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Original Research

The carbon footprint of acute care: how energy intensive is critical care?

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ABSTRACT

Objectives: Climate change has the potential to threaten human health and the environment. Managers in healthcare systems face significant challenges to balance carbon mitigation targets with operational decisions about patient care. Critical care units are major users of energy and hence more evidence is needed on their carbon footprint.
Study design: The authors explore a methodology which estimates electricity use and associated carbon emissions within a Critical Care Unit (CCU).
Methods: A bottom-up model was developed and calibrated which predicted the electricity consumed and carbon emissions within a CCU based on the type of patients treated and working practices in a case study in Cornwall, UK.
Results: The model developed was able to predict the electricity consumed within CCU with an error of 1% when measured against actual meter readings. Just under half the electricity within CCU was used for delivering care to patients and monitoring their condition.
Conclusions: A model was developed which accurately predicted the electricity consumed within a CCU based on patient types, medical devices used and working practice. The model could be adapted to enable it to be used within hospitals as part of their planning to meet carbon reduction targets.

Introduction

Climate change has been identified by some as the greatest threat to human health in the 21st century.[1] However, efforts to mitigate emissions of greenhouse gas (GHG) have been slow to emerge.[2] In the USA healthcare comprises 7% of total GHG emissions.[3] In England, this fraction is more than 3%,[4] reaching a total of 21 million tonnes of CO_2 equivalent in 2010.[5]

The National Health Service (NHS) has a self-imposed target to lower GHG emissions by 80% by 2050.[4] It is often considered within the NHS that mitigation against climate

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change is achievable in part through a reduction of the carbon footprint of hospitals.[6] Previous studies have evaluated GHG emissions associated with secondary healthcare[7] and renal care.[8] The Critical Care Unit (CCU) in acute hospitals is a major consumer of energy, and as such it is important to consider options for improving efficiency in acute care.[9]

The objective of this study was, therefore, to build a model to estimate the electricity consumption and the associated carbon footprint in a CCU based on the patient caseload. The model may then be employed to quantify the energy savings achieved through different ways of delivering care. The suitability of this approach was then assessed as a tool to minimize the carbon footprint of CCUs.

Methods

A bottom up model was developed based on observation of use of the CCU at the Royal Cornwall Hospital in the UK. This is a district general hospital of 750 in-patient beds, serving a population of approximately 450,000.[10,11] The CCU has 10 funded adult beds, with a mixed medical and surgical casemix. Data were collected using chart review in terms of organs supported for all patients on the CCU from 14th May to 11th June 2012, during which time the electricity supplied to the unit was also measured. Knowing the rate at which each machine consumed electricity, the electricity consumed by estimating the proportion of time that machines were being used for each patient was modelled.

The electricity used is supplied from two independent systems; the first supplies medical and bedside devices and the second supplies resources shared within the Unit. To reflect this, the electricity consumed was categorized within the Unit as:

- Bedside Energy, E_b – that required to power devices for organ support and for patient monitoring;
- Remote Energy, E_r – that used by equipment that is not allocated on medical grounds to an individual patient (for example: blood gas analysis at the point of care), for lighting in corridors and other communal areas, and for information technology.

The model estimates the energy required for 'bedside' purposes by analysing pathways of care. The 'remote' energy may be derived from consideration of the electricity required to power the shared space of the CCU, the thoroughfares, shared services and staff areas, which when added to the 'bedside energy', leads to an estimation of the Total Energy, E, expended in the Unit:

$$E = E_b + E_r$$

The model

To quantify the bedside energy required, the model assesses energy demands for specific devices used in care pathways, which are labelled according to the illness severity and the treatment administered. The organs supported are:

- Heart;
- Lungs;
- Gut;
- Kidneys; and
- Brain.

Four levels of support are available on the Unit which depict severity:[12]

- Level 3 – Patients requiring advanced respiratory support, or basic respiratory support together with support of at least two organ systems. Generally these will be patients with complex conditions requiring treatment that can only be delivered by a CCU;
- Level 2 – Patients requiring detailed observations or interventions including support for a single failing organ. This also includes patients requiring postoperative care and those 'stepping-down' from level 3 care. These patients also require care by a CCU;
- Level 1 – Patients at risk of deterioration or those recently relocated from a higher level of care. Whilst the care of these patients can be met on an acute ward, they often require support from the critical care team; and
- Level 0 – These patients can be managed on a normal ward.

These care pathways are sufficiently distinguishable to allow the assignment of a unique combination of devices to each. A patient with complex needs may receive more than one type of support. In this case the patient would receive the care pathway appropriate to each organ simultaneously.

The model automatically receives patient volumes through links established with sources of patient records. Data relating to expected machine usage for each patient type treated during a given period is entered into lists which are automatically fed into the model. This enables a calculation of the total bedside energy (E_b) expended for each patient according to the formula:

$$E_b = \sum_{i=1}^{5} \sum_{j=1}^{3} r_{i,j} p_{i,j} t_{i,j}$$

Where

i: is the organ supported
j: is the level of organ support
$r_{i,j}$: is the rating of the machine used in supporting organ i at level j in kW
$t_{i,j}$: is the total time that the patient received level j support to organ i
$p_{i,j}$: is the percentage of $t_{i,j}$ that the machine with rating $r_{i,j}$ was in use

For example, the equipment used in treating a patient undergoing Level 3 support for lung and kidney for two days and the associated energy use is shown in Table 1.

This calculated E_b is then summed across all patients treated in the Unit and compared against actual readings.

Capacity-based 'remote' electricity usage, E_r, is then added to complete the energy consumption within the Unit: