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A Review of Sustainable Healthcare

Policy, Practice, and Research with a Focus on Safety and Quality

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Preface

The Australian Commission on Safety and Quality in Health Care's (the Commission) role is to lead and coordinate national improvements in the safety and quality of health care. The Commission works in partnership with the Australian Government, state and territory governments and the private sector to achieve a safe and high-quality, sustainable health system. In doing so, the Commission also works closely with patients, carers, clinicians, managers, policymakers and healthcare organisations.

The Commission is responsible under the National Health Reform Act 2011 for the formulation of standards relating to health care safety and quality matters and for formulating and coordinating national models of accreditation for health service organisations.

The Commission developed the National Safety and Quality Health Service (NSQHS) Standards in consultation with the Australian Government, state and territory governments, technical experts and other stakeholders. The NSQHS Standards aim to protect the public from harm and to improve the quality of health service provision.

Continuous improvement is a cornerstone of the NSQHS Standards. The Commission is responsible for reviewing evidence and being informed of new or emerging issues which have the potential to compromise the safety and quality of health service delivery and patient outcomes. The Commission engaged the Climate and Health Alliance (CAHA) and Monash Sustainable Development Institute (MSDI) to conduct a review of existing policies and literature, to better understand the potential safety and quality implications and solutions facing health service organisations related to climate change and the associated extreme weather events and changing patterns of disease.

The report has been delivered in collaboration between CAHA and MSDI and provides a unique opportunity to better understand current action being taken across health service organisations and jurisdictions and the evidence base on both the risks facing health service organisations and the opportunities to ensure sustainable health care. The views expressed in this report are the result CAHA and MSDI's engagement with the healthcare sector, relevant jurisdictional agencies, and a literature review.

The purpose of this review is to provide background information, context, and relevant evidence to support an understanding of the safety and quality risks facing the healthcare sector. This will inform the development of a draft Sustainable Healthcare Module for public consultation.

A partnership between:

MONASH University | MONASH SUSTAINABLE DEVELOPMENT INSTITUTE | BehaviourWorks AUSTRALIA | CLIMATE AND HEALTH ALLIANCE | AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

A REVIEW OF SUSTAINABLE HEALTHCARE

POLICY, PRACTICE, AND RESEARCH WITH A FOCUS ON SAFETY AND QUALITY

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Executive Summary

Healthcare service providers across Australia are increasingly facing climate events and in response, need to dramatically scale up action in sustainability across the healthcare sector. It is increasingly urgent for healthcare services to harness mitigation, adaptation, and resilience strategies to meet the challenges of the future. The good news is that many opportunities exist to do this, and there are now many examples of practice, nationally and internationally for Australian providers to draw on. This review of sustainable healthcare policy, practice, and research serves as a background briefing to support the development of a sustainable healthcare module to guide health services seeking accreditation in Australia and guide its content and format.

The policy analysis demonstrates that internationally, the response to climate change is increasingly recognised as a healthcare priority. Various international programs now exist to strengthen collaboration on sustainable healthcare between jurisdictions and between health service organisations, allowing the sharing of resources and best practices. Countries such as the United Kingdom and the United States are making significant progress on implementing sustainable healthcare goals, even though currently there is a relative lack of standardised regulations or guidelines on sustainable healthcare in most countries. In Australia, sustainable healthcare policies and programs are now in place for most states and territories. However, many are at an early stage of implementation, and often have not yet been consistently incorporated at the level of individual health services. There are currently no policies that directly support sustainable healthcare at a federal level.

Based on the **institutional analysis**, a significant proportion of Australian health services are actively pursuing sustainable healthcare goals. Around a third of all Australian hospitals are part of the Global Green and Healthy Hospitals (GGHH) network and are actively working on a range of more than 10 sustainability goal areas, such as energy, waste, leadership, procurement, and others. Many health services now have sustainability plans or strategies in place, and increasingly monitor the progress and effectiveness of their sustainability efforts. There is a reported? lack of standardised processes and metrics for monitoring, and close to half (45%) of surveyed health care services were unsure about the implications of sustainability activities on safety and quality of care.

A **systematic rapid review of research** identified 37 studies, comprising 9 systematic reviews, 7 narrative reviews and 21 primary studies. The highest volume of evidence (15 out of 37 studies) pertained to life cycle assessment, waste and other audits and organisational readiness studies to support recommendations for sustainable healthcare interventions. These studies also reported on substantial carbon emissions and waste and energy reductions, including across the UK National Health Service (NHS), which is considered a global leader in sustainable healthcare. Empirical research also reports substantial (12 – 67%) reductions in operating room waste and reductions in carbon footprint through use of telehealth. Research has also quantified the potential impacts of efforts in energy reduction, food procurement and pharmaceutical practices such as extending shelf life and rational prescribing. This positions the Australian health system well to invest in evidence-based policies and practices, and to deliver safe and high-quality models of care that are environmentally sustainable. As previously reported and underlined by the example of the NHS, environmentally sustainable healthcare initiatives have their greatest impact at scale. In this context it is imperative to connect isolated efforts across health services and systems so that they can be co-ordinated and evaluated at jurisdictional and national levels.

