unit	Source
			Protection Agency (2015)
Conversion of carbon to CO_2e (CO_2e)	3.67	CO_2e	United States Environmental Protection Agency (2015)
Emission offset per tree ($kgCO_2e$)	50.98	Tree/$kgCO_2e$	Calculated
Carbon value conversion factor (£/$kgCO_2e$)	0.256	£/$kgCO_2e$	GOV.UK (2021)
Scenario analysis			
Number of annual uses (laryngeal blades) in England	2,900,000	Devices	Dalton et al. (2024)
Number of annual uses (LMAs)	18,000,000	Devices	Dalton et al. (2024)
Number of annual uses (ETTs)	5,300,000	Devices	Dalton et al. (2024)
Proportion of laryngeal blades that are single-use in UK hospitals	95%	Percentage	Dalton et al. (2024)

8.5. Appendix E: Health economic modelling approach continued

Optimism bias

The approach taken by Unity Insights is an adaptation of the model created by the Greater Manchester Combined Authority (GMCA), Research Team (HM Treasury et al., 2014), supplemented by *The Magenta Book* (HM Treasury, 2020). The GMCA model is featured in the supplementary guidance of HM Treasury's *The Green Book* and offers a robust and prudent approach to economic analysis (HM Treasury, 2022). The results outlined in this document include results in which an assumption-specific OB correction has been applied to each benefit stream.

It is important to note that summary measures are not without limitations, for example, measures may not fully capture all potential impacts of the intervention and counterfactual pathways. The risk of an over-optimistic estimate is greatest when data is of low quality. This is due to the applicability of the estimate to the modelled pathway (HM Treasury et al., 2014). The quality of the data is defined by the relevance of the source data to the project data or age. Each data variable is graded according to its quality, and an assumption-specific optimism bias factor is applied to the calculation at the benefit and cost stream level (Figure 23). This factor is decided by the lowest grade amongst the stream's data inputs.

			Data Source									
	Confidence grade		Formal service delivery contract costs Figures derived from local stats / RCT trials		Practitioner monitored costs Figures based on national analysis in similar areas		Costs developed from ready reckoners Figures based on generic national analysis		Costs from similar interventions elsewhere Figures based on international analysis		Cost from uncorroborated expert judgement	
			1		2		3		4		5	
Age of Data (publication)	< 2 Years	1	1.1	0%	2.1	10%	3.1	15%	4.1	25%	5.1	40%
	2 - 3 Years	2	1.2	5%	2.2	10%	3.2	15%	4.2	25%	5.2	45%
	3 - 5 Years	3	1.3	10%	2.3	15%	3.3	20%	4.3	30%	5.3	50%
	5 - 10 Years	4	1.4	15%	2.4	25%	3.4	30%	4.4	40%	5.4	55%
	> 10 Years	5	1.5	25%	2.5	30%	3.5	40%	4.5	50%	5.5	60%

Figure 23: Optimism bias matrix.

Adjusting for inflation

Adjusting for inflation removes the general effects of inflation and presents costs and benefits included within the appraisal in '*real*' base year prices rather than in nominal prices[4] (in other words, the first year of the intervention). Within this appraisal a Gross Domestic Product (GDP) deflator (HM Treasury, 2021) of 2% was used to convert nominal to real values. Various rates were applied depending on data type, namely:

- Inflation rate (using March 2024; Office for Budget Responsibility & HM Treasury, 2024).
- PSSRU NHSCII Healthcare inflation.

Discounting

Discounting is a technique that enables the comparison of costs and benefits across time on a consistent basis and accounts for the concept of '*social time preference*'[5] (in other words, it allows costs and benefits that occur at different time periods to be compared on a "*present value*" basis). Discounting is applied to all future costs and benefits and is not applied retrospectively.

A discount rate of 3.5% is applied to benefits to deflate outcomes to real terms and reflect the changing value of healthcare within GDP (HM Treasury, 2022). For social outcome streams linked to welfare or utility values (for example, QALYs), a discount rate of 1.5% is applied as this excludes the change in expected growth per capita over time and only considers health and life effects.

Sensitivity analysis

A degree of uncertainty in the estimates of the model are accounted for by using sensitivity analysis. It is important to note that the sensitivity differs from optimism bias because sensitivity was applied on each individual assumption or input in the model, rather than by benefit or cost stream, in the case of optimism bias. The method used was Monte Carlo simulation, which was used to provide a range of estimates of the overall return on investment or net benefit. Monte Carlo analysis is a modelling technique that simulates the impact of the expected variance in key variables on the output of interest, in this case the net present value return on investment.

[4] Nominal prices reflect current monetary value (in other words, do not account for inflation).

[5] Society prefers to receive goods and services sooner rather than later.

8.6. Appendix F: Benefit and cost streams continued

Benefit stream 1: Cost difference of reusable steel laryngeal blade use

Logic: Due to reuse of the laryngeal blades, the number of items to be purchased by the NHS for the same number of use cases will fall, creating a cost-saving.

- The total number of uses per year were calculated proportionally to the average number of operating rooms (NHS England, 2024) for the given scenario.
- The estimated uses per operation room was calculated using the NHS England disposal data provided by the University Hospitals Sussex project team (Dalton et al., 2024).
- In order to account for those laryngeal blades that are already reusable, and so the benefit stream would not apply, a multiplication by 0.95 was included (Dalton et al., 2024).
- The cost per single-use and reusable device was modelled at £3.30.
- The number of reuses per device was modelled as 40.
- A benefit-specific optimism bias of 10% was applied was applied due to the relevance and age of the national dataset driven assumptions.
- The calculation for benefit stream 1 is displayed in Figure 24.

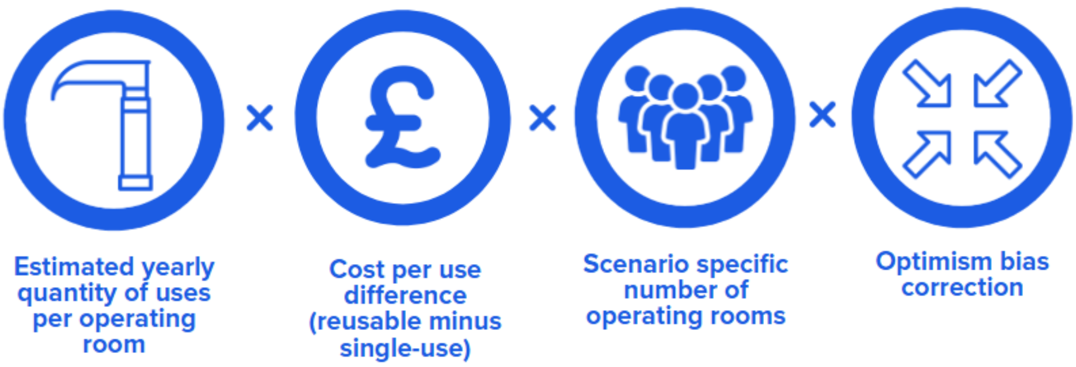

Figure 24: Benefit stream 1 calculation.

Benefit stream 2: Cost difference of reusable LMA use

Logic: Due to reuse of the LMAs, the number of items to be purchased by the NHS for the same number of use cases will fall, creating a cost-saving.

- The total number of uses per year were calculated proportionally to the average number of operating rooms (NHS England, 2024) for the given scenario.

- The estimated uses per operation room was calculated using the NHS England disposal data provided by the University Hospitals Sussex project team (Dalton et al., 2024).
- The cost per single-use and reusable device was modelled at £7.20.
- The number of reuses per device was modelled as 40.
- From discussion with the University Hospitals Sussex project team, it was understood that no reusable versions of this device are currently used in practice.
- A benefit-specific optimism bias of 10% was applied was applied due to the relevance and age of the national dataset driven assumptions.
- The calculation for benefit stream 2 is displayed in Figure 25.

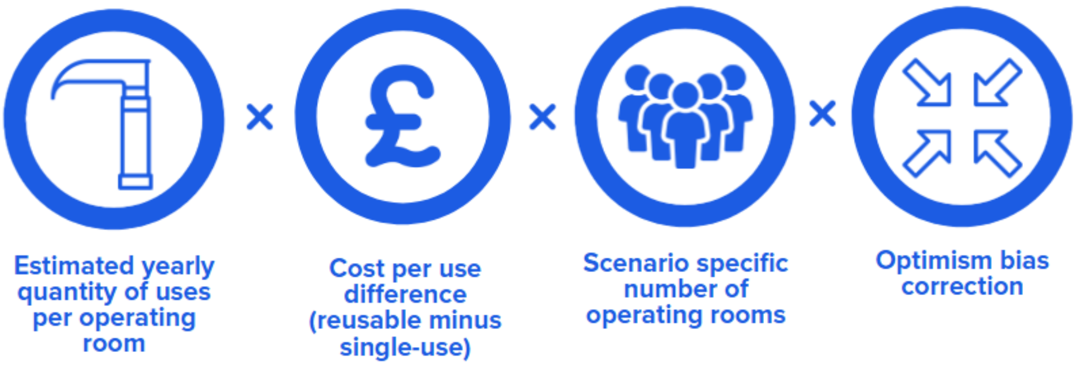

Figure 25: Benefit stream 2 calculation.

