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Decarbonising clinical care in Australia

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All due care is taken to ensure that the information contained in this work is accurate at the time of publication.

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Key Messages

- The Australian healthcare sector is a significant contributor to national carbon emissions, contributing to poor population health outcomes through its own pollution. Policy and investment action is needed at the national level to address the carbon footprint of clinical care, including low value care. Action for effective policy and practice change will require identifying barriers and enablers to action.
- There is limited evidence to enable health services to accurately monitor usage and evaluation of emissions reduction initiatives, to guide clinical decisions and a transition to low carbon clinical care, and to inform health policy. Coordinated and standardised collection and reporting of carbon emissions data across the health sector should be prioritised.
- Incentivising carbon reduction strategies in clinical care will benefit from leveraging funding mechanisms, such as health technology assessment processes and procurement contracts, to consider the carbon footprint of health goods and services, and the contribution of low value care to carbon emissions. This will assist to driving better value, low carbon healthcare.
- Establishing carbon reduction strategies for the health sector will be critical to reducing the carbon footprint and promoting high value care in healthcare settings. This will require strong governance and national health leadership to drive policy action for reducing emissions across the sector. A national sustainability unit to facilitate coordinated action, monitoring, and evaluation of reduction initiatives should be established.
- Integral to a low carbon health system is prioritising effective, efficient, evidence-based delivery of care at the right time, and in the right setting, to prevent escalation of care or low value care.

Executive Summary

The global healthcare sector is a major contributor to climate change, with a carbon footprint equivalent to the fifth-largest emitting country on the planet. Australia's healthcare system is no exception, producing 7% of national carbon emissions or equivalent to half of the emissions of the entire Australian construction sector. To meet Australia's domestic and international commitments to carbon emissions reduction, and ensure better environmental outcomes, the Australian healthcare sector will have a key role to play in mitigating its own impact. However, there is currently a lack of domestic initiatives which will make a substantial difference to the sector's carbon footprint, and little data is being collected at any level to inform changes in practice.

Delivery of care, that is medical devices, consumables, and pharmaceuticals, is estimated to account for the majority of the sector's total emissions, rather than energy consumption or capital costs. Low value healthcare which provides little value, or may even harm consumers, has an estimated prevalence of approximately one third of care provided, and so it is a significant source of negative environmental impact. The identification and elimination of sources of low value care is an opportunity to reduce avoidable emissions from the health sector in a direct and immediate way.

In Australia, there is little data collected and reported on the carbon footprint of specific healthcare goods and services. While the opportunities for emissions reductions in low value care are significant, more data is needed to understand the carbon footprint of healthcare provision if more environmentally sustainable ways of providing high value care are to be found and implemented. The collection and reporting of the lifecycle carbon footprint of healthcare at both an aggregate level and at the level of individual care decisions provides the foundation for effective interventions and targeted mitigation strategies.

To date, the scope of incentives for emissions reduction in the Australian healthcare sector has mostly been limited to action by state governments, local health organisations, and individual clinicians. This action has largely focused on efficiencies in emissions contributors such as energy usage. The collection of more detailed data on the lifecycle carbon footprint of healthcare could broaden the incentives to reduce the emissions from clinical care as the majority source of emissions in the sector. This could improve the carbon literacy of key decisionmakers in healthcare, to inform clinical decisions, and investment and disinvestment decisions in high value, low carbon healthcare.

This brief highlights the current gaps in understanding of the healthcare sector's contribution to Australia's carbon footprint. It focuses on the environmental impact of the delivery of care as the major source of emissions which is not reflected in emissions reductions policies. It identifies the need to reduce low value care, including current areas of interest for reform. It describes how better data collection and reporting on the carbon footprint of healthcare can be harnessed to inform and incentivise sector-wide reform for a more environmentally sustainable and high-quality healthcare system.

Introduction

The Australian healthcare industry has a key role to play in mitigating its own impact on the environment. The 2021 UN Climate Conference in Glasgow (COP26) saw the governments of 50 countries commit to decarbonising their healthcare systems (COP26 Health Programme)[1]. As of publication, Australia is yet to make this commitment. This means that Australia has no obligation to conform to international emissions reduction targets (ERT), no accountability, and no reason to measure and track the environmental impact of its health industry.

The global health sector – hospitals, health services, and its medical supply chain - is estimated to be responsible for approximately 4.6% of global greenhouse gas (GHG) emissions and is therefore a significant contributor to climate change (Pichler et al., 2019). This carbon footprint is equivalent to being the fifth-largest emitting country on the planet (HCWH, 2019).

As part of the Paris Agreement, Australia has set national carbon emission reduction targets to reduce emissions by 43% from 2005 levels by 2030 (Department of Industry, 2022). These targets specifically encompass renewable energy generation, transport, agriculture, mining/manufacturing, and construction sectors. No national action has yet been taken to reduce emissions of the healthcare sector. As health accounts for 10.2% of the GDP in Australia (2019-20) (AIHW, 2022) and is a significant contributor to national GHG emissions, meaningful gains could be achieved towards decarbonising the Australian economy if the healthcare industry was explicitly acknowledged as a large emitter and included in national emissions reporting schemes.

Some individual health systems in Australia are investing in green initiatives such as energy efficiency and green infrastructure to decrease emissions (Department of Health, 2015a; Department of Health, 2015b; VHBA, 2022) but only approximately 30% of the carbon footprint of Australia's healthcare system is attributable to building energy, water, and waste pollution (HCWH, 2019). Although these initiatives are essential, renewable energy only makes up a small percentage of the footprint. To drive down emissions, the focus must shift to how healthcare is performed. It is not widely recognised that the majority of healthcare emissions arise from the provision of clinical care itself - specifically, emissions associated with carbon-intensive inputs bought and consumed by the health system (HCWH, 2019). Wasteful and low value care remains a problem internationally (Brownlee et al., 2017) and has a carbon cost. It is critical that efforts to decarbonise the health sector consider the carbon footprint of the system in its entirety.

The health sector must prioritise high value care and give due consideration to low carbon emissions models of care in clinical decisions so that health – like all sectors – can not only meet international carbon reduction commitments and local legislative requirements, but also improve population health outcomes by reducing its own pollution.

[1] *From June2022, the COP 26 Health Programme will be taken forward in the form of an Alliance for Transformative Action on Climate Change and Health (ATACH). The inaugural meeting was held 27 June 2022.*

The carbon footprint of healthcare in Australia

A carbon footprint is the sum of direct and indirect greenhouse gas emissions which are attributable to a given process, product, or organisation, usually expressed in carbon dioxide equivalents (CO_2e) (East, 2008). Calculating the carbon footprint of healthcare organisations, goods, services, and clinical pathways quantifies their environmental impact which provides understanding of carbon intensive areas, aids comparison of different services, models, or products, and enables emissions reduction efforts to be tracked over time (Centre for Sustainable Healthcare, 2022a).

The Australian healthcare sector produces 7% of national carbon emissions (Malik 2018). As a comparison, the entire construction sector in Australia (buildings, houses, pipelines, dams, road, rail) produces 14% of the national CO_2e emissions. Australian healthcare's carbon footprint is higher, as a proportion of national emissions and per capita, than England's (3%), Canada's (4.6%), Japan's (5.2%), and China's (2.7%), and almost as great as the United States (8.5%) (Tennison et al., 2021; Eckelman and Sherman, 2016; Nansai et al., 2020; Wu, 2019; Pichler et al., 2019).

Of Australia's 7% national footprint, hospitals make up the largest share of the emissions of healthcare (public hospitals 34%, private hospitals 10% of total emissions), followed by pharmaceuticals (19%), capital expenditure for buildings (8%), specialist medical services (6%), community and public health (6%), general practice (4%), and patient transport (1%) (Malik et al., 2018) (Figure 1).

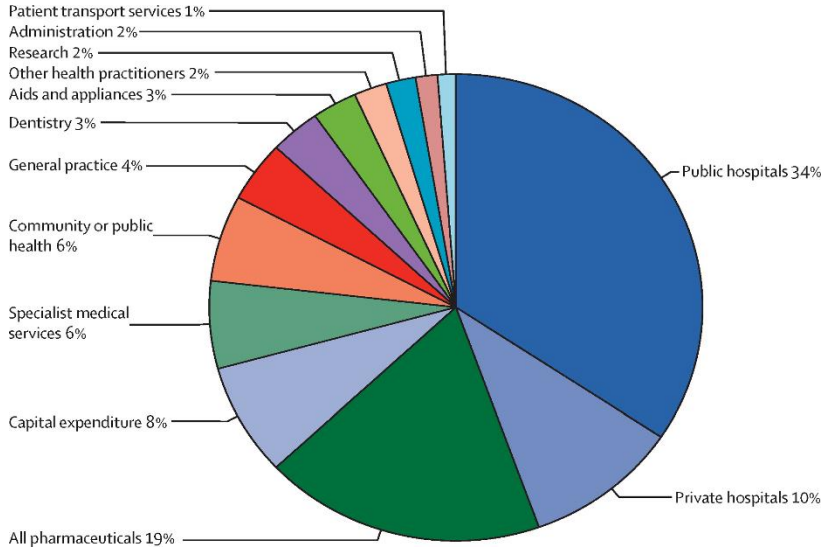

Figure 1: The carbon footprint of Australian Healthcare (Malik, et al., 2018)

A comprehensive assessment of the environmental impact of the NSW private and public (government-funded) health system – contributing around one-quarter of the national health

system's total footprint - was conducted in 2017 to assess the footprint at a state level, and similarly showed that hospitals had the largest emissions (24% of GHG emissions), with pharmaceutical products (21%), medicinal goods (18%), pathology and diagnostic imaging, specialist and general practice services also contributing (Malik et al., 2021) (Figure 2).

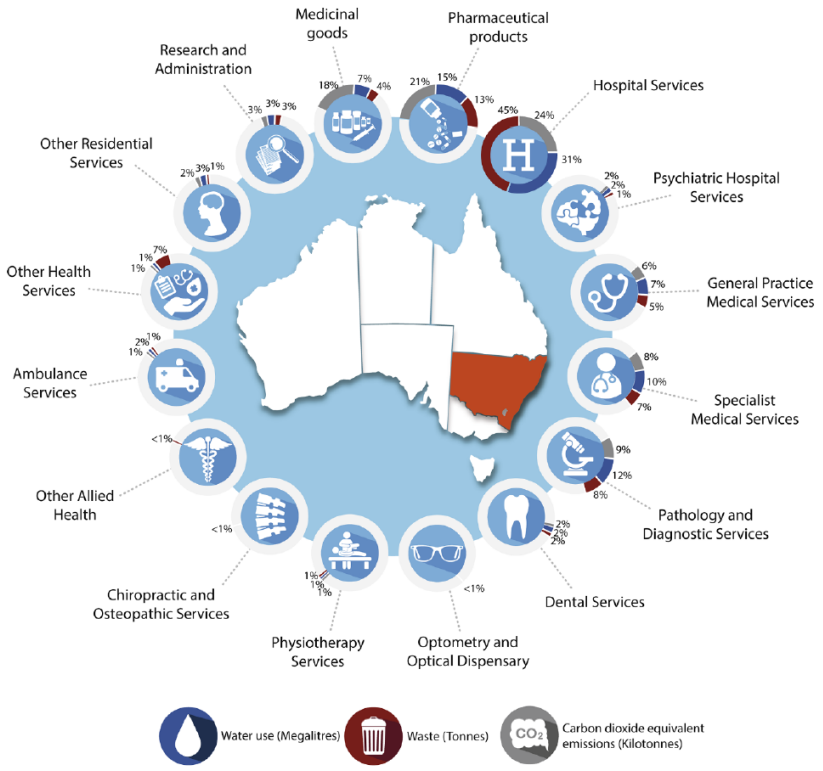

Figure 2: Contribution of selected health sectors to emissions (Malik et al., 2021)

Direct and indirect emissions in healthcare

Explicit consideration of direct and indirect emissions and the entire lifecycle of healthcare goods, services, and clinical pathways is necessary for any meaningful decarbonisation of the healthcare sector.

While in Australia there is not yet a detailed breakdown of the primary sources of healthcare emissions, detailed data is available from the UK and for the global healthcare footprint (HCWH, 2019). Drawing from these data, it is estimated that in Australian hospitals, on-site and purchased energy (scope 1 & 2) such as gas for hot water and electricity used for heating and cooling contributes to an estimated 30% of the total emissions, while approximately 70% of the CO_2e emissions are indirect, stemming from national and global supply chains involved in the manufacture, distribution, and provision of healthcare goods and services (HCWH, 2019). This means that actions focused solely on decarbonising the direct activity of the health system, such as

investment in renewable energy, is only part of the solution. Product purchasing and the health care supply chain (scope 3) explains most of the health sector's carbon footprint. Addressing this footprint requires changing patterns of clinical pathways and use of healthcare, and this can be done while improving health and wellbeing.

Box 1: Scopes of emissions

Greenhouse gas emissions are categorised into three categories or 'scopes' by the Greenhouse Gas Protocol, an international accounting tool used by governments to understand, quantify, and manage greenhouse gas emissions. In healthcare:

- **Scope 1 emissions** are direct emissions from healthcare facilities or emissions that are released on site (e.g., on-site fossil fuel use, anaesthetic gases).
- **Scope 2 emissions** are indirect emissions from purchased energy sources (e.g., electricity, cooling, heating).
- **Scope 3 emissions** covers all other emissions, such as those generated from the suppliers of the components used to make medicines (i.e., embedded in supply chain and manufacturing and production, transport, use and disposal of pharmaceuticals, medical equipment, water and waste).

About 70% of the total carbon footprint of Australian healthcare is clinical care/consumables, with the rest being buildings and infrastructure (HCWH, 2019). Measuring the carbon footprint of healthcare as a proportion of the emissions of the Australian economy is useful for comparing the health sector to other economic sectors in Australia and the global healthcare sector but is not informative for understanding and shaping carbon reduction initiatives at the level of clinical care itself. Low value and carbon intensive care can still occur in a healthcare system supplied by renewable energy for example and result in a large carbon footprint. Intervention and action in the health sector must be occurring in each of the 3 scope areas.

Evidence at the granular level of clinical care is lacking for clinicians, health services and policymakers to be able to identify carbon and low value care hotspots that will then allow for targeted and effective intervention in clinical activity. Fewer than 50 studies have measured the carbon footprint of items embedded in clinical activity such as pathology, imaging tests, specific drugs, and treatments (McGain and Naylor, 2014; Seifert et al., 2021; Alshqaqeeq et al., 2020). Those studies that have been done in Australia using life cycle analysis (which uses an international standard and underpins all international product carbon footprinting standards) have measured environmental outcomes associated with, for example, single-use and reusable anaesthetic equipment (McGain et al., 2017), morphine production (McAlister et al., 2016), and critical care (McGain et al., 2018).

There is limited evidence on the carbon emissions produced through purchased medical products and services (scope 3). As a consequence, it is unclear where and how to target GHG mitigation policies and carbon reduction initiatives. Establishing reporting standards for individual products

procured by the health sector, across their entire lifecycle, is critically important to informing targeted strategies.

The environmental impact of low value care

Clinical care itself makes a substantial contribution to the carbon footprint of Australian healthcare (80%) (Figure 3; Barratt et al., 2022). Pharmaceuticals are the second highest health care emission producer in Australia (19%), behind hospitals (44%) (Malik et al., 2018). Reducing unnecessary clinical investigations and the use of unnecessary medications, as well as avoiding clinically ineffective surgeries, procedures, and critical care admissions would accelerate both a reduction in CO_2e emissions and a decrease in healthcare expenditure and should be done without adversely affecting patient outcomes.

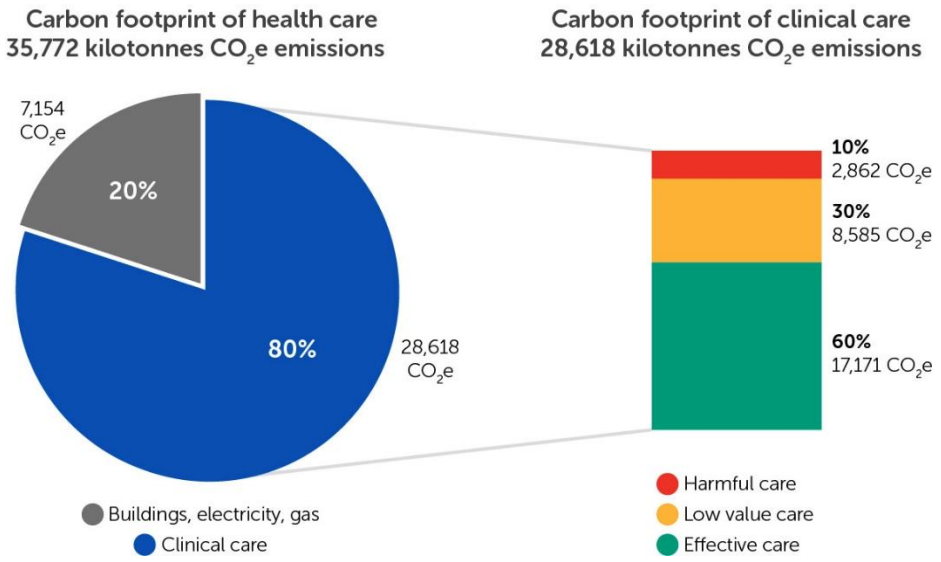

Figure 3: The carbon footprint of Australian health care and the share of its carbon emissions attributable to harmful, low value and effective care (Barratt et al., 2022)

It is estimated that 30% of clinical healthcare around the world is wasteful or low value care, and a further 10% is harmful care (Braithwaite et al., 2020). Low value, or unnecessary, healthcare is care that provides little or no benefit to patient health, may cause harm, or provides marginal benefits at a disproportionately high cost (Scott and Duckett, 2015). Since every test, service, and procedure has a carbon footprint, low value care also creates an avoidable environmental cost.

Low value health services include, for example, the provision of screening and/or diagnostic tests that have not been clinically recommended, surgery for knee and hip osteoarthritis, spinal fusion for uncomplicated back pain, and unnecessary prescribing of antibiotics (Brownlee et al., 2017).

Low value care is a significant source of cost to patients and the health system. In the US, $270 billion was spent on low value care in 2013 (Brownlee et al., 2017). In Australia, it has been estimated that savings from reducing low value treatments in public hospitals could amount to over $4 billion per year and low value care outside of the public hospital sector could ultimately be reduced by approximately $7 billion per year (2016 prices) (Productivity Commission, 2017). Some small-scale estimates have been calculated with the total cost of 27 low value care procedures in NSW public hospitals shown to be $49.9-$99.3 million in 2016-2017 (Badgery-Parker et al., 2019).

Regarding environmental costs, it has been estimated that over 8000 kilotonnes of CO_2e emissions could be saved in Australia per year by reducing low value care (Barratt et al., 2022). In 2020, unnecessary Vitamin D testing (>3 million tests per year) cost Medicare more than $87 million and a carbon burden equivalent to 28,000–42,000kg CO_2e or driving approximately 160,000-230,000km in a standard, petrol-fueled passenger car, yet provided no net health benefit for patients (Breth-Petersen et al., In Press).

Low value care also has downstream consequences for patient health outcomes, but there has been limited research on patient harms caused by overuse (Brownlee and Korenstein, 2021). For example, patients admitted to the hospital for a low-value procedure are at risk of developing hospital-acquired complications, and delay care for other patients for whom the services would be appropriate (Badgery-Parkeret al., 2019). Other potential harms include unnecessary CT scans exposing the body to harmful radiation, overuse of antibiotics contributing to antibiotic resistance, and the substantial psychological harms incurred as a result of medical labelling (Copp et al., 2017), and overdiagnosis (McCaffery et al., 2019; Davies et al., 2017). Overuse of unnecessary care is a source of preventable harm and an issue for patient safety (Lipitz-Snyderman and Korenstein, 2017), but also a significant burden on planetary health.

Efforts to change clinical behaviour away from low value care to date have not had large success (Rosenberg et al., 2015; Mafi and Parchman, 2018). Support from clinician leaders for environmental sustainability (Talley et al., 2021) suggests that the potential to reduce emissions may be more effective in motivating clinical change.

Value-based healthcare provides a useful framework for transitioning to more sustainable healthcare models. It has been proposed that the value of a service or intervention should include carbon outcomes in the cost benefit analysis evaluation of healthcare, with these costs to the environment incorporated into the financial reporting of health services (Hoban et al., 2021; Vergunst et al., 2020). The health system could leverage off existing policy such as the National Health Reform Agreement (Department of Health, 2020) and the Australian Health Performance Framework (AIHW, 2020), with a focus on delivering value-based healthcare, to reduce the footprint of low value care and in turn improve patient outcomes.

The Atlases of Healthcare Variation (ACSQHC, 2021), by providing an indirect indication of where low value or harmful care is occurring, could be used to identify national priority areas for intervention, such as the provision of patient care that is not supported by evidence, and in turn reduce the health, financial, and environmental costs of investigations or treatments that provide little benefit.

The case of pathology services

Pathology services are responsible for considerable health care costs in Australia, accounting for 14.1% of all Medicare spending and $3.9 billion in 2020-21 (Medicare Australia, 2022). Unnecessary pathology testing is known to significantly contribute to low value care and can lead to additional unnecessary tests, overdiagnosis, and potentially harmful health outcomes. It has been estimated that 12-44% (Zhi et al., 2013) of pathology tests are unnecessary or not clinically needed (Müskens et al., 2022). Such tests may be ordered with belief that more testing equates to better patient care however patient's do not always benefit, and each test adds to the carbon footprint.

An Australian study reported that the carbon impact of five common hospital pathology tests ranged from 49g/test to 116g/test, equivalent to driving a car between 3m and 770m per single test (McAlister et al., 2020). This translates to a significant GHG emissions impact when multiplied by the number of tests ordered in Australia each year, given the 56.2 million biochemistry tests performed in 2018-2019 (McAlister et al., 2020). Reducing requests for low value pathology would improve the clinical effectiveness and cost effectiveness of pathology services and provide significant co-benefits for the environment. Pathology stewardship, similar to the antimicrobial stewardship program in Australia, may be an effective policy pathway to reduce unnecessary hospital pathology collections and save carbon emissions and costs (McAlister et al., 2021; Spelman, 2015).

Emissions in delivery of care

In Australia, few studies have undertaken carbon footprinting (using life cycle analysis) which include detailed information about the individual components of healthcare that contribute to overall emissions. This evidence is essential to guide decision making at individual institutions and at the point of clinical care. Internationally, a UK-based study identified carbon hotspots in the healthcare system arising both directly from on-site healthcare facilities, and indirectly through supply chains (Tennison et al., 2021). For example, volatile anaesthetics and inhaled medicine propellants make up a substantial proportion of healthcare emissions that are released on site during delivery of care (Figure 4). These should be measured and prioritised in national efforts to mitigate GHG emissions.

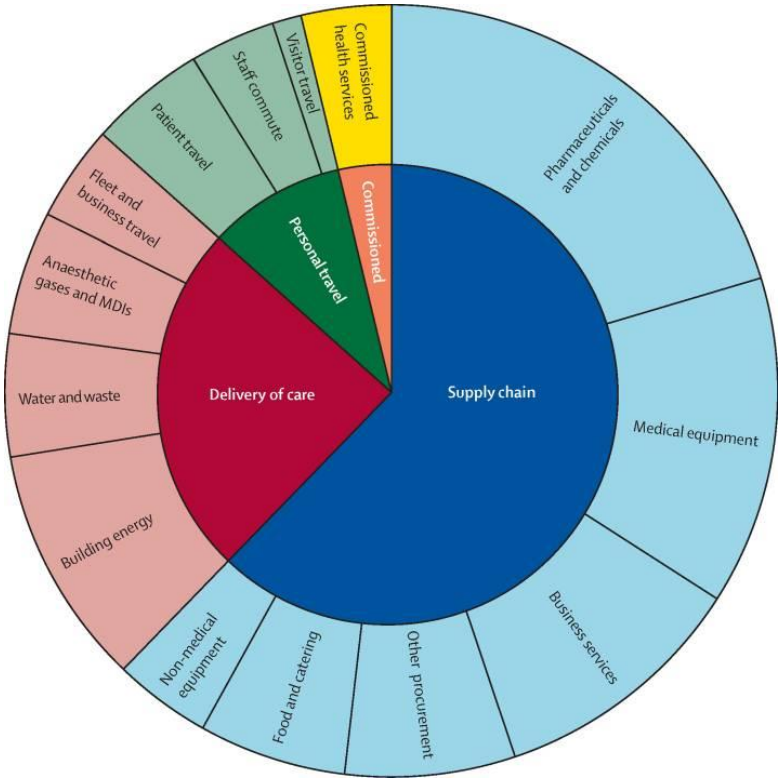

Figure 4: Contribution of different sectors to the greenhouse gas emissions of the NHS England in 2019 (Tennison et al., 2021)

Volatile anaesthetics

Most anaesthetics that are inhaled, as opposed to injected, are hydrofluorocarbons and are potent greenhouse gases. Australian data on the contribution of volatile anaesthetics to the national carbon footprint is lacking, but data from the United Kingdom shows that the use of anaesthesia contributes up to 2% of the NHS carbon footprint or 5% of an acute hospital's carbon footprint (NHS, 2021).

Desflurane, used for the maintenance of general anaesthesia, and nitrous oxide, are the highest greenhouse gas potential anaesthetic gases; and switching away from the use of these should be prioritised (McGain et al., 2020). Desflurane use is both associated with high financial costs and a high carbon footprint; with the use of one bottle of anaesthetic having the same global warming effect as burning 440kg of coal (NHS, 2021). Nitrous oxide also known as laughing gas, is predominantly used in maternity wards in Australia but there is no national data available on medical consumption of nitrous oxide or its carbon footprint from a supply chain perspective.

Table 1: Comparison of environmental footprint of various anaesthetic gases used in clinical settings (Centre for Sustainable Healthcare, 2022b)

Anaesthetic Gas	Global Warming Potential (GWP_{100})	KgCO2e (per container)
Sevoflurane	130	44
Isoflurane	510	190
Desflurane	2540	886
Nitrous Oxide	310	1054

Anecdotally, both desflurane and nitrous oxide remain in common use by anaesthetists in Australia at much higher rates than overseas. One hour of anaesthesia using desflurane and nitrous oxide produces 55kg CO_2e, whilst one hour of propofol based total intravenous anaesthesia produces 10g CO_2e (Sherman et al., 2012), a vast difference for functionally equivalent choices.

It has been suggested that the clinical indication to continue using desflurane is poor and its use has been eliminated in some hospitals nationally such as the Alfred Hospital in Melbourne (ANZCA, 2021), and internationally such as in Freeman Hospital Newcastle, UK(Centre for Sustainable Healthcare, 2022b); and for almost all forms of surgical procedures and indications, total intravenous anaesthesia can be used instead of volatile anaesthesia agents or nitrous oxide (Irwin et al., 2020).

Any reduction in usage of desflurane and nitrous oxide will have a significant impact on climate change through the reduction in GHG emissions. Decreased use of anaesthetic gases with high global warming potential, choosing lower emission substitutions, and reducing fresh gas flow have potential to be high impact without altering patient care (Tennison et al., 2021), saving costs to hospitals and the health system and hundreds of tonnes of CO_2e annually.

Metered dose inhalers

Devices used to deliver inhaled medication contribute to carbon emissions and in Australia 7.4 million people have a chronic respiratory condition (ABS, 2017-18). In 2015, respiratory conditions contributed 8% of total disease burden in Australia (AIHW, 2019a). In 2015–16, an estimated 3.5% ($4 billion) of total disease expenditure in the Australian health system was attributed to respiratory conditions (AIHW, 2019b). Pressurised metered dose inhalers are the most common delivery device used internationally for the treatment of respiratory conditions (Usmani et al., 2018).

Metered dose inhaler usage accounts for 13% of NHS carbon emissions related to delivery of care, and 3% of total NHS carbon emissions (NHS England, 2020). As an alternative, dry powder inhalers lack the propellant gases that contribute to GHG emissions. Switching from metered dose inhalers to dry powder inhalers has been shown to result in large carbon savings at both an individual and national level, reduced costs, and does not worsen asthma control (Janson et al., 2020; Wilkinson et al., 2019).

To achieve widespread uptake and thereby environmental gains, this approach must be incorporated into larger respiratory disease prevention strategies while acknowledging patient preferences, inhaler usage patterns, and clinical efficacy (Janson et al., 2020). A patient decision aid has been developed in the UK to help people with asthma, and their health professionals, to identify their best option (NICE, 2021).

Primary care

Primary care comprises 4% of the total national carbon footprint (Malik et al., 2018). Medicine prescribed in primary care has been identified as a hotspot for intervention (BMA, 2020). Primary care providers - as prescribers of therapeutics - have substantial influence over low value prescribing practices so are well positioned to reduce the environmental impact of unnecessary care. General practitioners in Australia are also the gatekeepers to referral services such as imaging and laboratory tests (Healthdirect, 2020). Primary care providers therefore have considerable influence over the carbon footprint of pharmaceuticals via the rate and type of prescribing.

Factors that contribute to unnecessary pharmaceutical carbon emissions include over-prescription, pharmaceutical waste, and drugs prescribed often due to a lack of preventive healthcare (Richie, 2022). A UK study found that the average primary care consultation produces 66kg CO_2e; with drug prescribing (including pharmaceuticals supply chain and metered dose inhalers) representing 60% of the total footprint (Tennison et al., 2021). The NHS has not yet measured primary care emissions generated on-site (Nicolet et al., 2022).

The individual components making up the carbon footprint of primary care in Australia has not been evaluated using a life cycle assessment (LCA) or addressed. Doing so would require access to, and understanding of, Medicare and PBS data collections, and practice-level purchasing and electricity data.

However, primary care has a critical and direct role in mitigation of the healthcare footprint. International literature highlights the environmental benefits of changing patterns of care provision in the primary care setting (Cussans et al., 2021). For example, low carbon prescribing encouraging clinicians to choose lower emission options such as dry powder inhalers or prescribe from manufacturers that have a sustainable impact policy (Sherman et al., 2021), or use non-medical alternatives such as social prescribing. Research is underway exploring the effectiveness of carbon labelling of medicines and incorporating carbon cost information in prescribing advice and messaging (Vautrey, 2020). Results should be used to inform labelling mechanisms in Australia.

In Australia, Primary Health Networks (PHNs) have capacity to influence the priorities and activities of primary care and play a key role in clinician education and awareness raising. Some PHNs now have some form of sustainability or climate roadmap. For example, the Sydney North Health Network has developed a Climate and Health Strategy, aiming to achieve 'better health, better climate, better health system' with explicit acknowledgement of the need to transition operations to low/zero carbon footprint (North Sydney PHN, 2020). This Strategy could be replicated and implemented by PHNs more broadly, and mitigating emissions should be embedded as a key priority

in the ongoing work of PHNs nationally. Improving data and central reporting of the emissions of primary care services at a national level would support PHNs in this role.

The role of primary health care in reducing the carbon footprint of the healthcare sector is through direct action by lowering its own emissions, as outlined above, but also indirectly by decreasing reliance on hospital-based, carbon intensive healthcare. However, Australian government investment in preventive health care is low when compared to other developed economies such as Canada, the UK, and New Zealand, where 5-6% of their health budgets is spent on prevention. By comparison, 1-2% total annual health spending in Australia has historically been dedicated towards preventive health (Jackson and Shiell, 2017), with Australia ranked 27th out of 33 OECD countries for spending as a proportion of health budget in 2018 (Department of Health, 2021a). An increase in preventive health investment to 5% of total annual health expenditure has been publicly called for by the AMA, DEA, and PHAA and this target has been included as a priority in the National Preventive Health Strategy 2021-2030 (Department of Health, 2021a). Government investment in preventive healthcare implemented at the population level (e.g., healthy urban planning, clean air legislation, vaccination, taxes on sugary drinks) is a priority to reduce the carbon output of the sector while improving health outcomes and lowering healthcare costs.

Monitoring and reporting emissions

There is limited evidence to enable health services to accurately monitor usage and evaluation of carbon emission reduction initiatives across healthcare facilities. There are no measures in place to guide clinician decisions or promote an informed transition to low carbon clinical care; as well as informing the development of health policy. A successful strategy to decarbonise healthcare is not feasible without granular information of the sector's GHG emissions. Establishing capacity and infrastructure for the Australian healthcare sector to measure and report its carbon footprint is essential for aligning the sector with international sustainability pledges.

To fulfil Australia's domestic and international GHG emissions reporting obligations under the UN Framework Convention on Climate Change, Kyoto Protocol, and Paris Agreement, the National Greenhouse Gas Inventory was established in 1990 and has since tracked annual emissions for the energy, industrial processes, agriculture, waste, and land use sectors (Department of Industry, 2021). However, this reporting does not include the health sector which remains excluded from processes. Consequently, data and information systems required to calculate environmental impacts of the procurement and delivery of healthcare services remain largely unavailable in Australia in general. To make this data readily available in Australia to allow calculation of environmental impacts, the health system should be added as a category to the inventory.

To align with the Australian Government's longstanding objective to enhance health data monitoring and transparency internationally (Department of Health, 2020), it will be essential to measure, monitor, and publicly disclose annual GHG emissions of the health sector at the national level and include in national GHG reporting inventories.

In 2007, the Australian Government legislated an integrated GHG emissions company reporting system, the National Greenhouse and Energy Reporting Scheme through the National Greenhouse and Energy Reporting Act (Parliament of Australia, 2007). Public hospitals in Australia that meet specified daily energy consumption criteria[2] are required to report their scope 1 and 2 emissions annually under the NGER scheme. However, reporting is limited to medium and large-scale hospitals (hospitals with approximately 200 acute beds) and threshold standards are lacking and based on energy use only. Scope 3 emissions embodied in the supply chain are not a regulatory requirement under the scheme so are not measured or reported despite being the largest contributor to the healthcare footprint.

The Australian Health Performance Framework (AHPF) (AIHW, 2020) contains 45 indicators to track the performance of Australian health and the healthcare system, and yet indicators that could be used to measure the impacts of carbon emissions generated by the health sector on health and patient outcomes is lacking. In the UK, annual sustainability reporting is mandated for clinical commissioning groups and trusts. Key indicators such as anaesthetics, inhalers, and building energy use are reported nationally through the Greener NHS Dashboard and included in annual reports (NHS, 2020). GHG emission indicators should be standardised across the Australian health sector and built into monitoring systems as another performance measure. For example, emissions indicators could be included in the National Hospital Cost Data Collection (NHCDC) under responsibility of the Independent Health and Aged Care Pricing Authority (IHACPA) remit to provide high quality, cost efficient public hospital services across Australia. In this way, healthcare organisations would have systems and requirements in place to benchmark and monitor their environmental performance in addition to health and cost outcomes at a national standard.

Measuring the carbon footprint of healthcare goods and services

Calculating the carbon footprint of healthcare is essential to understanding the interaction between health service supply/demand and the environment, and effective intervention. It involves sourcing data (activity and carbon intensity), tracking through the supply chain, and using accounting measures to calculate impacts across systems.

Life cycle assessment (LCA) (Figure 5) is used to evaluate the environmental footprint associated with a product or process through its life cycle, from resource extraction and manufacturing, to packaging and transport. There are two types commonly used in healthcare: (1) process-based LCAs and (2) environmentally extended economic input-output (EEOI) LCAs.

[2] if energy consumption is 100TeraJoules or more per year and/or if emissions equal 25kt CO_2e emissions/annum

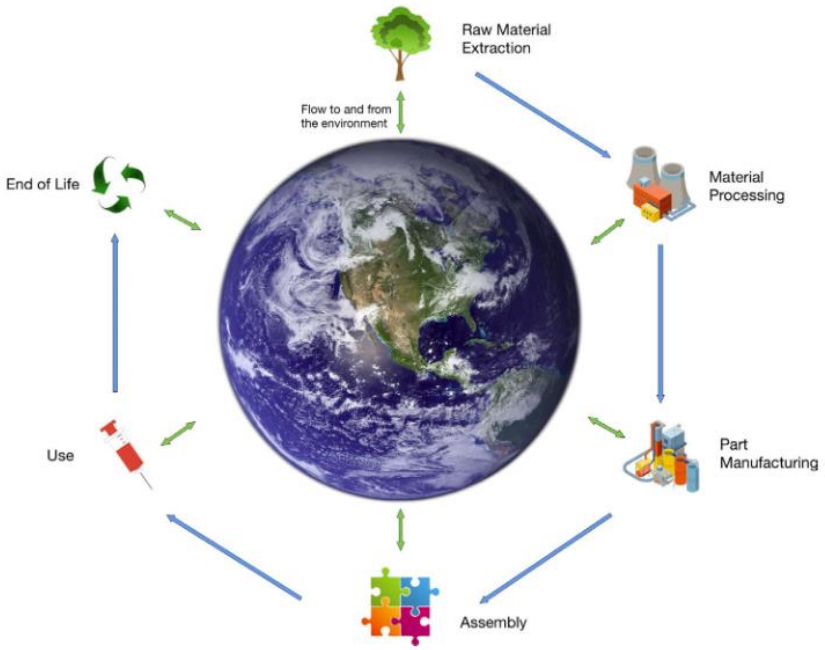

Figure 5. Life cycle assessment (LCA) estimates the environmental footprint of a product or service throughout its entire life cycle

Box 2: Commonly used methods for life cycle assessments (LCA) of environmental footprints

Process-based LCA: quantifies the environmental impact of specific healthcare goods, services, and models of care. This bottom-up approach requires identifying and quantifying all inputs at the smallest resolution practical (e.g., energy use, medical instruments/equipment, pharmaceuticals, water use, waste disposal, travel). Process-based LCAs are useful for comparing a defined product or process with another, for example, reusable versus disposable equipment (McGain et al., 2020).

Environmentally extended economic input-output (EEOI) LCAs: are most appropriate for large scale datasets. This top-down approach relies on monetary input-output tables coupled with physical data on multiple environmental (energy, emissions, water, land), social, and economic indicators. Financial spend in a sector is converted into CO_2e value or carbon footprint. EEOI is most appropriate for sectoral and national level environmental footprint estimation.

LCA analysis is key to measuring and reporting but its application to healthcare has lagged behind other sectors such as the construction sector. Healthcare-specific life cycle inventory data for healthcare items and pharmaceuticals is lacking. For example, there is currently only data from 31 countries internationally on the climate impact of the sector's use of anaesthetic gases (HCWH, 2019). This is problematic because data is at the centre of carbon footprinting, but most systems are

limited by data availability and methodological inadequacies. Only a small number of the thousands of procedures, products, and pharmaceuticals used in clinical care have been studied using environmental life cycle data (Weisz et al., 2020).

Further disaggregation of the carbon footprint of the health sector is essential. LCA can help to identify the contribution to the total impact of different products, carbon hotspots, and where to intervene and target mitigation strategies effectively. LCA studies enable modelling of clinically effective and lower impact practice to see where resources and costs and associated GHG emissions can be saved (McGain et al., 2012). For example, in the UK, healthcare emissions have been broken down by source of emission, such as delivery of care or the supply chain (Tennison et al., 2021). This study also separated out the NHS carbon footprint by type of clinical activity, such as acute care and primary care, which further helps to identify mitigation targets. LCA of individual components of healthcare in Australia is only just beginning and currently most commonly used for scope 1 and 2 emissions (personal correspondence). Investment in bottom-up data collection should be implemented across the sector to feed into annual carbon footprint modelling. Doing so would facilitate understanding and reporting of the environmental impact of healthcare in its entirety.

Incentivising carbon reduction strategies

Incentivising carbon reduction strategies in the health sector will require leveraging funding mechanisms to assist in driving better value, low carbon healthcare.

Embedding carbon footprint information into health technology assessment

In Australia, processes differ across jurisdictions and public hospitals in relation to how new technologies are assessed and implemented, making it difficult to know if the technology leads to better patient outcomes and at an efficient cost. It is not possible to tell if this is associated with lower carbon footprints.

Health Technology Assessment (HTA) processes provide a mechanism that could be used to consider the carbon footprint of health goods and services, and the contribution of low value care to carbon emissions. Environmental impacts (emissions) are not yet part of the value assessment in Australia (Marsh et al., 2016).

HTA recommendations are made based on quality, safety, ethical, efficacy, and cost effectiveness of health products and services, so that decision makers can make informed decisions about optimal use; and the Australian government can accelerate actions toward more sustainable healthcare via regulatory systems such as HTA (McGain et al., 2009).

New criteria have recently been added to HTA panel processes stipulating that Tenderer's consider the environmental sustainability of proposed goods and services as part of its value-for-money assessment, under economic 'benefit to the Australian economy' (Department of Finance 2020a). However while HTA applications are evaluated in accordance with the Commonwealth Sustainable Procurement Guide (Department of Finance, 2020b), environmental impact metrics are not

specified. Environmental impact data across the lifecycle of a health technology might be lacking to enable a comprehensive assessment of the carbon footprint. An insufficient evidence base makes it difficult to accurately compare the environmental outcomes of technologies.

In 2021, the Medical Services Advisory Committee (MSAC) included a request for evidence of consideration of the environmental impacts of HTA applications in its guidelines for preparing HTA assessment reports (MSAC, 2021). However, this is not a core reporting requirement and no process for reporting or assessing of environmental impacts is described. To date, no MSAC applications have occurred where 'environmental aspects' have been discussed by the panel (Personal correspondence).

Internationally, Sweden, Canada, and the UK have demonstrated that it is possible to embed environmental considerations into their HTA (Polisena et al., 2018; Marsh et al., 2016). For example, the Swedish Government has mandated that prescription drug companies be required to account for environmental pollution during manufacturing of their products that receive government subsidies. In Australia, industry sectors other than health, such as transport, are required to undertake environmental assessment of new technologies.

Evidence of carbon footprinting can be integrated into the HTA process via four approaches: (1) to modify a decision; (2) to be one criterion of a multi-criteria decision analysis (MCDA) ; (3) to be monetised and included in a cost-benefit analysis; or (4) as an additional societal cost in a cost-effectiveness analysis. However more work is needed to develop the best methodology for capturing and synthesising data as part of HTA (Marsh, et al. 2016; Marsh et al., 2017). An agreed framework or standards for assessment of environmental impacts and outcomes should be developed.

Clear HTA process for disinvestment in low value care

In Australia, few resources are invested in assessing the safety and effectiveness of existing technologies and comparing existing technologies to new.

Post market review processes through the MBS and PBS (Department of Health, 2015c; Department of Health 2021b) do not take into account environmental considerations and clear HTA processes for de-adoption or disinvestment in low value care and high carbon care, where there are appropriate clinical alternatives, should be put in place.

The Addendum to the National Health Reform Agreement (Department of Health, 2020) recognises that HTA processes for disinvesting in low value care are under-developed but will be improved in the proposed updates to the national HTA framework (2020-2025). A process for disinvesting in healthcare products and services, where appropriate, has been proposed to be included as part of the HTA process. Doing so will improve practice, requesting, and the management, delivery, and consumption of Medicare services in Australia by minimising low value care (McCreanor, 2017); reducing the risks of patient and environmental harm.

This initiative is aligned with the MBS review taskforce recommendation to implement Health Technology Reassessment (HTR) to reduce low value care (MBS Review Taskforce, 2020). As proposed, a HTR will assess the effectiveness of low-value technology, and also advise on its removal

from practice, or a change in scope-of-use of the technology. HTR is still an emerging field internationally. In Australia, HTR reviews are rare and only conducted when requested by authorities. This is in contrast to France, for example, where regular reviews of publicly funded technologies are conducted to form the basis for a potential HTR (MBS Review Taskforce, 2020). In Australia, priorities for assessment of HTAs are led by applicants (manufacturers or developers of the technology) (Boxall, 2012). Environmental impact indicators could also be added to the framework for HTR.

Strengthening reform efforts such as MBS and PBS review will assist to driving better value, low carbon healthcare.

Carbon health literacy: decision makers and the healthcare work

There is public misunderstanding of carbon footprints and environmental impacts of human activities. People often underestimate GHG emissions and need guidance for emissions-related decision making (Wynes et al., 2020). National policy and practice change is critically reliant on decision maker's capability to access, understand, and act on information about the health carbon footprint. Carbon literacy has been defined as 'an individual's ability to obtain, understand and evaluate the relevant information necessary to make decisions with an awareness of the likely consequences regarding greenhouse gas emissions' (Howell, 2018).

To maximise the effectiveness of environmental policies and reduce the carbon footprint of the health sector, policymakers and the healthcare workforce must be carbon literate to equip them to influence healthcare decision making at the national level and at the level of clinical care, for example, through choice of anaesthetics agents, or prescribing and purchasing of drugs and equipment.

In this regard, assessments such as HTA and HTR will require new competencies by assessors to understand methods used to measure carbon footprints including LCAs, to determine acceptable GHG emissions parameters, and weigh up carbon equivalent tests, pharmaceuticals, and models of care in terms of emissions (Adshead et al., 2021). In February 2022, the request for tender for HTA panel members in Australia included a clause for the first time requiring that applicants meet 'environmental policy and procurement' criteria. This should be reinforced as a priority, rather than buried at clause 37 of the document.