Table 1: Summary of Australian practice and identified research evidence by GGHH area

GGHH Sustainability Area	INSTITUTIONAL ANALYSIS Percentage of survey respondents reporting activity & summary from 439 hospitals & 1687 health service providers in the GGHH network	DESKTOP RESEARCH REVIEW Number of studies identified in the review and summary
Leadership 	**55%** Many health districts and services have set organisational priorities to improve sustainability; capacity building for the health workforce is increasingly recognised as a leadership priority; some examples exist of new models of care that incorporate both environmental, social and financial costs in decision making.	**15 * (3 reviews, 12 primary studies)** High volume of evidence of life cycle assessment, waste and other audits and organisational readiness studies to support recommendations for sustainable healthcare interventions; evidence of substantial carbon emissions, waste and energy reductions including at scale (NHS).
Energy 	**77%** Energy is the sustainability area which is most commonly pursued by health care services. The deployment of on-site renewable energy, a switch to renewable energy providers, and the implementation of energy efficiency measures were most commonly observed.	**2 ** (1 review, 1 primary study)** Recommended energy reduction initiatives include improvements to energy efficiency in buildings, optimising thermostat settings, automating and using LED lights and reducing standby use. Lower-energy radiology imaging modalities are available for many conditions.
Chemicals 	**14%** A limited number of health care services are substituting harmful chemicals with safer alternatives. Existing initiatives include the replacement of certain anaesthetic agents, reducing the use of chemical cleaning agents, and audits for chemical products to identify potential alternatives.	No evidence was identified with a primary focus on this area
Waste 	**68%** The reduction, treatment, and safe disposal of healthcare waste is a relatively common area of action for health care services pursuing sustainability goals. Examples include the reduction of plastic and medical waste, and improved recycling and disposal.	**10 (7 reviews, 3 primary studies)** High volume of evidence identifying opportunities for waste reduction based on audits; evidence of substantial (12 – 67%) reductions in operating room waste; carbon footprint reduced over 80% converting to re-useable sharps disposal; changing anaesthetic gases to less volatile alternatives.
Water 	**23%** Examples of initiatives that have reduced water consumption in health care services include on-site recycling of water, the installation of water tanks, and various water saving measures. A notable example is the reuse of dialysis wastewater as grey water.	No evidence was identified with a primary focus on this area

GGHH Sustainability Area	INSTITUTIONAL ANALYSIS Percentage of survey respondents reporting activity & summary from 439 hospitals & 1687 health service providers in the GGHH network	DESKTOP RESEARCH REVIEW Number of studies identified in the review and summary
Transportation 	**36%** Various initiatives have emerged relatively recently to improve transportation strategies for patients and staff. Several health care services are phasing out petrol and diesel vehicles, transitioning to zero emission vehicles, and/or promoting more active modes of transport.	**4 (4 primary studies)** Environmental impact and modelling studies have quantified carbon footprints associated with transport. Studies show that telehealth can substantially reduce CO2e emissions
Food 	**23%** Examples exist of health care initiatives that purchase and serve sustainably grown, healthy food. New models are being trialled, such as a room service model to avoid food waste, the redistribution of unused food, and the creation of food gardens in hospitals.	**4 (3 reviews, 1 primary study)** Review-level evidence focuses on local procurement and reduction of food waste. Toolkits have shown some impact in reducing purchasing volumes. Waste audits demonstrate high potential for recycling and composting to reduce waste to landfill and carbon footprint.
Pharmaceuticals 	**9%** A limited number of health care services are exploring ways to safely manage and dispose of pharmaceuticals. Initiatives largely relate to pharmaceutical waste and improved disposal.	**2 (2 reviews)** Reviews recommend extending medication shelf life; adjusting package sizes; optimising stock management; rational prescribing; awareness raising and conscious ordering by patients. New generation propellants for inhalers show promise.
Buildings 	**55%** Many healthcare services support green and healthy hospital design and construction, both in the construction of new buildings and in redesigning existing facilities. Some examples of sustainable design standards for health care facilities exist.	No evidence was identified with a primary focus on this area
Purchasing 	**55%** The procurement of safer and more sustainable products and materials was highlighted as a priorityservices, with procurement strategies showing varying degrees of comprehensiveness and strictness. In some cases, efforts are underway to align sustainable purchasing and the model of care.	No evidence was identified with a primary focus on this area

* Includes health workforce education; sustainable models of care; and resilience strategies
** Includes emissions reduction initiatives

Rationale for use of the Global Green and Healthy Hospitals agenda to categorise findings

Various frameworks and guidance documents already exist to describe and categorise healthcare sustainability efforts. Some of the most widely adopted guidance has been developed by the World Health Organization, the National Health Service of the United Kingdom, and the international organisation Healthcare Without Harm.

For the purpose of this report, the summary table above, institutional analysis and literature review (parts 2 and 3 of the report) structure findings according to a set of ten healthcare sustainability categories used by the “Global Green and Healthy Hospitals network” (GGHH).

GGHH is an international network of hospitals, health care facilities, health systems, and health organisations dedicated to reducing their environmental footprint and promoting public and environmental health. The network is present in over 75 countries, including Australia and New Zealand. Australian health institutions are part of the Pacific regional network of GGHH - which was founded and is managed by the Climate and Health Alliance (CAHA). As of 2022, 108 Australian health institutions have joined this network, representing 439 hospitals and 1687 health service providers across the country. This represents around 33% of all Australian hospitals.

The GGHH network categorises healthcare sustainability efforts into ten “goal areas”: Leadership - Chemicals - Waste - Energy - Water - Transportation - Food - Pharmaceuticals - Buildings & Infrastructure - Procurement. In this report, some categories were expanded to accommodate sustainability practices that currently do not neatly fit in one of the ten goal areas, such as sustainable models of care and resilience strategies.

The ten GGHH sustainability areas were used in this report to present the results of the institutional analysis and literature review, as they provide a framing that is both practical and well understood by many healthcare institutions in Australia and internationally. This report does not make any assertions on whether this is the most appropriate or most comprehensive framework, and recognises a sustainable healthcare module could adopt a different set of categories, depending on sustainability needs and the diversity of existing sustainability efforts.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) concluded in 2022 that climate change is already harming human health and wellbeing in Australia and worldwide in various ways and is exacerbating existing health inequities.[1] The IPCC has identified the health sector as particularly vulnerable to climate risks. Their 2022 report highlighted the need for improved health protection measures to reduce people's vulnerability to climate-related health risks. Health service organisations across Australia are increasingly facing climate risks, while health service providers will need to harness mitigation, adaptation and resilience strategies to meet the challenges of the future.

Implementing sustainability within health services is important for protecting and promoting the health and wellbeing of current and future generations. Australia's health system contributes approximately 7% to the nation's CO2 emissions[2] - an emissions output equivalent to the whole of South Australia.[3] Australia's healthcare emissions compare with a global figure of 4.4%[4] with figures of 6% and 10% in the UK and USA respectively.[2] Health service organisations need to be prepared to manage increasingly extreme and frequent weather events and reduce the burden of disease which individuals and communities experience associated with climatic events. The formation and growth of the GGHH network demonstrates that building climate-resilient health services and recognising the opportunity to improve the health and wellbeing of the community through adaptation and mitigation measures is a growing priority for health services.[5]

This review of sustainable healthcare research, policy, and practice was developed in collaboration with the Australian Commission on Safety and Quality in Health Care (the Commission). It serves as a background briefing to support the development of a **sustainable healthcare module**. Some of the key functions of the Commission include the development of national safety and quality standards, and the development of clinical care standards to improve the implementation of evidence-based health care, among others. The Commission hopes to develop a sustainable healthcare module for consultation over the course of 2022-2023. It is envisaged that the module will consist of actions that can be implemented in any health service organisation across Australia on a voluntary basis, and that could be assessed as part of an organisation's routine accreditation, if the organisation so chooses. The module will rely upon the health service organisation's existing governance structures and complement other standards such as the NSQHS Standards.

A sustainable healthcare module would provide an opportunity to support health service organisations to: adapt their services and build climate-resilience to the effects of weather events, strengthen collaboration across the health system and consider opportunities and recommendations for improvement, use evidence-based practices and resources, and align with existing environmentally sustainable initiatives and innovations that are being implemented. Such a module would be harmonised with other national safety and quality standards, while recognising the need for health sector boards, management, clinicians, and other members of the workforce to lead on practices which improve the organisation's sustainability.

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5 Health Care Without Harm. 2021. Global Road Map for Health Care Decarbonization.

Policy Analysis: summary and findings

Summary

This section comprises a high-level review of the existing policy responses related to sustainable healthcare, in Australia and internationally. It maps existing government policies and programs that relate to the health system's response to climate change, and their relevance to sustainable healthcare. It also identifies trends, progress, gaps and opportunities to advance the safety and quality of health care in an environmentally sustainable manner. Our analysis draws on a semi-systematic review of policy literature, and interviews with policy makers and experts as key informants. It is intended to be exploratory and insightful, but not exhaustive. Further details about the study design and methods are provided in the Appendix.

Sustainable healthcare initiatives internationally

Policy analysis reveals that, internationally, the response to climate change is increasingly recognised as a healthcare priority. This is exemplified by a recent commitment by 50+ governments at COP26 in November 2021 to develop climate-resilient and sustainable healthcare, which has since been endorsed by the G7 in May 2022. Various international programs are strengthening collaboration on sustainable healthcare between jurisdictions and between health services, allowing the sharing of resources and best practices.

The United Kingdom is a notable example of a country that has made significant progress on implementing sustainable healthcare goals at a national level, with a conducive and coordinated approach to legislation, regulations, reporting, innovation and budgeting for sustainable healthcare. This analysis identified over 25 developed countries - including the United States and most European countries - which are currently "translating down" their national climate commitments to individual sectors, including the healthcare sector. There is currently still a relative lack of standardised regulations or guidelines on sustainable healthcare in most jurisdictions. However, efforts to translate these into standards for healthcare safety and quality are emerging. For example, the US Department of Health in 2022 is in the process of "identifying clear metrics for assessing greenhouse-gas emissions and resilience, with the goal of introducing them as measures of health system quality".

Sustainable healthcare policies in Australia

Policy analysis relating to sustainable healthcare in Australia reveals the increasing prioritisation of sustainable healthcare policies at the state and territory level, with a wide range of policies and programs directly supporting a transition to climate resilient and low carbon health systems. However, there is considerable variation in approaches across jurisdictions, and a current lack of specific sustainable healthcare programs at a federal level.

Sustainable healthcare policies and programs are now in place for the majority of states and territories, although many are at an early stage of implementation, and often have not been "translated down" to the level of individual health systems in each jurisdiction.

Commonwealth
At the level of the Commonwealth, relevant initiatives include the Australian Health Protection Principal Committee (AHPPC) which has identified climate change as a health protection priority, and the Healthy Environments and Lives (HEAL) research network funded by the National Health and Medical Research Council to strengthen the Australian health system's resilience, preparedness, and responsiveness to climate change.

Queensland
The Queensland government has adopted a suite of policies in support of sustainable healthcare. In 2021, Queensland Health released a Climate Risk Strategy 2021–2026 'to foster a climate ready and environmentally sustainable public health system', along with Climate Change Adaptation Planning Guidance to support hospitals and health services to undertake climate risk assessment and adaptation planning. It also adopted a health adaptation plan and established an office of hospital sustainability, which offers the opportunity to streamline healthcare sustainability activities throughout the state.

New South Wales
The government of New South Wales was the first Australian government to commit to the COP26 Health Programme in May 2022, an international partnership with over 50 national governments committed to developing climate resilient and sustainable health systems. This commitment complements the state's ongoing efforts to monitor emissions and establish climate risk assessments for healthcare, while ensuring continued "access to timely, high quality, patient-centred health care".

Australian Capital Territory
Healthcare sustainability goals have been closely aligned to the state's emissions reduction target in the ACT. The ACT government has committed to achieve net zero emissions for the public health sector by 2040, has established a healthcare decarbonisation roadmap and monitoring processes, and has a strong suite of policies in place that directly and indirectly support healthcare transformation in the territory.

Victoria
The Victorian Department of Health has established an extensive set of policies that align the healthcare sector with the state-wide Climate Change Strategy and net zero emissions target. Sustainable healthcare policies in Victoria include a health adaptation plan, an Environmental Sustainability Strategy for healthcare, and a wide range of stand-alone health sector emission reduction targets and programs. Well-established reporting mechanisms and sustainability guidelines help ensure safety and quality of care throughout the state.

Tasmania
The government of Tasmania was one of the first state governments to formally assess the impacts of climate change on healthcare, through a series of roundtable discussions in 2019. The state has limited reporting on any progress in implementing the roundtable's recommendations, and the currently there are no sustainable healthcare policies.

South Australia
The South Australian Department of Health has committed to assess SA's health service and policy needs with regards to healthcare sustainability, and to conduct a vulnerability assessment of its healthcare assets and programs. Several regional climate adaptation plans also prioritise healthcare sustainability, but there is currently only limited state-wide guidance.

Western Australia

The government of Western Australia held the world's first statutory Inquiry on the health impacts of climate change in 2019. This led to a set of recommendations and a 10-year plan to build climate resilience in WA's health system and ensure ongoing quality and safety of healthcare in the context of climate change. Various recommendations are being implemented, including the establishment of a Sustainable Development Unit in the Department of Health, and the establishment of a Community of Practice on climate and health.

Northern Territory

The Northern Territory Health department has established a climate change and health advisory committee to help advise on the climate risks the NT health sector is facing, and which might threaten safety and quality of care. NT's climate policies provide a supportive policy framework for action on sustainable healthcare, but there is currently only limited guidance on sustainable healthcare in the territory.

Institutional Analysis: summary and findings

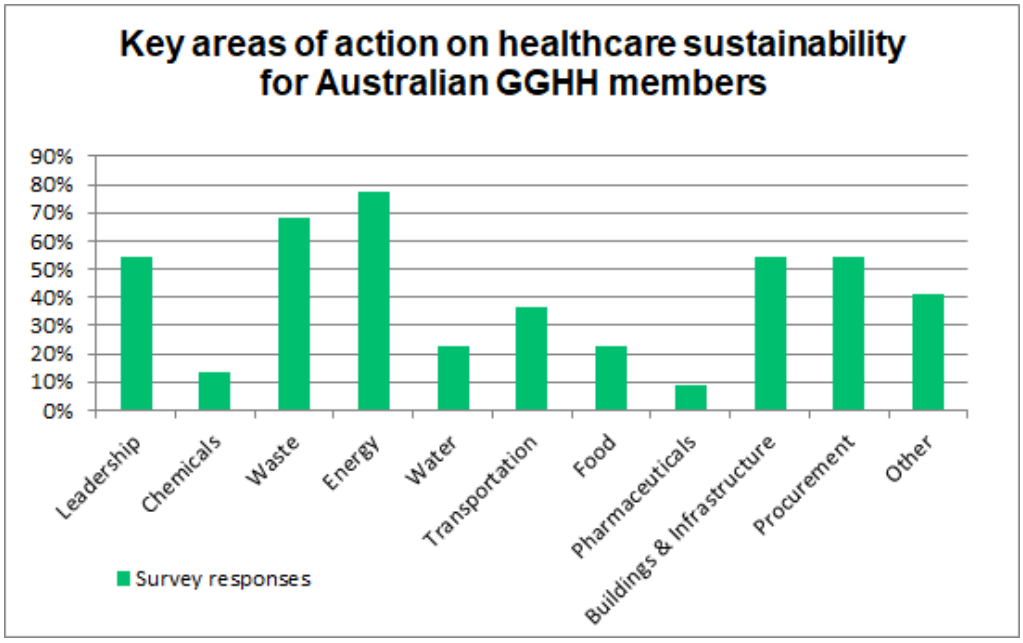
Summary

This section maps the existing standards, programs or initiatives that currently operate within Australia to improve health care sustainability. An institutional mapping exercise was used on the Pacific regional network of **Global Green and Healthy Hospitals** (GGHH). GGHH is a collaborative network of Australian and New Zealand health services that are committed to reducing their ecological footprint and promoting public and environmental health. The network was founded and is managed by the Climate and Health Alliance (CAHA).

