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Financial and environmental costs of reusable and single-use anaesthetic equipment

F. McGain[1,2,*], D. Story[3], T. Lim[1] and S. McAlister[4]

[1]Department of Anaesthesia, [2]Department of Intensive Care, Western Health, Gordon Street, Footscray, VIC 3011, Australia, [3]Department of Anaesthesia, Austin Hospital, Banksia Street, Heidelberg, VIC 3084, Australia and [4]Ecoquantum Consulting Suite 43A Crisp Avenue, Brunswick, VIC 3056, Australia

*Corresponding author. E-mail: forbes.mcgain@wh.org.au

Abstract

Background. An innovative approach to choosing hospital equipment is to consider the environmental costs in addition to other costs and benefits.

Methods. We used life cycle assessment to model the environmental and financial costs of different scenarios of replacing reusable anaesthetic equipment with single-use variants. The primary environmental costs were CO_2 emissions (in CO_2 equivalents) and water use (in litres). We compared energy source mixes between Australia, the UK/Europe, and the USA.

Results. For an Australian hospital with six operating rooms, the annual financial cost of converting from single-use equipment to reusable anaesthetic equipment would be an AUD$32 033 (£19 220), 46% decrease. In Australia, converting from single-use to reusable equipment would result in an increase of CO_2 emissions from 5095 (95% CI: 4614–5658) to 5575 kg CO_2 eq (95% CI: 5542–5608), a 480 kg CO_2 eq (9%) increase. Using the UK/European power mix, converting from single-use (5575 kg CO_2 eq) to reusable anaesthetic equipment (802 kg CO_2 eq) would result in an 84% reduction (4873 kg CO_2 eq) in CO_2 emissions, whilst in the USA converting to reusables would have led to a 2427 kg CO_2 eq (48%) reduction. In Australia, converting from single-use to reusable equipment would more than double water use from 34.4 to 90.6 kilolitres.

Conclusions. For an Australian hospital with six operating rooms, converting from single-use to reusable anaesthetic equipment saved more than AUD$30 000 (£18 000) per annum, but increased the CO_2 emissions by almost 10%. The CO_2 offset is highly dependent on the power source mix, while water consumption is greater for reusable equipment.

Key words: life cycle assessment; environment; footprint; health economics; anaesthesia

Environmental sustainability is achieving increasing prominence within anaesthesia.[1–3] There are several recent studies examining the ‘environmental footprint’ of anaesthesia, including volatile anaesthetics,[4] laryngeal mask airways (LMAs),[5] drug trays,[6] and whole operations.[7 8] Such studies rely upon life cycle assessment (LCA) to measure the environmental and financial costs throughout an entire life cycle, ‘cradle to grave’.[9 10] Our previous studies[6 11] have shown that there is some complexity in the relative benefits of reusables *vs* disposables for different environmental effects [CO_2 equivalent (eq) emissions, water use etc.] and for different energy sources (e.g. coal, renewables).

Anaesthetists use anaesthetic breathing circuits, face masks, LMAs and laryngoscopes that can be reusable or single use/disposable. We considered that reusable anaesthetic equipment would be less expensive, have similar associated CO_2 emissions, and a higher water use in Australia, but in the UK/Europe and the USA the CO_2 emissions for reusables would be considerably lower as a result of different marginal (new) energy sources.

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Editor's key points

- Anaesthetists use large amounts of equipment for airway management and ventilation.
- The authors estimated the financial and environmental costs for a small hospital to switch from single-use to reusable airway equipment.
- Estimated costs halved, whereas water consumption almost trebled.
- Estimates of CO_2 emissions increase for some countries and decrease for others, depending on the national power source mix.

Australia has an electricity mix principally based upon coal, which is associated with high CO_2 emissions. New electricity generation in the UK/Europe is now principally sourced from renewables (mainly wind power), whereas in the USA, natural gas has become the most important new source. For the same amount of electricity use, brown coal produces approximately twice the CO_2 emissions compared with gas and at least six times that of wind power.[12 13]

This study was a consequential LCA; that is, we were interested in the consequences of changing from one pattern of equipment use to another, looking to whether new labour would be required or where the next kilowatt hour of electricity (the marginal supplier) would be sourced from (e.g. coal, renewables, natural gas). We sought to define the environmental and financial consequences of the following five different scenarios: Scenario 1, the current practice at Hospital 1 of using reusable anaesthetic circuits, face masks, 'Proseal'® (Teleflex, Westneath, Ireland) LMAs, and direct and videolaryngoscope blades and handles; Scenario 2, changing the practice at Hospital 1 to that occurring at Hospital 2 of using disposable anaesthetic circuits, and single-use face masks, LMAs, and direct laryngoscope blades, retaining reusable direct laryngoscope handles and reusable videolaryngoscopes; Scenario 3, replacing all reusable with single-use/disposable anaesthetic equipment; Scenario 4, from Scenario 1, replacing only reusable with single-use face masks; and Scenario 5, from Scenario 1, replacing only reusable with single-use direct laryngoscope blades.