Benefit stream 3: Cost difference of reusable ETT use

Logic: Due to reuse of the ETTs, the number of items to be purchased by the NHS for the same number of use cases will fall, creating a cost-saving.

- The total number of uses per year were calculated proportionally to the average number of operating rooms (NHS England, 2024) for the given scenario.
- The estimated uses per operation room was calculated using the NHS England disposal data provided by the University Hospitals Sussex project team (Dalton et al., 2024).
- The cost per single-use and reusable device was modelled at £1.10.
- The number of reuses per device was modelled as 40.
- From discussion with the University Hospitals Sussex project team, it was understood that no reusable versions of this device are currently used in practice.

- A benefit-specific optimism bias of 10% was applied was applied due to the relevance and age of the national dataset driven assumptions.
- The calculation for benefit stream 3 is displayed in Figure 26.

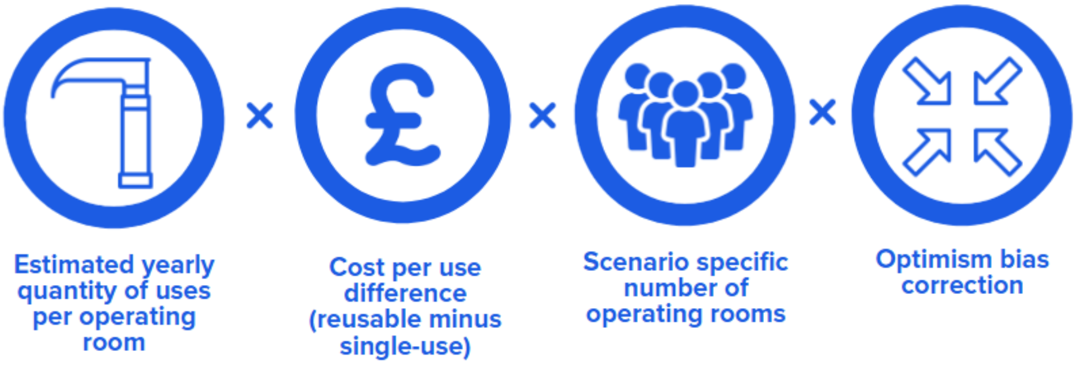

Figure 26: Benefit stream 3 calculation.

Benefit stream 4: Environmental saving of reusable steel laryngeal blade use

Logic: Due to reuse of the laryngeal blades, the associated environmental impact identified through the carbon impact analysis has been converted in a financial factor, this is a social benefit.

- The same assumptions for uses as per benefit stream 1 were applied.
- The estimated reduction in kgCO2 per reusable laryngeal blade use was 0.40.
- The cost per kg of CO2 was £0.256 in 2024 terms (GOV.UK, 2021).
- A benefit-specific optimism bias of 15% was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for benefit stream 4 is displayed in Figure 27.

Figure 27: Benefit stream 4 calculation.

Benefit stream 5: Environmental saving of reusable LMA use

Logic: Due to reuse of the LMAs, the associated environmental impact identified through the carbon impact analysis has been converted in a financial factor, this is a social benefit.

- The same assumptions for uses as per benefit stream 2 were applied.
- The estimated reduction in kgCO2 per reusable LMA use was 0.14.
- The cost per kg of CO2 was £0.256 in 2024 terms (GOV.UK, 2021).
- A benefit-specific optimism bias of 15% was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for benefit stream 5 is displayed in Figure 28.

Figure 28: Benefit stream 5 calculation.

Benefit stream 6: Environmental saving of reusable ETT use

Logic: Due to reuse of the ETTs, the associated environmental impact identified through the carbon impact analysis has been converted in a financial factor, this is a social benefit.

- The same assumptions for uses as per benefit stream 3 were applied.
- The estimated reduction in kgCO2 per reusable ETT use was -0.13.
- The cost per kg of CO2 was £0.256 in 2024 terms (GOV.UK, 2021).
- A benefit-specific optimism bias of 15% was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for benefit stream 6 is displayed in Figure 29.

Figure 29: Benefit stream 6 calculation.

Cost stream 1: Cost of D25 devices

Logic: The sterilisation method modelled for the laryngeal blades is through use of D25 machines. This would incur a cost to be purchased, which is assumed to be relative to the number of operating rooms and therefore expected device uses.

- The number of D25 machines required per operating room is equal to 0.5, or one D25 per two rooms, therefore the total number of machines is relative to each scenario room / usage estimation.
- The cost per D25 machine has been provided by a trusted third party provider (Wassenburg Medical, 2025).
- All costs are included in the first year of each scenario.
- All machines are expected to not require replacement during the timeline of the modelled results (2024/25 to 2028/29).
- No cost-specific optimism bias was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for cost stream 1 is displayed in Figure 30.