Noting the development of a mircocreditional in Sustainable Healthcare in Practice (Monash University 2022), the availability of national formal education, training, or accreditation programs in Australia to build carbon-literate workforce capacity is lacking. Climate literacy and carbon footprinting of healthcare training programs have been implemented in the UK (SEE Sustainability, 2022). These could be readily adapted to suit the healthcare context in Australia, to provide the prerequisite carbon-literacy for informed decision making in HTA and HTR assessments, and at the point of clinical care.

In 2021 the Australian Commission on Safety and Quality in Health Care (ACSQHC) established a Sustainable Environment Advisory Group to provide expert technical advice and guidance on the

development of a Climate Risk Module (ACSQHC, 2021). While outcomes of this work will support building the health workforce's carbon literacy and enable clinical decision making which is sensitive to climate risk, agreement has not yet been reached on the key environmental metrics to be included in this module. PHNs and the Practice Incentives Program (PIP) should be closely involved in this process and implementation, as key stakeholders in the delivery of quality clinical care and repositories of industry knowledge.

Decarbonisation of the healthcare supply chain

Greenhouse gas emissions embedded in healthcare supply chains contribute a large proportion of the overall impact of healthcare systems on the environment. Internationally, the World Health Organisation has identified sustainable procurement strategies as key to creating environmentally sustainable healthcare systems (WHO, 2015). But in Australia, data is not being collected on scope 3 emissions of the health sector and national standards for supply chain management in healthcare are lacking. These must be included in emissions reduction targets.

GHGs embodied in the healthcare supply chain occur as a consequence of the health system interacting with other economic sectors such as the mining, agricultural, and transport sectors. This includes indirect emissions stemming from the supply chain involved in the manufacture, distribution, and provision of health goods and services and comprise approximately 70% of the carbon footprint of Australia's health system (Karliner et al., 2021).

Decreasing demand for healthcare goods and services (via reducing, reusing, and removing), shifting to low-carbon options, and reducing the emissions intensity of manufactured goods and services is essential to influencing supply chain emissions (Tennison et al., 2021).

Sustainable procurement activities present an opportunity to govern and reduce the carbon footprint of Australia's healthcare sector and are a key means of implementing environmental policies. In the UK, the NHS will cease purchasing from suppliers that do not meet or exceed their net zero commitments by 2027 (NHS, 2020). Kaiser Permanente California requires a sustainability scorecard from suppliers to provide environmental data of medical equipment and products used in healthcare facilities (Kaiser Permanente, 2010). The EU and Nordic organisations have included sustainability criteria in their pharmaceutical procurement strategies (Hernández, 2018; Nicolet et al., 2022).

At the local level, public hospitals and health services in Victoria and the ACT are expected to apply sustainable procurement criteria to their procurement strategies and activities, to assist implementation of Climate Change Policy objectives (Department of Health Victoria, 2021; ACT Health, 2010). A sector-wide strategy to monitor and regulate supply chain emissions, and to set targets, metrics, and key performance indicators to measure and track against national environmental standards is needed. However standardized methodology for calculating the health sectors supply chain is limited at this time (HCWH, 2019).

The Australian Government could use purchasing power to drive markets towards sustainable options by regulating purchasing only from manufacturers making progress towards net zero, while

legislating for suppliers to provide evidence of the carbon footprint of their products. Health Care Without Harm are progressing work in this area (HCWH, 2019).

Clinical governance and leadership

Current government policies and investments do not support actions for reducing the footprint of the health system. This is compounded by the federated funding of healthcare.

There is no regulatory obligation to account for environmental impacts of the health sector. Consequently, the sector is unaccountable for its contribution to the national footprint and not required to set and meet sector-wide emissions reduction initiatives such as measuring and reporting on GHG emissions or monitoring procurement or health delivery performance.

Any decarbonisation efforts of health jurisdictions in Australia have so far been siloed and inconsistent across states and territories. Establishing and investing in carbon reduction strategies for the health sector will be critical to reducing the carbon footprint and promoting high value care in healthcare settings. This will require strong governance and health leadership and education at all levels to drive policy action, and clinical practice changes to overcome barriers and blocks to reducing emissions across the sector.

Calls have been made for Australia's health system to commit to zero net carbon emissions by 2040 (Talley et al., 2021). There is broad support across the sector for the healthcare system to reach net zero by 2040, with an 80% reduction target by 2030 (Australian Medical Association and Doctors for the Environment Australia, 2021; CAHA and GGHH, 2021). A global coalition of healthcare organisations have developed a Global Roadmap for Decarbonisation (Karliner et al., 2021) of all health systems internationally. Similar, work is progressing in the Australian context (CAHA, 2022)

While there are signs of individual state-level commitment to decarbonising healthcare, there has been little attention on emissions generated by clinical care provision and there is no capacity to track and report.

State governments and local health districts taking action

In Australia, individual jurisdictions have set targets and policies on environmental sustainability in healthcare. WA, VIC, SA, TAS, and ACT have policies for net zero by 2050, without exemption for healthcare (Department of Water and Environmental Regulation, 2020; Parliament of Victoria, 2017; Department for Environment and Water, 2022; ReCFIT, 2022; ACT Government, 2019). The NSW Government has a net zero plan aiming to deliver net zero emissions by 2050, but no climate action plan for health (Malik et al., 2021). Queensland Health has developed a Climate Risk Strategy 2021-2026 for the health sector to align with Queensland Government targets of net zero emissions by 2050.

As an example, the Victorian State Government, through the Climate Change Act 2017 (Parliament of Victoria, 2017), has legislated an environmental sustainability in health care strategy led by the state Building Authority with a focus on infrastructure (Department of Health and Human Services,

2018). All public hospitals and health services are required under the policy to have an environmental management plan and to report publicly on environmental performance (with targets) including energy use, greenhouse gas emissions, water use, and waste generation. In addition, the Climate Change Adaptation Action Plan 2022-2026 (Department of Health, 2022) assists the sector to embed climate change considerations into policies, planning, guidelines, and operations.

The focus of state-based policies and action plans so far has been largely on building resilience and adaptation to climate change impacts on health and healthcare, rather than strategies to mitigate the carbon footprint of clinical healthcare itself. Those state-led initiatives that have a mitigation component (e.g. emissions reduction) prioritise maximising the efficiency of buildings, on-site renewables, and waste and water programs to deliver carbon savings. For example, Hunter New England Local Health District released the Sustainable Healthcare – Together towards Zero 2030 (HNE LHD, 2021) initiative in 2021, with a focus on solar power, water sustainability, and energy efficient practices, but no explicit goal to address the direct and indirect emissions of clinical activity. This approach ignores that the majority of the carbon footprint of healthcare occurs due to clinical activity (Barratt et al., 2022).

There are some local exceptions which are acting on healthcare sustainability, as some Local Health Districts have established sustainability committees and officers for awareness raising, and to integrate healthcare sustainability frameworks system wide. For example, the Northern Sydney Local Health District produced a Planetary Health Framework 2021-2023 (NS LHD, 2021) and appointed staff to implement the strategies across primary and tertiary health. Priority actions include ensuring models of care are sustainable and have a low environmental impact. Mercy Health's Caring for People and Planet report (Mercy Health, 2020-25) similarly has building sustainable models of care at the core of its emissions reduction strategy.

While it is important for governments to continue to invest in decarbonising the energy systems of public hospitals for example (public hospitals consume over half of public sector energy in most Australian states and territories) (Burch et al., 2021), and phasing out fossil fuel use as per the national emissions reduction plan (Department of Industry, 2021a), there is no national leadership to coordinate efforts all of the individual activities that are being enacted to drive down healthcare emissions.

NHS leading the way

In the UK, the National Health Service (NHS) has declared an ambition to deliver a net-zero health service by 2040 (NHS, 2020a) with an evidence-based action plan. On 1 July 2022, the NHS became the first health system to embed new zero into legislation, through the Health and Care Act 2022. It is considered the world leader in developing a strategic approach towards healthcare sustainability and is backed by strong government support, political will, and investment. The NHS has also signed a Memorandum of Understanding with the WHO (WHO, 2022) that will see the two organisations cooperate on activities to promote and facilitate the decarbonization of healthcare systems around the world.

In 2008 the NHS established a national Sustainable Development Unit (SDU) to ensure that the NHS met its commitments under national climate change legislation, the UK Climate Change Act (Parliament of the United Kingdom, 2008), and the global Sustainable Development Goals (United Nations, 2015). The Unit has systematically measured and reported the carbon footprint of the NHS since inception and monitored progress against carbon reduction targets. These assessments are the longest-running effort to quantify healthcare GHGs in the world (Tennison et al., 2021). The SDU also provides guidance to health professionals on energy use and waste, for example, and has produced tools to guide green procurement (Public Health England, 2020).

The Unit has facilitated a reduction in NHS healthcare emissions by 26% since 1990 (1990-2019) (Tennison et al., 2021), with associated financial savings (Pencheon, 2018; Nuttall and Yaqub, 2019) despite a rise in healthcare activity. This has been achieved largely through decarbonisation of the energy system (e.g. reduction in building energy) (Tennison et al., 2021). Achieving further reductions will require addressing the footprint of clinical care itself, and the NHS is only just beginning to focus on making changes to how healthcare is delivered (Tennison et al., 2021).

The national Australian Medical Association, among others, has called for the Australian Government to establish a National SDU. While the successful UK SDU model has developed policies, tools, and training specific to the UK health sector, it could be adopted and adapted to the Australian context.

Three states in Australia now have Sustainable Development Units or equivalent: including Queensland (Office of Hospital Sustainability), NSW (Climate Risk and Net Zero Unit), and WA (Sustainable Development Unit of the WA Department of Health).

Implementing a national SDU in Australia could build on environmental sustainability efforts implemented in healthcare systems at the state level by acting to liaise between States, Territories, and individual health jurisdictions to align state-based emissions management plans with national targets, integrate these efforts and provide central coordination of emissions mitigation initiatives. As outlined in Doctors for the Environment Australia's National Sustainable Healthcare Unit proposal, a national SDU could partner with sectors beyond the remit of state governments (i.e. public hospitals) to incorporate primary care, private healthcare organisations (including industry), PBS, MBS, and not-for-profits, to maximise resources and finances.

The overarching purpose of a national SDU would be to measure and monitor current strategies, set national targets and measure progress against these targets, guide actions and initiatives across individual sites, further workforce training provision and advice, and incentivise cultural and behavioural change.

Conclusion and recommendations

- Reduce low value care and switch to low carbon options
- Establish nationally coordinated data collection, monitoring, and reporting
- Add carbon footprint indicators to health technology assessment processes
- Decarbonise healthcare supply chains
- Establish a national healthcare sustainability unit or task force
- Invest in research

The WHO has highlighted the interconnectedness and reinforcing nature of economic, environmental, and social sustainability within health systems (WHO, 2017). Climate mitigation efforts in the health sector can have positive impacts beyond reduced GHG emissions and lead to enhanced patient care, staff satisfaction, cost savings, and reduce health inequities (Watts et al., 2019; MacNeill et al., 2021). Healthcare will benefit from health and environmental co-benefits resulting from decarbonising the sector (Eckelman and Sherman, 2018; Lenzen et al., 2020). Human health and wellbeing is improved via measures to create a sustainable healthcare system through cleaner air, better diets, and increased physical activity. Co-benefits in turn offset costs of mitigation interventions (Milner et al., 2020; Williams et al., 2018). A large challenge to improving environmental sustainability of the health system is the growing demand for health services. The proposals put forward here are generally supported by the Australian Government as demonstrated in their commitment to the Addendum to the Health Reform Act 2020- 2025.

Reduce low value care and switch to low carbon alternatives to reduce carbon intensity of health services and delivery

Unnecessary and low value healthcare leads to patient harm, financial cost to individuals and the healthcare system and budget, and preventable carbon emissions. The health system could leverage off recently introduced policy with a focus on delivering value-based healthcare, to reduce the footprint of low value care. Taking the lead of other public organisations, the health sector could utilise Triple Bottom Line (health, environmental, financial) assessments to provide a comprehensive picture of the total impact of low value care on health, financial, and environmental outcomes as a measure of value. The Atlases of Health Variation (ACSQHC) could be used to identify low value priority areas to direct health technology reassessment and disinvestment initiatives, particularly highlighting treatments and services where there is clear evidence of lack of efficacy or cost effectiveness to reconsider or withdraw public funding. Overuse of unnecessary pathology test ordering may be reduced by introducing a national system of stewardship to optimise clinical use. Reducing demand for care and shifting to low carbon options is key to decarbonising the sector. Increasing Government investment in population-level preventive healthcare must be prioritised to reduce the carbon output of the sector while improving population health and lowering healthcare costs. Respiratory disease prevention programs could promote uptake of dry powder inhalers in place of metered-dose inhalers.

Establish nationally coordinated data collection, monitoring, and reporting

In Australia, comprehensive understanding of healthcare's environmental impact is limited by a lack of evidence to guide transition to lower carbon clinical care. A key priority is to establish capacity and infrastructure for the Australian health sector to measure and report its carbon footprint. The introduction of a centrally collated national minimum dataset (AIHW, 2022) for health sector emissions would facilitate this process. A national SDU could work in partnership with States and Territories to ensure standardised and consistent measurement of healthcare sector emissions at a granular and national level. Improving data and central reporting of the emissions of primary care services at a national level would support PHNs to implement tailored climate and health strategies locally.

Publicly disclosing health sector emissions in the national GHG reporting inventory (Department of Industry, 2021) is essential to aligning the health sector with reporting requirements placed on other sectors of the economy. The carbon footprint of the pharmaceutical sector, and medical use of anaesthetic gases for example, particularly desflurane and nitrous oxide, should be measured and reported as a priority and monitored in the national GHG inventory.

The federal government could introduce regulatory frameworks to facilitate implementation and assessment of environmental performance standards as a mandatory component of quality healthcare accreditation (as part of the remit of the ACSQHC).

The social cost of carbon (SCC) is a measure of the damage caused by carbon emissions and has been used as an indicator of value-based care by some policymakers, such as the ACT Government, for public investment decisions (ACT Climate Change Council, 2021). Some argue (Senay et al., 2022) that all healthcare facilities should be accountable for their emissions like all business enterprises as part of corporate social responsibility and environment, social, and governance reporting. Such reporting would provide a framework to report and monitor true costs associated with health system overuse and low value care, better aligning with a values-based healthcare model.

Add carbon footprint indicators to health technology assessment processes

Authorities should move to include carbon costs in HTA processes as part of the value assessment of health products, services, and clinical pathways in Australia. Health technologies could be required to comply with emissions impact thresholds to be considered eligible for public subsidy and rated on environmental impact criteria within the tendering process. In addition, the government should prioritise developing a structured HTA process for reassessment of health technologies throughout their lifecycle and disinvestment in low value goods and services. This will improve environmental and health system sustainability and enable reallocation of resources towards high value healthcare. Sustainability experts will be required on HTA panels to interpret and analyse environmental impact statements. Commonwealth investment in training a carbon literate health workforce is recommended through development of online training modules with terms and conditions to be met for HTA panel selection.

Decarbonise healthcare supply chains

Sustainable procurement policy and standards for reporting the environmental impacts of products across their entire lifecycle must be embedded into health sector procurement contracts to decarbonise national healthcare supply chains. Healthcare suppliers should be regulated to measure and provide evidence on the carbon footprint of their products and undergo environmental accreditations to meet sector-wide environmental standards and align with net zero commitments; supported by sector-wide policies to preference carbon-neutral suppliers. Sustainable procurement policies and practices can drive demand for more environmentally conscious manufacturing across the supply chain. Pharmaceutical and medical device companies could be required to introduce carbon labelling or mandatory sustainability statements like other sectors for accountability and facilitate awareness and understanding of the carbon footprint of healthcare products.

Establish a national healthcare sustainability unit or task force

Individual health services vary in their ability to influence different scopes of emissions so national leadership is needed. In addition to national policies targeting monitoring and reporting of emissions of the health sector, a further shift to reduce healthcare-related emissions will simultaneously require changes in clinical service models and a commitment to behavioural change within the profession**.** A national sustainability unit to facilitate coordinated action, monitoring, and evaluation of emissions reduction initiatives should be established. This could further support healthcare providers through the provision of resources and training in carbon health literacy.

Invest in research

An evidence base for measuring the carbon emissions of healthcare is lacking. Investment in bottom-up life cycle assessment data collection and carbon footprinting of individual healthcare items and models of care (to enable process-based life cycle assessment) is essential to progressing the research agenda.

References

ABS: Australian Bureau of Statistics. (2018). National Health Survey. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release

ABS: Australian Bureau of Statistics. (2022). Australian Industry 2020-21 Financial Year. Australian Government, Canberra, Australia. Accessed 20 June 2022: https://www.abs.gov.au/statistics/industry/industry-overview/australian-industry/latest-release

ACSQHC: Australian Commission on Quality and Safety in Healthcare. (2021). Sustainable Healthcare Module. ACSQHC, Australian Government, Canberra, Australia. Accessed 20 June 2022: https://www.safetyandquality.gov.au/standards/nsqhs-standards/sustainable-healthcare-module

ACSQHC: Australian Commission on Quality and Safety in Healthcare. (2021). Australian Atlas of Healthcare Variation Series. ACSQHC, Australian Government, Canberra, Australia. Accessed 20 June 2022: https://www.safetyandquality.gov.au/publications-and-resources/australian-atlas-healthcare-variation-series

ACT Climate Change Council. (2021). The Social Cost of Carbon and Implications for the ACT. ACT Government, Canberra, Australia. Accessed 20 June 2022: https://www.environment.act.gov.au/__data/assets/pdf_file/0004/1864894/the-social-cost-of-carbon-and-implications-for-the-act.pdf

ACT Health. (2010). ACT Health Policy: ACT Health Procurement. ACT Government, Canberra, Australia. Accessed 24 June 2022: https://www.health.act.gov.au/sites/default/files/2019-02/Procurement%20Policy.pdf

Adshead F, Salman R, Aumonier S, Collins M, Hood K, McNamara C, … Williamson PR. (2021). A strategy to reduce the carbon footprint of clinical trials. *The Lancet*. 398: 281-82. https://doi.org/10.1016/S0140-6736(21)01384-2

AIHW: Australian Institute of Health and Welfare. (2019a). Australian Burden of Disease Study: impact and causes of illness and death in Australia 2015. Australian Burden of Disease series no. 19. AIHW, Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.aihw.gov.au/reports/burden-of-disease/burden-disease-study-illness-death-2015/summary

AIHW: Australian Institute of Health and Welfare. (2019b). Disease Expenditure Study: Overview of analysis and methodology 2015–16. AIHW, Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.aihw.gov.au/getmedia/e966d2ce-c579-4f47-846d-47255f4aa7fc/aihw-hwe-76.pdf.aspx

AIHW: Australian Institute of Health and Welfare. (2020). Australia's health performance framework. AIHW, Australian Government, Canberra, Australia. Accessed 20 June 2022: https://www.aihw.gov.au/reports-data/indicators/australias-health-performance-framework

AIHW: Australian Institute of Health and Welfare. (2022). Data set specifications. AIHW, Australian Government, Canberra, Australia. Accessed 20 June 2022: https://meteor.aihw.gov.au/content/344846

Alshqaqeeq F, Esmaeili MA, Overcash M and Twomey J. (2020). Quantifying hospital services by carbon footprint: a systematic literature review of patient care alternatives. *Resources, Conservation and Recycling*. 154: 104560. https://doi.org/10.1016/j.resconrec.2019.104560

ANZCA: Australian and New Zealand College Of Anaesthetists. (2021). The Alfred ditches desflurane. ANZCA, Brisbane, Australia. Accessed 22 June 2022: https://www.anzca.edu.au/news/top-news/the-alfred-ditches-desflurane

Australian Industry and Skills Committee. (2021). Industries/Health. Australian Industry and Skills Committee. Accessed 8 June 2022: https://nationalindustryinsights.aisc.net.au/industries/health

Australian Medical Association and Doctors for the Environment. (2021). Joint statement - Medical Professionals call for emissions reduction in health care. Australian Medical Association, Canberra, Australia. Accessed 24 June 2022: https://www.ama.com.au/media/joint-statement-medical-professionals-call-emissions-reduction-health-care

Badgery-Parker T, Pearson S, Chalmers K, Brett J, Scott IA, Dunn S, … Elshaug AG. (2019). Low-value care in Australian public hospitals: prevalence and trends over time. *BMJ Quality & Safety*. 28: 205-14. http://doi.org/10.1136/bmjqs-2018-008338

Badgery-Parker T, Pearson S, Dunn S and Elshaug AG. (2019). Measuring hospital-acquired complications associated with low-value care. *JAMA Internal Medicine*. 179: 499-505. http://doi.org/10.1001/jamainternmed.2018.7464

Barratt AL, Bell KJL, Charlesworth K and McGain F. (2022). High value health care is low carbon health care. *Medical Journal of Australia*. 216: 67-68. http://doi.org/10.5694/mja2.51331

BMA: British Medical Association. (2020). Sustainable and environmentally friendly general practice, GPC England Policy Document. BMA, London, England. Accessed 8 June 2022: https://www.bma.org.uk/media/2570/bma-sustainable-and-environmentally-friendly-general-practice-report-june-2020.pdf

Boxall A. (2012). What are we doing to ensure the sustainability of the health system?. Department of Parliamentary Services, Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1112/12rp04

Braithwaite J, Glasziou P and Westbrook J. (2020). The three numbers you need to know about healthcare: the 60-30-10 challenge. *BMC Medicine*. 18: 102. https://doi.org/10.1186/s12916-020-01563-4

Breth-Petersen M, Bell K, Pickles K, McGain F, McAlister S, Barratt A. The health, financial and environmental impacts of unnecessary vitamin D testing: a triple bottom line assessment adapted for healthcare. BMJ Open 2022 (In press)

Brownlee S, Chalkidou K, Doust J, Elshaug AG, Glasziou P, Heath I, … Chalmers K. (2017). Evidence for overuse of medical services around the world. *The Lancet*. 390: 156-68. https://doi.org/10.1016/S0140-6736(16)32585-5

Brownlee, Shannon M and Korenstein D. (2021). Better understanding the downsides of low value healthcare could reduce harm. *BMJ*. 372. https://doi.org/10.1136/bmj.n117

Burch H, Anstey MH and McGain F. (2021). Renewable energy use in Australian public hospitals. *Medical Journal of Australia*. 215: 160-63. https://doi.org/10.1101/2021.02.25.21252432

CAHA and GGHH: Climate and Health Alliance and Global Green and Healthy Hospitals. (2021). Health Sector Gets First-Ever Guide to Reach Zero Greenhouse Gas Emissions by 2050. CAHA, Melbourne, Australia. Accessed 24 June 2022: https://www.caha.org.au/healthcare_decarbonisation

CAHA: Climate and Health Alliance (2022) Australian Health Leadership on Climate Action. Accessed 24 August 2022: https://assets.nationbuilder.com/caha/pages/34/attachments/original/1657509197/Policy_Brief_-_Health_Leadership_on_Climate_Action.pdf?1657509197

