Editorial

The `Great Theatre Turn-off´: what do we need to do?

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In addressing the massive contribution of healthcare to imminent climate collapse, low-value care is a primary target, as around 20% of healthcare spend does not actually result in improvements in health [1,2]. If an activity does not benefit our patients, then why should we continue with it? Most clinical teams will be addressing wasteful clinical care, but attention should also be focused on operational waste, including the systems and infrastructure of our hospitals. In particular, the need for certain 24/7 facilities should be challenged, given ever-changing clinical practice.

Infrastructure systems provide surgical operating theatres and the wider hospital with many essential tools and conditions to ensure optimal safe and efficient operating and patient care, and most of these systems have been in place for decades. Inevitably, clinical practice changes in response to new technology or improvement evidence, but the pace of change is often not matched by revision of building or infrastructure regulations. Hospital design, therefore, needs regular review and matching with clinical demand in order to avoid waste.

Some infrastructure systems have local protocols for set-back or switch-off, but others remain switched on permanently despite limited use, utilising energy unnecessarily and contributing to the carbon footprint of the NHS. The specific systems are heating, ventilation and air conditioning; 7-bar air; central vacuum systems; and anaesthetic gas scavenging systems. Consideration should also be given to water use, lighting and general space heating, and even allocation of floor space in the form of anaesthetic rooms. A summary of recommendations is shown in Table 1.

Heating, ventilation and air conditioning is regulated by Health Technical Memorandum 03-01 and Scottish Health Technical Memorandum 03-01 [9,10], which describe

Table 1 Summary of recommendations.

System	Use	Recommendation
Heating, ventilation and air conditioning	Required only when theatre occupied	Automated shut off with temperature, humidity and occupancy controls [3]
7-bar air	Assess local use; many areas have < 1% utilisation	Supply with near- or in-theatre cylinders and decommission plant [4]
Central vacuum	Assess local use; many areas have < 1% utilisation	Default to `switch on when required´ units where appropriate [5]
Anaesthetic gas scavenging systems	Variable need but legal requirement and generally running 24/7	Shut down protocol overnight, or tied to volatile anaesthetic use [6]
Water	Reducing need due to use of alcohol-based hand rub	Review number and location of scrub sinks [7,8]

energy control strategies for air handling units, including out-of-hours automated switch off. This is controlled by building management systems, with temperature, humidity and occupancy control measures in place to protect equipment and anticipate daytime activity. Where ultra-clean ventilation is present, this should also be linked to the building management systems and local air handling units as `*there is no aerobiological benefit in keeping the ultra-clean ventilation terminal fans running when the theatre is not in use, it results in wasted energy*´ [9,10].

The regulations recommending automatic switch-off have been in place for many years, but newly constructed facilities are still being delivered without this control, meaning that the potential for energy savings up to 70% is not realised [3]. Automation of older existing plant can be more challenging, but there may be a case for upgrading to newer equipment given the carbon and financial savings, and short return on initial investment. Estimating the potential savings across hospitals and health boards can be difficult, as air handling units use a varying combination of electricity and gas for heating the airspace. However, a review of existing plant in Scotland suggested that almost 6000 tonnes of carbon dioxide equivalent (CO_2e) could be saved by out-of-hours switch off, equating to £3.5 million (US$4.6 million, €4.1 million) of recurrent savings [3]. If extrapolated across the UK, this would represent annual savings of approximately 75,000 tonnes CO_2e and £44 million (US$58.1 million, €51.0 million) [3].

Surgical or 7-bar air is provided at multiple outlets in each operating theatre, traditionally for the use of air-powered tools such as drills and saws. However, an audit of use showed limited retention of air-powered tools, with residual utilisation of 7-bar air in orthopaedic surgery of only 0.28% per day, mainly for 30 s bursts during cement mixing [4]. In cardiothoracic and neurosurgical units, air tools have been superseded by mains-powered tools. Other identified uses were for dermatomes for split skin grafts in plastic surgery and mini-drivers for oral surgery, both of which have mains-powered alternatives in use in around 50% of units [4]. A further residual use is in dental clinics, but in these settings a lower standard of air quality is required, and most units utilise standalone, locally sited compressors rather than whole hospital systems.

In assessing the need for 7-bar air, the key metrics for healthcare facilities are the volume used and the selection of the most efficient method of provision, such as a local manifold or cylinder meeting the requirements, rather than a centralised compressed air system. Carbon and financial savings are realised in reduced energy use, with 7-bar air being 21% more energy intensive than 4-bar provision, and in not installing additional pipeline and compressor networks in new hospitals [11]. If extrapolated across the UK, the potential dividend for the removal of 7-bar air could reduce annual CO_2e emissions by 333 tonnes and provide recurring cost savings of £500,000 (US$660,000, €579,000).

The need for central vacuum systems should be examined as many low-acuity wards within hospitals are supplied with end terminals at every bedspace despite utilisation of $\leq$ 0.21% [5]. For patient safety, all clinical spaces should have access to resuscitation trolleys that include battery-driven suction units. All other suction use should be based on the principle of `switch on only as and when required´ rather than being available 24/7. Modern units driven by mains, battery or Venturi compressed gas offer several options for different clinical situations at similar cost to current central vacuum systems suction terminal units. For high volume use in higher acuity areas, the recent development of mains-powered local vacuum units that discharge direct to sewerage means that modern hospitals could be built without a central vacuum system in place [12]. For a 450-bed hospital, the capital cost of a central vacuum is around £1.5 million (US$1.97 million, €1.73 million) with estimated annual running costs of £7396 (US$9459, €8570) [11]. In UK terms, the potential green dividend for reviewing central vacuum systems provision for 123,000 acute beds [13] is £2.0 million (US$2.6 million, €2.3 million) recurring and around 1300 tonnes of CO_2e reduction [5].

Anaesthetic gas scavenging systems were introduced into clinical practice in the 1980s in response to concerns about high levels of nitrous oxide in operating theatre environments. At that time, anaesthetists used linear circuits with high fresh gas flows including nitrous oxide as a carrier gas in operating theatres with no specifically designed ventilation. Clinical practice has changed to minimal flow circle systems requiring around 5% of historic fresh gas flow; minimal to no use of nitrous oxide [14]; and increased use of regional anaesthesia and total intravenous anaesthesia occurring primarily in spaces with designed volume air changes of 25–40 per h.

Anaesthetic gas scavenging systems often run 24/7 as the pumps might supply dual operating theatres or whole theatre suites or simply have no local control switch. Regulations in the UK mean that each anaesthetic gas scavenging system port scavenges excess fresh gas flow from the anaesthetic circuit and entrains the remaining 50–80 $l.min^{-1}$ of warmed and humidity-controlled air from the operating theatre space, discharging externally without heat recovery. Worst-case scenarios from computer simulations of the impact of removing anaesthetic gas scavenging systems show levels of sevoflurane slightly above acceptable levels for some countries (there is no legal exposure limit for sevoflurane in the UK) [6] but justify the need for further real-life trials to examine actual exposure in modern practice. The question arises of whether anaesthetic gas scavenging systems are required at all, but at the very least, these should be programmed to operate only during working hours and, better still, linked to the detection of sevoflurane within the breathing circuit.

Alcohol-based hand rub, rather than routine scrubbing with water and soap, is embedded in UK surgical practice and is associated with significant carbon savings [15,16]. One co-benefit is to reassess the need for multiple scrub sinks in each operating theatre space. Models that employ common sinks in a theatre suite corridor for initial scrub or soiled skin, followed by alcohol-based hand rub can reduce the number of scrub sinks significantly. Taps and drains develop biofilms which can become colonised with bacteria, requiring vigilant monitoring and flushing regimes, so rationalising sink provision can reduce hot water consumption and infection, prevention and control requirements to maintain patient safety [7,8].

Finally, we should consider the additional environmental and financial costs of continuing to provide (and use) anaesthetic rooms. The clinical contentions for and against this traditional habit have been discussed previously [17,18], but with only passing reference to environmental sustainability. Whilst debate continues over operating theatre efficiency and patient experience associated with anaesthetic room use, the following should also be considered: duplication, maintenance and running of hardware equipment like anaesthetic machines and monitors; increased use of volatile anaesthetic agent; and duplication of disposable equipment, like airway circuits and filters. The latter are changed weekly regardless of use and provision in anaesthetic rooms generates an estimated 63 tonnes of plastic in the UK annually. The duplication of each of these items, when one would suffice, is simply wasteful. In addition, recent simulation work confirms the highest volatile anaesthetic agent exposure to staff occurs in anaesthetic rooms during induction, particularly in paediatric practice when open-ended non-scavenged circuits are utilised [6]. This can be minimised by using the operating theatre for induction, as is common practice outside the UK.

Clinical teams cannot make unilateral changes to existing hospital infrastructure in isolation, but we should engage regularly with our colleagues in healthcare facilities and medical physics to explain our changing clinical requirements, and with architecture and engineering design teams when new projects are proposed. These teams work to specific guidelines with limited evidence for alternate provision and it can be difficult to derogate from traditional design. The recent Scottish Health Technical Memorandum 02-01 [19] goes some way to improving that situation, recognising that the main driver for design teams must be localised clinical demand and use, based on the specialties on-site and their specific tools, equipment and practices.

Designing and building new hospitals for the future now comes with two additional core requirements related specifically to tackling climate collapse. First, rapid reduction of fossil fuel dependence to mitigate carbon dioxide emissions and the reduction of plastics and pharmaceutical pollution of our environment to protect biodiversity. Second, climate change adaptation to ensure continuation of care during adverse weather and in response to changing societal need and conditions. Matching changing clinical need to leanest provision requires regular communication with our wider colleagues in healthcare facilities and can best be done with widespread recognition that more modern and safe healthcare provision can come with reduced financial and environmental cost.

The question is not simply whether these systems can be reduced, switched off, redesigned or removed; it is whether we can justify continuing to provide them where there is little or no demonstrable clinical value. At a time when healthcare faces unprecedented financial pressures and an urgent need to reduce its environmental impact, longstanding infrastructure assumptions must be subjected to the same scrutiny as clinical practice.

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