The only differences between Hospital 1 (Scenario 1) and Hospital 2 (Scenario 2) that were of relevance for this study were that Hospital 1 used reusable anaesthetic equipment, whereas Hospital 2 had mainly single-use equipment. The other three scenarios were models of what was anecdotally occurring in other local hospitals.

Methods

We performed an LCA using Monte Carlo analysis[14 15] at two major hospitals in Melbourne, Victoria, Australia (ethical approval from Western Health WH/LRE-2013.165). We obtained data (including numbers used and the nature of their use) for breathing circuits, face masks, LMAs, and direct and videolaryngoscopes. Data of anaesthetic equipment use were obtained for Hospital 1 (Scenario 1, reusable variants) and for Hospital 2 (Scenario 2, mainly single use) for 2015. Scenario 3 (completely single use=Scenario 2 plus single-use direct laryngoscope blades) was anecdotally the routine approach in many USA hospitals and to a lesser extent elsewhere. We were also interested in the financial and environmental consequences of substitution of only one reusable to single-use device (purchased in high volume) for two further scenarios. Scenarios 4 (reusables except for single-use face masks) and 5 (reusables except for single-use laryngoscope blades) were chosen because they were occurring in Australian hospitals and were high-volume products.

We modelled what the financial and environmental consequences would be if reusable equipment in Scenario 1 was replaced with single-use equipment as per Scenarios 2–5). We measured the environmental and financial costs [in Australian dollars (AUD$)], including the labour, electricity, and water costs for the Central Sterile and Supply Department (CSSD).

Health economists from the University of Melbourne, Victoria, Australia, gave advice about the financial costs requiring inclusion. As we wished to know the financial consequences of substituting reusable with single-use anaesthetic equipment from the viewpoint of the hospital, we examined real changes in labour times, electricity use etc. If, for example, the substitution of single-use with reusable equipment did not increase the amount of casual/part-time/full-time hospital labour, from the perspective of hospital staff there was no financial cost increase. On the contrary, if the number of washer loads increased, these financial and environmental costs were included. We did not include washer and sterilizer maintenance and depreciation because these would be unaltered by the presence or absence of reusable anaesthetic equipment; maintenance and depreciation costs were fixed annually, regardless of the number of loads performed.

In accordance with the International Organization for Standardization (ISO) 14040 Standards, an LCA has a system boundary; that is, included and excluded items (Supplementary Fig. S1).[16] For example, all capital costs of existent infrastructure (to make single-use equipment or clean reusable equipment) are not included within the system boundary.[16] An LCA has inputs and outputs;[9] every input has a degree of uncertainty associated with it.[15 17] A final 95% confidence interval (CI) for a process is achieved based upon the random sampling thousands of times anywhere within the 95% CIs for all inputs.[14 15] We gave 95% CIs for the comparisons between Scenarios 1 and 2 because these were of most importance, and performing thousands of runs for each comparison was unlikely to provide further clinically useful information. We performed LCA modelling with SimaPro software (PRé Consultants, Amersfoort, The Netherlands). Further details of LCA methods for a medical audience can be found elsewhere.[3 5 6] Some of our data were obtained from life cycle inventories (LCIs; Ecoinvent v2.1; Swiss Centre for Life Cycle Inventories, Zurich, Switzerland).[18]

In 1991, the Society for Environmental Toxicology and Chemistry (SETAC) defined the components of an LCA of an item to be analysed as follows: (i) raw material acquisition; (ii) processing and manufacturing; (iii) distribution and transportation; (iv) use, reuse, and maintenance; (v) recycling; and (vi) waste management.[10] Further evolution saw the development of the impact assessment (environmental effects) method using ReCiPe LCIA (life cycle impact assessment).[19] In accordance with ISO 14040 standards for LCAs,[16] researchers decide *a priori* what will be the environmental impacts likely to be of greatest interest. For this study of anaesthetic equipment, the following impact categories (and their units) were calculated and results given: climate change (in grams of CO_2 equivalent; g CO_2 eq), water use (in kilolitres), eutrophication (as phosphorus deposition), and human, terrestrial, and marine ecotoxicity