As of 2022, 108 Australian health services have joined this network, representing **439 hospitals** and **1687 health service providers** across Australia. This represents around 33% of all Australian hospitals.

To be able to join the GGHH network, health services need to be active in at least two of the following 10 goal areas of sustainability: **Leadership - Chemicals - Waste - Energy - Water - Transportation - Food - Pharmaceuticals - Buildings & Infrastructure - Procurement**.

A survey conducted by CAHA of the GGHH Pacific network for ACSQHC indicates that all 10 action areas are being pursued by various Australian health services within the network (see figure). The large majority of GGHH members (81%) indicated they are actively working on more than one of the 10 sustainability goal areas, and many health services have comprehensive sustainability plans or strategies in place.



In addition to the 10 GGHH action areas, many health services are **measuring and reducing emissions**, building capacity within the **health workforce**, trialling **sustainable models of care**, and implementing activities to **build resilience** and adapt the health system.

The tables that follow highlight a selection of ongoing sustainable healthcare practices, across these various areas of sustainability. This overview is not comprehensive but is intended to highlight the scope and range of existing healthcare sustainability practices.

Effectiveness, safety and quality of sustainable healthcare

In response to survey questions, a slight majority (54%) of the respondents indicated that sustainable healthcare measures had a positive impact on the safety and quality of care, while 45% of respondents were unsure about the implications on safety and quality of care. Some of the responses from health services are included below.

Survey responses: How do your healthcare sustainability efforts influence the safety and quality of care?

"*Our healthcare sustainability efforts take into consideration impacts and implications of patient safety and quality of care*." - Epworth Healthcare

"Enhancing our environmental sustainability through reducing carbon emissions, curtailing waste, and managing resources efficiently, allows us to deliver better outcomes for patients, and provide broader social and economic benefits." - NT Health

"*Including sustainability in healthcare standards applied for accreditation purposes would assist in embedding sustainability into clinical care and raise the awareness of sustainability in health care*." - South Metropolitan Health Service

"*As GGHH Members we look for guidance on standards and regulations to support sustainability, safety and quality of care for our organisation*." - Tresillian Family Care Centres

"*Sustainability should be considered a domain of quality. We are in early discussions with our Safety and Quality team to discuss ways that sustainability can be embedded into existing safety and quality mechanisms*." - WA Department of Health

Survey responses of GGHH members indicated that at least two thirds (64%) of respondents monitor the progress and/or effectiveness of their sustainability efforts or have plans to do so in the near future. A third of respondents (36%) did not have monitoring in place or were unsure. Some of the responses from health services are included below.

Survey responses: How does your institution monitor, or otherwise measure the effectiveness, of your sustainability efforts?

"*We are actively measuring our emissions. We also have KPI's (key performance indicators) in place for 4 pillars of our Social and Environmental Responsibility Strategy: People; Community; Environment and Supply Chain."* - Ambulance Victoria

"*[We conduct] annual external auditing for our NABERS (National Australian Built Environment Rating System) rating and CitySwitch report. Our environment committee oversees implementation of [our] Environment Management Plan.*" - ANMF, Victoria Branch

"*We currently don't have an environment or sustainability officer and everything is still fairly new to the [sustainability] working group. We're hoping to engage auditors soon to get an idea of where we are currently and how to measure [progress]*." - West Wimmera Health Service

"*We have 25 key performance indicators that have been approved by the Executive and Board, and which align with the GGHH action areas.*" - Mater Health Services

Literature review: summary and findings

This rapid desktop literature review identified 37 studies, comprising 9 systematic reviews, 7 narrative reviews and 21 primary studies. Review quality was moderate overall. Literature was mapped to the ten areas of the Global Green and Healthy Hospitals (GGHH) network. Fifteen of the 37 studies focused on **leadership** in sustainable healthcare; 10 on **waste**; 4 on **food**; 4 on **transportation**; 2 on **pharmaceuticals** and 2 on **energy.**

The majority of included studies focused on life cycle assessments, audit and environmental impact activities; organisational readiness for sustainable practices; modelling; and recommendations arising from these activities. These are critical baseline strategies for meaningful sustainable healthcare action. Primary studies and reviews that did report on the success of sustainability interventions presented evidence of considerable benefit across individual services, regional and country-level efforts. The United Kingdom NHS presented two of the largest examples:

- Tennison (2021) reported a decrease in reduction of 26% of carbon emissions in 2019 compared to 1990 with decarbonisation of the energy system the key contributor. The reported per-capita 540kg CO2e (not including social care and public health) was approximately one third of Australia's (1,495 kg CO2e)
- Grimmond (2021) reported a before and after trial of converting from single-use to reusable sharps containers across 40 NHS hospitals, resulting in reduction of 3267.4 tonnes CO2 e (−83.9%); eliminating incineration of 900.8 tonnes of plastic and disposal/recycling of 132.5 tonnes of cardboard; and reducing container exchanges by 61.1%.

Other reported benefits of sustainability interventions included:

- a nurse-led sustainability initiative in a US regional hospital resulting in recycling of > 2,000,000 pounds of waste, which saved over $250,000 annually; and additional savings for **energy** efficiency of ($1.5m), renewable electricity ($120k) and single-use device reprocessing ($700k) (Stamps 2020)
- the review of Pradere (2022) outlined results of waste reduction initiatives in the setting of operating rooms, reporting on primary studies showing 12%, 50% and 67% reductions in solid waste; 59 – 75% less medical bag waste and 19% increase in recycling across various waste reduction programs
- Vacharathit (2022) reported on a physician-led waste reduction education program across 214 operating rooms. Projects undertaken within this program resulted in a 20% reduction in water waste; diversion of 1 million pounds of plastic from landfill and savings of $53,000 and 717 tons of CO2
- Two studies of telehealth reported reductions of CO2e of 8,754 kg of CO2e over one year in a preoperative evaluation centre (Wang 2021) and over 600 tonnes of CO2e saved through 2,000 teleconsultations (Whetten 2019).

Although empirical evidence pertaining to sustainable healthcare interventions was limited across the 37 included studies, the above examples provide compelling evidence that sustainable healthcare activities, particularly at scale, can result in a range of energy, waste and other benefits. More empirical research is required to further quantify these benefits.

Results

Study selection and quality (Appendix 2)

Following database searching and deduplication (see Appendix 2), a total of 3423 citations were identified. Following independent dual screening of titles and abstracts, 113 publications were reviewed in full text. A total of 37 studies met inclusion criteria. These comprised 9 systematic reviews, 7 narrative reviews and 21 primary studies. Six of the nine systematic reviews were of moderate to high methodological quality, fulfilling more than half of applicable quality criteria (Appendix 2). Four of the seven narrative reviews were also moderate to high quality, with the remaining three scoring half of applicable quality criteria. The overall body of review evidence is therefore moderate quality, and this should be factored into interpretation of the review-level evidence. The 21 primary studies were not evaluated for methodological quality as the study design was highly variable.

Summary by GGHH area

The following section describes the literature in relation to the 10 areas of the Global Green and Healthy Hospitals (GGHH) network. These are described in full in Appendix 3.

Leadership (3 reviews, 12 primary studies)

Fifteen of the 37 included studies focused on leadership in sustainable healthcare. However, it should be borne in mind that (i) the definition of "leadership" used in this review expanded on that outlined by GGHH by incorporating activities not covered by the other nine GGHH areas – specifically vulnerability assessments, carbon accounting / auditing and life cycle analysis and (ii) many articles with a focus on leadership also encompassed other GGHH categories, notably energy and waste.

Although the three review articles focusing on leadership collectively examined over 600 individual studies they presented little in the way of empirical research. Drew (2021) examined 44 studies of life cycle assessment (LCA) in surgical settings, presenting estimates of annual climate impact of operating suites of 3.2 – 5.2 million kg CO2 and identifying target areas to reduce this impact. However, results of intervention studies were not within scope, and the authors concluded that the evidence base did not cover most surgical services, procedures and products. Li (2021) presented an overview of 374 healthcare facility resilience studies at a thematic level, reporting climate change impact as one of four knowledge domains. Research in this area focused on resilience measures such as energy supply management and early warning systems to collect climate and morbidity information. Qin (2022) reviewed 220 studies on integrating climate change into surgical planning, presenting strategies pertaining to energy (equipment, consumables and anaesthetic gases); waste (anaesthetic gases); transportation (telemedicine); sustainable building design and leadership through education, sustainable performance indicators, monitoring climate change impact and reviewing institutional and national policies.

The 12 primary studies echoed many of the themes identified in the reviews, in particular a focus on quantifying sustainability impacts of healthcare rather than reporting on the effectiveness of strategies to enhance sustainability. The studies of Gordon (2021), Mann (2022), McAlister (2021), Prasad (2022), Rammelkamp (2021), Rizan (2021), Rizan (2022), and Vergunst (2020) were all focused on LCA or audit activities resulting in estimates of waste, carbon footprint or other parameters. Husain (2021) examined organisational factors that facilitate or inhibit NHS carbon reduction strategies, and Omer (2022) presented a methodology for analysing sustainability issues. Two of the 12 primary studies did report on outcomes of interventions:

- Tennison (2021) presented a comprehensive carbon footprint for the entire UK NHS, reporting a decrease in reduction of 26% of carbon emissions in 2019 compared to 1990 - a decrease of 64% in the emissions generated per inpatient finished admission episode. The predominant contributor to this reduction was the decarbonisation of the energy system. The per-capita 540kg CO2e (not including social care and public health) was approximately one third of Australia's (1,495 kg CO2e)
- Stamps (2020) reported that a nurse-led sustainability initiative in a US regional hospital resulted in recycling of > 2,000,000 pounds of waste, which saved over $250,000 annually; and additional savings for **energy** efficiency of $1.5m, renewable electricity $120k and single-use device reprocessing $700k

Waste (7 reviews, 3 primary studies)

Ten of the 37 included studies focused on waste, comprising three moderate to high quality systematic reviews; 1 low quality systematic review; 3 moderate to high quality narrative reviews and 3 primary studies. All of the systematic reviews except one focused on identifying opportunities for waste reduction, alongside potential initiatives in areas including energy, water, transportation and leadership. Similarly, the three narrative reviews focused on describing opportunities for reducing waste and energy rather than results of waste reduction efforts. Consequently, the reviews focused on making recommendations for action, with few references to empirical research.

- Only the review of Pradere (2022) outlined results of waste reduction initiatives in the setting of operating rooms, reporting on primary studies showing 12%, 50% and 67% reductions in solid waste; 59 – 75% less medical bag waste and 19% increase in recycling across various waste reduction programs.

The primary study of Ghersin (2020) was a waste audit of a 14-bed ICU which reported 76kg of unused medical waste collected over a three-week period, with the vast majority of items unopened. The other primary studies reported on results of waste reduction initiatives:

- Grimmond (2021) conducted a before and after trial of converting from single-use to reusable sharps containers across 40 NHS hospitals. The 40 trusts converting to RSC reduced their combined annual GWP by 3267.4 tonnes CO2 e (−83.9%); eliminated incineration of 900.8 tonnes of plastic; eliminated disposal/recycling of 132.5 tonnes of cardboard; and reduced container exchanges by 61.1%.
- Vacharathit (2022) reported on a physician-led waste reduction education program across 214 operating rooms. Projects undertaken within this program resulted in a 20% reduction in water waste; diversion of 1 million pounds of plastic from landfill and savings of $53,000 and 717 tons of CO2

Food (3 reviews, 1 primary study)

Three systematic reviews addressed food, with two being of higher quality. Collectively the reviews encompassed over 100 primary studies. The reviews collectively identified literature focusing on procurement, environmental impacts of food waste and leadership in establishment of sustainable food services. The review of Carino (2020) reported high awareness of local food and the impact of a toolkit in reducing meat purchasing by 10 – 20%. One primary study by Thiel (2021) audited food waste at a large New York city hospital, reporting annual generation of over 440,000 kg of waste, emitting almost 300,000 kg CO2e in its disposal. The authors estimated that recycling and composting could reduce waste to landfill from 85% to 55%, also reducing emissions by 64%.

Transportation (4 primary studies)

Two of the four transportation primary studies were non-interventional. Bowden (2021) conducted an environmental impact of a Welsh National dental program, reporting the program had an annual carbon footprint of 388 tonnes of CO2e. Chen (2020) modelled access to healthcare under various climate and water-level scenarios, demonstrating the

value of such assessments for addressing climate change risk. The other two studies presented results of transportation initiatives:

- Wang (2021) reported that a telehealth preoperative evaluation centre model reduced CO2e emissions by 8.09 kg (9.6%) per patient. This equated to 8,754 kg of CO2e emissions saved when extrapolated to one year of elective spinal surgeries
- Whetten (2019) also calculated emissions reductions from over 2,000 teleconsultations, reporting that this avoided over 475,000 miles of travel, reducing greenhouse emissions of over 600 tonnes of CO2e

Pharmaceuticals (2 reviews)

Both of the narrative reviews focused on quantifying potential gains associated with waste avoidance. Smale (2021) identified initiatives including extending medication shelf life; adjusting package sizes; optimising stock management; rational prescribing; awareness raising and conscious ordering by patients. Wilkinson (2021) reviewed low carbon alternatives to salbutamol metered dose inhalers in the UK, reporting that new-generation propellants have the potential to dramatically reduce carbon footprint. However, neither review focused on reporting actual gains from empirical studies.

Energy (1 review, 1 primary study)

Fathy (2021) conducted a narrative review of recommendations for sustainable outpatient healthcare, reporting energy initiatives including improvements to energy efficiency in buildings, optimising thermostat settings, automating and using LED lights and reducing standby use. Initiatives in purchasing, water, waste and chemicals were also presented. The primary study by Alshqaqeeq (2020) reviewed radiology criteria, showing that in 48% of patient conditions there are low-energy alternative imaging modalities that if used could save between $2 million and $25 million USD annually.

Policy Analysis: Tables

Table 2: Sustainable healthcare initiatives internationally

Geography	Policy or Program	Institution	Relevance to sustainable healthcare
Global	**COP26 Health Programme**	**World Health Organization**	A global partnership between the World Health Organization and over 50+ governments, who have committed at the COP26 UN climate conference to develop climate-resilient and sustainable healthcare. The partnership is supported by an "Innovation and Technical Support Platform", hosted by WHO and the UK National Health Service, to help coordinate and mainstream efforts across jurisdictions. In 2022, the health ministers of the G7 have endorsed and joined the initiative.
Global	**IANPHI roadmap for action on health and climate change**	**International Association of National Public Health Institutes**	The International Association of National Public Health Institutes (IANPHI), representing over 100 institutes, has set up a program to build the capacity of NPHIs' globally, improve coordination, and develop local and national climate and health programs. The G7 has endorsed the program.
Global	**Standards for Health Promoting Hospitals and Health Services**	**International Network of Health Promoting Hospitals and Health Services**	Set of guidelines around policy, practice, and evidence in order to create health promoting hospitals and health services. Sustainability has been mainstreamed across all standards, while standard 5, sub-standard 3, provides specific guidance on environmental health.
China	**Technical guidelines on climate change and health**	**China National Health Commission**	The National Health Commission of China and relevant departments have compiled technical guidelines related to climate change and public health, such as guidelines for health protection from air pollution and from "environmental health emergencies". The government has developed 12 health and epidemic prevention guidelines and programs, many of which take into account climate factors. The National Health Commission runs a series of research projects related to health risk assessment and adaptation to climate change, and has formulated technical guidelines for the health risk assessment of climate change.
Fiji	**National guidelines for climate resilient and environmentally sustainable health care facilities**	**Ministry of Health and Medical Services**	Fiji has developed national guidelines for sustainable healthcare, which was the result of a three-year project in partnership with WHO. This made Fiji the first country worldwide to apply WHO's Global Guidance for Climate Resilient and Environmentally Sustainable Health Care Facilities. Various other countries are implementing sustainable healthcare guidelines in partnership with WHO.
Germany	**Developing indicators for sustainable healthcare**	**German Alliance on Climate Change and Health (KLUG)**	Initiative to develop over 350 indicators for sustainable healthcare in Germany. Developed in collaboration with medical associations, health insurers, and several large hospital systems. The initiative is currently in dialogue with the German department of health.