Centre for Sustainable Healthcare. (2022a). Carbon Footprinting and Triple Bottom Line Analysis. Centre for Sustainable Healthcare, Oxford, England. Accessed 20 June 2022: https://sustainablehealthcare.org.uk/what-we-do/carbon-footprinting-and-triple-bottom-line-analysis

Centre for Sustainable Healthcare. (2022b). The Desflurane Reduction Project. Centre for Sustainable Healthcare, Oxford, England. Accessed 21 June 2022: https://sustainablehealthcare.org.uk/what-we-do/sustainable-specialties/anaesthetics/desflurane-reduction-project

Clean Energy Regulator. (2021). Reporting thresholds. Australian Government, Canberra, Australia. Accessed 8 June 2022: http://www.cleanenergyregulator.gov.au/NGER/Reporting-cycle/Assess-your-obligations/Reporting-thresholds#:~:text=The%20current%20facility%20threshold%20is,TJ%20or%20more%20of%20energy

Copp T, Jansen J, Doust J, Mol BWJ, Dokras S and McCaffery K. (2017). Are expanding disease definitions unnecessarily labelling women with polycystic ovary syndrome?. *BMJ*. 358. https://doi.org/10.1136/bmj.j3694

Cussans A, Harvey G, Kemple T, and Tomson M. (2021). Interventions to Reduce the Environmental Impact of Medicines: A UK perspective. *Journal of Climate Change and Health*. 4: 100079. https://doi.org/10.1016/j.joclim.2021.100079

Davies L, Hendrickson CD and Hanson GS. (2017). Experience of US patients who self-identify as having an overdiagnosed thyroid cancer: a qualitative analysis. *JAMA Otolaryngology–Head & Neck Surgery*. 143: 663-69. https://doi.org/10.1001/jamaoto.2016.4749

Department of Health. (2015a). Energy efficiency in hospitals. Victorian Government, Melbourne, Australia. Accessed 20 June 2022: https://www.health.vic.gov.au/planning-infrastructure/energy-efficiency-in-hospitals

Department of Health. (2015b). Capital works and sustainability. Victorian Government, Melbourne, Australia. Accessed 20 June 2022: https://www.health.vic.gov.au/planning-infrastructure/capital-works-and-sustainability

Department of Health. (2015c). Post-Market Reviews of Pharmaceutical Benefits Scheme Subsidised Medicines. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.pbs.gov.au/info/reviews/subsidised-medicines-reviews

Department of Health. (2020). 2020–25 National Health Reform Agreement. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.health.gov.au/initiatives-and-programs/2020-25-national-health-reform-agreement-nhra

Department of Health. (2021a). National Preventive Health Strategy 2021–2030. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.health.gov.au/sites/default/files/documents/2021/12/national-preventive-health-strategy-2021-2030_1.pdf

Department of Health. (2021b). Medicare Benefits Schedule (MBS) Review. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.health.gov.au/initiatives-and-programs/mbs-review

Department of Health. (2021). Procurement. Victorian Government, Melbourne, Australia. Accessed 8 June 2022: https://www.health.vic.gov.au/planning-infrastructure/procurement

Department of Finance. (2020a). Consideration of broader domestic economic benefits in procurement. Department of Finance, Australian Government, Canberra, Australia. Accessed 23 June 2022: https://www.finance.gov.au/sites/default/files/2020-08/consideration-of-broader-economic-benefits-in-procurement.pdf

Department of Finance. (2020b). Commonwealth Procurement Rules. Department of Finance, Australian Government, Canberra, Australia. Accessed 23 June 2022: https://www.finance.gov.au/government/procurement/commonwealth-procurement-rules

Department of Industry, Science, Energy and Resources. (2021a). Australia's whole-of-economy Long-Term Emissions Reduction Plan. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.industry.gov.au/sites/default/files/October%202021/document/australias-long-term-emissions-reduction-plan.pdf

Department of Industry, Science, Energy & Resources. (2021b). National Greenhouse Gas Inventory Quarterly Updates. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-updates

Department of Industry, Science, Energy & Resources. (2022). International climate change commitments. Australian Government, Canberra, Australia. Accessed 8 June 2022: https://www.industry.gov.au/policies-and-initiatives/international-climate-change-commitments

East AJ. (2008). What is a Carbon Footprint? An overview of definitions and methodologies. Horticulture Australia, Sydney, Australia. Accessed 20 June 2022: https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/59025/Hort-Fruit-Drought-Carbon-Report1.pdf

Eckelman MJ and Sherman J. (2016). Environmental impacts of the US health care system and effects on public health. *PLOS One*. 11: e0157014. https://doi.org/10.1371/journal.pone.0157014

Eckelman MJ and Sherman J. (2018). Estimated Global Disease Burden From US Health Care Sector Greenhouse Gas Emissions. *American Journal of Public Health*. 108: S120_S122. https://doi.org/10.2105/AJPH.2017.303846

HCWH: Health Care Without Harm. (2019). Health care's climate footprint: How the health sector contributes to the global climate crisis and opportunities for action. Health Care Without Harm and Arup. Accessed 8 June 2022: https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf

Healthdirect. (2020). The role of a GP. Healthdirect Australia, Australian Government, Canberra, Australia. Accessed 23 June 2022: https://www.healthdirect.gov.au/the-role-of-a-gp

Hernández OP, Jósa V and Long A. (2018). Reducing the carbon footprint of healthcare through sustainable procurement. Health Care Without Harm, Washington DC, USA. Accessed 8 June 2022: https://noharm-europe.org/sites/default/files/documents-files/5624/2018-09-25_Reducing_carbon_footprint_healthcare%20WEB.pdf

Hoban E, Haddock R and Woolcock K. (2021). Transforming the health system for sustainability: environmental leadership through a value-based health care strategy. Deeble Issues Brief 41. Australian Healthcare and Hospitals Association, Canberra, Australia. Accessed 8 June 2022: https://ahha.asn.au/system/files/docs/publications/deeble_issues_brief_no_41._transforming_the_health_system_for_sustainability_2.pdf

Howell RA. (2018). Carbon management at the household level: a definition of carbon literacy and three mechanisms that increase it. *Carbon Management*. 9: 25-35. https://doi.org/10.1080/17583004.2017.1409045

Irwin MG, Chung CKE, Ip KY and Wiles MD. (2020). Influence of propofol-based total intravenous anaesthesia on peri-operative outcome measures: a narrative review. *Anaesthesia*. 75: e90-e100. https://doi.org/10.1111/anae.14905

Jackson H and Shiell A. (2017). Preventive health: How much does Australia spend and is it enough?. La Trobe University, Melbourne, Australia. Accessed 8 June 2022: http://fare.org.au/wp-content/uploads/Preventive-health-How-much-does-Australia-spend-and-is-it-enough_FINAL.pdf

Janson C, Henderson R, Löfdahl M, Hedberg M, Sharma R and Wilkinson AJK. (2020). Carbon footprint impact of the choice of inhalers for asthma and COPD. *Thorax*. 75: 82-84. http://doi.org/10.1136/thoraxjnl-2019-213744

Kaiser Permanente. (2010). Kaiser Permanente launches sustainability scorecard for medical products. Kaiser Permanente, Oakland, USA. Accessed 8 June 2022: https://share.kaiserpermanente.org/article/kaiser-permanente-launches-sustainability-scorecard-for-medical-products/

Karliner J, Roschnik S, Boyd R, Ashby B and Steele K. (2021). Global Road Map for Health Care Decarbonization. A navigational tool for achieving zero emissions with climate resilience and health equity. Health Care Without Harm and Arup. Accessed 8 June 2022: https://www.arup.com/-/media/arup/files/publications/h/hcwh-road-map-for-health-care-decarbonization.pdf

Lenzen M, Malik A, Li M, Fry J, Weisz H, Pitchler PP, … Pencheon D. (2020). The environmental footprint of health care: a global assessment. *The Lancet Planetary Health*. 4(7): E271-E279. https://doi.org/10.1016/S2542-5196(20)30121-2

Lipitz-Snyderman A and Korenstein D. (2017). Reducing overuse—is patient safety the answer?. *JAMA*. 317: 810-11. https://doi.org/10.1001%2Fjama.2017.0896

MacNeill AJ, McGain F and Sherman JD. (2021). Planetary health care: a framework for sustainable health systems. *Lancet Planetary Health*. 5(2): E66-E68. https://doi.org/10.1016/S2542-5196(21)00005-X

Mafi JN, and Parchman M. (2018). Low-value care: an intractable global problem with no quick fix. *BMJ Quality and Safety*. 27(5): 333-336. http://doi.org/10.1136/bmjqs-2017-007477

Malik A, Lenzen M, McAlister S and McGain F. (2018). The carbon footprint of Australian health care. *The Lancet Planetary Health*. 2: e27-e35. https://doi.org/10.1016/S2542-5196(17)30180-8

Malik A, Padget M, Carter S, Wakiyama T, Maitland-Scott I, Vyas A, … Lenzen M. (2021). Environmental impacts of Australia's largest health system. *Resources, Conservation and Recycling*. 169: 105556. https://doi.org/10.1016/j.resconrec.2021.105556

Marsh K, Ganz M, Nørtoft E, Lund N and Graff-Zivin J. (2016). Incorporating environmental outcomes into a health economic model. *International Journal of Technology Assessment in Health Care*. 32: 400-06. https://doi.org/10.1017/s0266462316000581

Marsh K, Sculpher M, Caro JJ and Tervonen T. (2017). The Use of MCDA in HTA: Great Potential, but More Effort Needed. *Value in Health*. 21(4): 394-397. https://doi.org/10.1016/j.jval.2017.10.001

MBS Review Taskforce. (2020). An MBS for the 21st Century Recommendations, Learnings and Ideas for the Future Medicare Benefits Schedule Review Taskforce: Final Report to the Minister for Health. Accessed 20 June 2022: https://www.health.gov.au/sites/default/files/documents/2020/12/medicare-benefits-schedule-review-taskforce-final-report-an-mbs-for-the-21st-century-recommendations-learnings-and-ideas-for-the-future.pdf

McAlister S, Barratt AL, Bell KJL and McGain F. (2020). The carbon footprint of pathology testing. *Medical Journal of Australia*. 212: 377-82. https://doi.org/10.5694/mja2.50830

McAlister S, Ou Y, Neff E, Hapgood K, Story D, Mealey P and McGain F. (2016). The Environmental footprint of morphine: a life cycle assessment from opium poppy farming to the packaged drug. *BMJ Open*. 6: e013302. https://doi.org/10.1136%2Fbmjopen-2016-013302

McAlister S, Smyth B, Koprivic I, Di Tanna GL, McGain F, Charlesworth K, … Konecny P. (2021). Carbon emissions and hospital pathology stewardship: a retrospective cohort analysis. *Internal Medicine Journal*. https://doi.org/10.1111/imj.15622

McCaffery K, Nickel B, Pickles K, Moynihan R, Kramer B, Barratt A and Hersch J. (2019). Resisting recommended treatment for prostate cancer: a qualitative analysis of the lived experience of possible overdiagnosis. *BMJ Open*. 9: e026960. https://doi.org/10.1136/bmjopen-2018-026960

McCreanor V. (2017). Active disinvestment in low-value care in Australia will improve patient outcomes and reduce waste. Deeble Issues Brief 23. Australian Healthcare and Hospitals Association, Australia. Accessed 24 June 2022: https://ahha.asn.au/system/files/docs/publications/171004_issues_brief_no_23-_disinvestment_2.pdf