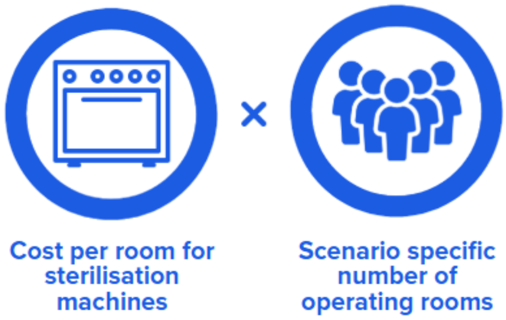

Figure 30: Cost stream 1 calculation.

Cost stream 2: Cost of off-site hydrogen peroxide (V-PRO maX) cleaning

Logic: The sterilisation method modelled for the LMAs and ETTs is through outsourced hydrogen peroxide cleaning. This would incur a cost per device as agreed contractually between the supplier and the NHS. The number of devices required to be cleaned is relative to the given scenario.

- The full cost of transport, pre-clean and full V-PRO maX cycle has been modelled, with an estimated ten devices per cycle, the actual figure is confidential and was shared by an undisclosed third-party provider.
- A cost-specific optimism bias of 10% was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for cost stream 2 is displayed in Figure 31.

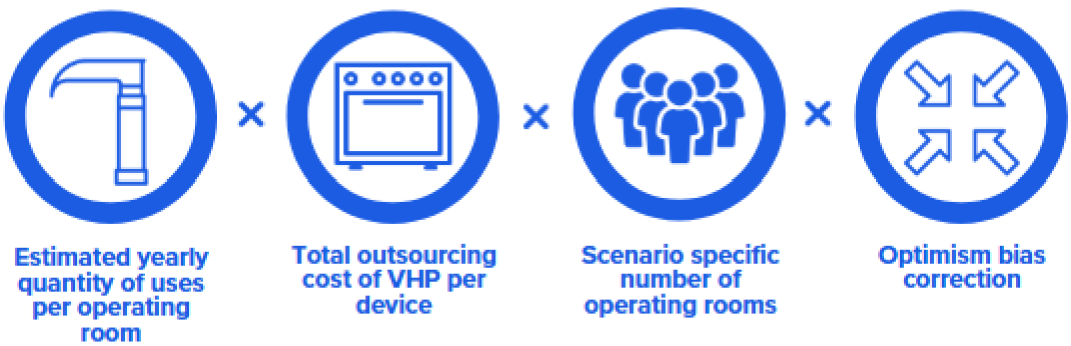

Figure 31: Cost stream 2 calculation.

Cost stream 3: Cost of D25 cleaning

Logic: The sterilisation method modelled for the laryngeal blades is through use of D25 machines. This would incur a cost per cleaning cycle; this is relative to the number device uses for the given scenario.

- Duration per cleaning cycle is 25 seconds (UV Smart, 2024).
- Energy consumption per D25 cycle equals 1.53 Watts (UV Smart, 2024).
- Electricity cost conversion factor of £0.245 kWh (Ofgem, 2025).
- In total this equates to a cost of £0.00037 per cleaning cycle.
- One device per cleaning cycle has been assumed, based on expert judgement at the University Hospitals Sussex NHS Foundation Trust.
- A cost-specific optimism bias of 10% was applied was applied due to the relevance and age of the assumptions utilised.
- The calculation for cost stream 3 is displayed in Figure 32.

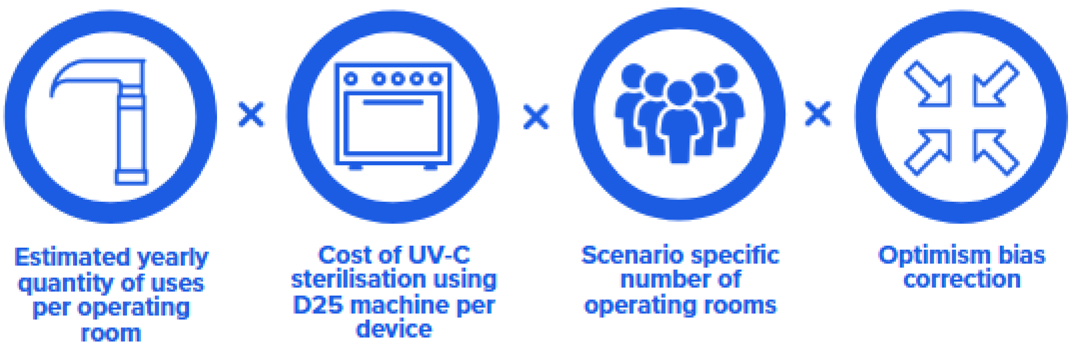

Figure 32: Cost stream 3 calculation.

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