McGain F, Blashki GA, Moon KP and Armstrong FM. (2009). Mandating sustainability in Australian hospitals. *Medical Journal of Australia*. 190: 719-20. https://doi.org/10.5694/j.1326-5377.2009.tb02659.x

McGain F, Burnham JP, Lau R, Aye L, Kollef MH and McAlister S. (2018). The carbon footprint of treating patients with septic shock in the intensive care unit. *Critical Care and Resuscitation.* 20: 304. PMCID: PMC6602529

McGain F, Muret J, Lawson C and Sherman JD. (2020). Environmental sustainability in anaesthesia and critical care. *British Journal of Anaesthesia*. 125: 680-92. https://doi.org/10.1016%2Fj.bja.2020.06.055

McGain F and Naylor C. (2014). Environmental sustainability in hospitals–a systematic review and research agenda. *Journal of Health Services Research & Policy*. 19: 245-52. https://doi.org/10.1177/1355819614534836

McGain F, Story D, Kayak E, Kashima Y and McAlister S. (2012). Workplace Sustainability: The "Cradle to Grave" View of What We Do. *Anaesthesia and Analgesia*. 114(5); 1134-3. https://doi.org/10.1213/ANE.0b013e31824ddfef

McGain F, Story D, Lim T and McAlister S. (2017). Financial and environmental costs of reusable and single-use anaesthetic equipment. *British Journal of Anaesthesia*. 118: 862-69. https://doi.org/10.1093/bja/aex098

Medicare Australia. (2021). Medicare by MBS category July 2020 to June 2021. Services Australia, Australian Government, Canberra, Australia. Available from: http://medicarestatistics.humanservices.gov.au/

Mercy Health (2020). Caring for people and planet. Mercy Health's strategic response to Laudato Si' 2020-25. Mercy Health, Melbourne, Australia. Accessed 9 August 2022: https://www.mercyhealth.com.au/wp-content/uploads/sites/61/2021/12/Mercy-Health-Care-for-People-and-Planet-online-1.pdf

Milner J, Hamilton I and Woodcock J. (2020). Health benefits of policies to reduce carbon emissions. *BMJ*. 368: l6758. https://doi.org/10.1136/bmj.l6758

MSAC: Medical Services Advisory Committee. (2021). Guidelines for preparing assessments for the Medical Services Advisory Committee. MSAC, Australian Government, Canberra, Australia. Accessed 24 June 2022: http://www.msac.gov.au/internet/msac/publishing.nsf/Content/E0D4E4EDDE91EAC8CA2586E0007AFC75/$File/MSAC%20Guidelines-complete-16-FINAL(18May21).pdf

Müskens JLJM, Kool RB, van Dulmen SA and WEstert GP. (2022). Overuse of diagnostic testing in healthcare: a systematic review. *BMJ Quality and Safety*. 31(1): 54-63. http://doi.org/10.1136/bmjqs-2020-012576

Nansai K, Fry J, Malik A, Takayanagi W and Kondo N. (2020). Carbon footprint of Japanese health care services from 2011 to 2015. *Resources, Conservation and Recycling*. 152: 104525. https://doi.org/10.1016/j.resconrec.2019.104525

NICE: National Institute for Health and Care Excellence. (2021). Asthma: diagnosis, monitoring and chronic asthma management. NICE, UK Government, London, England. Accessed 22 June 2022: https://www.nice.org.uk/guidance/ng80/resources

NHS: National Health Service. (2020). Delivering a 'Net Zero' National Health Service. NHS, London England. Accessed 8 June 2022: https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf

NHS: National Health Service. (2021). Putting anaesthetic-generated emissions to bed. NHS, London England. Accessed 8 June 2022: https://www.england.nhs.uk/greenernhs/whats-already-happening/putting-anaesthetic-generated-emissions-to-bed/

Nicolet J, Mueller Y, Paruta P, Boucher J and Senn N. (2022). What is the carbon footprint of primary care practices? A retrospective life-cycle analysis in Switzerland. *Environmental Health*. 21: 1-10. https://doi.org/10.1186/s12940-021-00814-y

North Sydney Primary Health Network (PHN). (2020). Climate and Health Strategy 2020. Sydney North Health Network, Sydney, Australia. Accessed 23 June 2022: https://sydneynorthhealthnetwork.org.au/wp-content/uploads/2020/11/SNHN-Climate-and-Health-Strategy-2020-WEB.pdf

Nuttall C and Yaqub F. (2019). A call for action: understanding medicine's role in climate change. *Perspectives on Medical Education*. 8: 378-78. https://doi.org/10.1007%2Fs40037-019-00546-3

Parliament of Australia. (2007). National Greenhouse and Energy Reporting Act. Parliament of Australia, Canberra, Australia. Accessed 22 June 2022: https://www.legislation.gov.au/Details/C2007A00175

Pencheon D. (2018). Developing a sustainable health care system: the United Kingdom experience. *Medical Journal of Australia*. 208: 284-5. https://doi.org/10.5694/mja17.01134

Pichle PP, Jaccard IS, Weisz U and Weisz H. (2019). International comparison of health care carbon footprints. *Environmental Research Letters*. 14: 064004. https://doi.org/10.1088/1748-9326/ab19e1

Polisena J, De Angelis G, Kaunelis D, Shaheen M and Gutierrez-Ibarluzea I. (2018). Environmental impact assessment of a health technology: a scoping review. *International Journal of Technology Assessment in Health Care*. 34: 317-26. https://doi.org/10.1017/s0266462318000351

Productivity Commission. (2017). Shifting the Dial: 5 year Productivity Review, Supporting Paper No. 6. Australian Government, Canberra, Australia. Accessed 21 June 2022: https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting6.pdf

Richie C. (2022). Environmental sustainability and the carbon emissions of pharmaceuticals. *Journal of Medical Ethics*. 48: 334-37. https://doi.org/10.1136/medethics-2020-106842

Rosenberg A, Agiro A, Gottlieb M, Barron J, Brady P, Liu Y, … DeVries A. (2015). Early trends among seven recommendations from the choosing wisely campaign. *JAMA Internal Medicine*. 175: 1913-20. https://doi.org/10.1001/jamainternmed.2015.5441

Scott IA, and Duckett SJ. (2015). In search of professional consensus in defining and reducing low-value care. *Medical Journal of Australia*. 203: 179-81. https://doi.org/10.5694/mja14.01664

SDU: Sustainable Development Unit (2013). Carbon Footprint from Anaesthetic gas use. National Health Service, London, England. Accessed 8 June 2022: https://www.sduhealth.org.uk/documents/publications/Anaesthetic_gases_research_v1.pdf

Seifert C, Koep L, Wolf P and Guenther E. (2021). Life cycle assessment as decision support tool for environmental management in hospitals: A literature review. *Health Care Management Review*. 46: 12-24. https://doi.org/10.1097/hmr.0000000000000248

Sherman J, McGain F, Lem M, Mortimer F, Jonas WB and MacNeill AJ. (2021). Net zero healthcare: a call for clinician action. *BMJ*. 374: n1323. https://doi.org/10.1136/bmj.n1323

Sherman J, Le C, Lamers V and Eckelman M. (2012). Life cycle greenhouse gas emissions of anesthetic drugs. *Anesthesia & Analgesia*. 114: 1086-1090. https://doi.org/10.1213/ANE.0b013e31824f6940

Spelman D. (2015). Inappropriate pathology ordering and pathology stewardship. *Medical Journal of Australia*. 202: 13-15. https://doi.org/10.5694/mja14.00814

Talley NJ, Stanley F, Lucas T and Horton R. (2021). Health and climate change MJA–Lancet Countdown report: Australia gets another failing grade in 2020 but shows signs of progress. *The Lancet*. 397: e12-e14. https://doi.org/10.5694/mja2.50895

Tennison I, Roschnik S, Ashby B, Boyd R, Hamilton I, Oreszczyn T, … Sherman JD. (2021). Health care's response to climate change: a carbon footprint assessment of the NHS in England. *The Lancet Planetary Health*. 5: e84-e92. https://doi.org/10.1016/S2542-5196(20)30271-0

Usmani OS, Lavorini F, Marshall J, Dunlop WCN, Heron L, Farrington E and Dekhuijzen R. (2018). Critical inhaler errors in asthma and COPD: a systematic review of impact on health outcomes. *Respiratory Research*. 19: 10. https://doi.org/10.1186/s12931-017-0710-y

Vautrey R. (2020). Re: Sustainable and environmentally friendly general practice. British Medical Association, London, England. Accessed 21 June 2022: https://www.worcslmc.co.uk/cache/downloads/BMA-letter---Sustainable-and-environmentally-friendly-general-practice-14-Oct-2020.pdf

Vergunst F, Berry HL, Rugkåsa J, Burns T, Molodynski A and Maughan D. (2020). Applying the triple bottom line of sustainability to healthcare research—a feasibility study. *International Journal for Quality in Health Care*. 32(1): 48-53. https://doi.org/10.1093/intqhc/mzz049

VHBA: Victorian Health Building Authority. (2022). Designing sustainable health infrastructure. Victorian Government, Melbourne, Australia. Accessed 20 June 2022: https://www.vhba.vic.gov.au/designing-sustainability

Watts N, Amann M, Arnell N, Ayeb-Karlsson S, Belesova K, Boykoff M, … Montgomery H. (2019). The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. *Lancet*. 394(10211):1836–1878. https://doi.org/10.1016/S0140-6736(19)32596-6

Weisz U, Pichler PP, Jaccard IS, Haas W, Matej S, Bachner F, … Weisz H. (2020). Carbon emission trends and sustainability options in Austrian health care. *Resources, Conservation and Recycling*. 160: 104862. https://doi.org/10.1016/j.resconrec.2020.104862

WHO: World Health Organisation. (2015). Operational framework for building climate resilient health systems. WHO, Geneva, Switzerland. Accessed 8 June 2022: https://www.who.int/publications/i/item/9789241565073

Wilkinson AJK, Braggins R, Steinbach I and Smith J. (2019). Costs of switching to low global warming potential inhalers. An economic and carbon footprint analysis of NHS prescription data in England. *BMJ Open*. 9: e028763. https://doi.org/10.1136/bmjopen-2018-028763

Williams ML, Lott MC, Kitwiroon N, Dajnak D, Walton H, Holland M, … Beevers SD. (2020). The Lancet Countdown on health benefits from the UK Climate Change Act: a modelling study for Great Britain. *Lancet Planet Heath*. 2(5): e202-e213. https://doi.org/10.1016/s2542-5196(18)30067-6

Wu R. (2019). The carbon footprint of the Chinese health-care system: an environmentally extended input–output and structural path analysis study. *Lancet Planetary Health*. 3: e413-e19. https://doi.org/10.1016/S2542-5196(19)30192-5

Wynes S, Zhao J, and Donner SD. (2020). How well do people understand the climate impact of individual actions?. *Climatic Change*. 162: 1521-1534. https://link.springer.com/article/10.1007/s10584-020-02811-5

Zhi M, Ding EL, Theisen-Toupal J, Whelan J and Arnaout R. (2013). The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLOS One*. 8: e78962. https://doi.org/10.1371/journal.pone.0078962

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AHHA acknowledge the Aboriginal and Torres Strait Islander peoples as Australia's First Nation Peoples and the Traditional Custodians of this land. We respect their continued connection to land and sea, country, kin, and community. AHHA also pays our respect to their Elders past, present, and emerging as the custodians of knowledge and lore.