Geography	Policy or Program	Institution	Relevance to sustainable healthcare
New Zealand	**Sustainable healthcare program**	**Health New Zealand**	Recent reforms in New Zealand's health system mean that the Ministry of Health will be focused on policy, strategy and regulation while a new body, Health New Zealand, will take over the planning and commissioning of services and the functions of the existing 20 District Health Boards. Health New Zealand's priorities will include carbon reduction in the health sector, as well as supporting it to adapt and prepare for the impacts of climate change.
United Kingdom	**Greener NHS**	**UK National Health Service**	The UK National Health Service is the largest single healthcare system in the world, and the first to commit to net zero emissions. It has adopted clear targets to achieve this goal, has set up a Sustainable Development Unit, and is implementing a wide variety of interventions in partnership with its regional trusts and local staff. Its commitments are set out in the "NHS Long Term Plan" and the "NHS Operational Planning and Contracting Guidance".
United Kingdom	**Environmentally Sustainable Healthcare programme**	**UK National Health Service**	E-learning platform for UK health professionals to provide the healthcare workforce with the knowledge and skills to deliver healthcare for financial, social and environmental sustainability.
United Kingdom	**High Quality and Low Carbon Asthma Care**	**Greener Practice**	Initiative developed by the UK's primary care sustainability network, Greener Practice, in partnership with the UK NHS, to help healthcare practices switch to a high-quality low carbon asthma care. Consists of a toolkit with step-by-step Quality Improvement (QI) projects.
United Kingdom	**Sustainability in Quality Improvement**	**Centre for Sustainable Healthcare**	Framework which is applied across the UK NHS to ensure sustainable quality care. The method assesses quality and value of care against its environmental, social and economic costs and impacts to determine its "sustainable value".
United States	**Developing sustainable healthcare metrics**	**Office of Climate Change and Health Equity, US Department of Health**	The Office of Climate Change and Health Equity (OCCHE) was established within the US Department of Health in 2021 to address the impact of climate change on the health of people. One of its current activities consists of "identifying clear metrics for assessing greenhouse-gas emissions and resilience, with the goal of introducing them as measures of health system quality".

Table 3: Sustainable healthcare policies in Australia

Commonwealth

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Sustainable Healthcare Module	**ACSQHC**	Development of a voluntary sustainable healthcare module for health services. Currently in the scoping and consultation phase. Will provide standardised guidance on enhancing the safety and quality of care through sustainable healthcare initiatives in Australia.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Long-term emissions reduction plan	**Commonwealth Government**	Australia's plan to reach net-zero emissions by 2050. The strategy includes a commitment for continued investment in local communities to have access to high quality healthcare and other services - including primary health, hospitals, aged care, disabilities, Aboriginal and Torres Strait Islander peoples' health and mental health.
National Climate Resilience and Adaptation Strategy	**Commonwealth Government**	National strategy (2021-2025) to anticipate, manage and adapt to our changing climate. The strategy recognises that climate change challenges the health and wellbeing of Australians and the capacity of its health and social support systems, now and in the future. However, it does not include specific healthcare resilience / adaptation objectives or activities.
National monitoring and evaluation framework for disaster recovery programs	**Commonwealth Government**	A framework to ensure that disaster recovery programs can be evaluated for their effectiveness. One of the goals of the framework is to ensure that community health needs are addressed and that community members have access to services and can meet health needs (including mental health) arising from the disasters.
Royal Commission into National Natural Disaster Arrangements	**Commonwealth Government**	The Royal Commission made the following relevant recommendations in 2020: • Recommends improved data and information frameworks, including on climate, health and impact data. • Highlights the impacts of natural disasters on essential services, and the risks to supply chains and critical infrastructure. • Recommends for the Australian, state and territory governments to identify a set of measures which enable access to healthcare and continuous access to medications during and following any natural disaster and incorporate these into relevant plans. • Recommends for the Australian government to develop consistent and compatible methods and metrics to measure health impacts related to natural disasters, including mental health, and take steps to ensure the appropriate sharing of health and mental health datasets.
Australian Health Protection Principal Committee (AHPPC)	**Department of Health**	Australia's key decision-making committee for health emergencies. It is composed of all state and territory Chief Health Officers. It has identified climate change as a health protection priority and tasked two of its committees to undertake relevant work: the Environmental Health Standing Committee (enHealth) and the National Health Emergency Standing Committee (NHEMS).
Healthier Environments and Lives (HEAL) Network	**Australian National University**	An NHMRC-funded initiative (2022-2027) creating a multidisciplinary, nationally focused, collaborative network of researchers on climate and health across Australia. The goal of HEAL is to strengthen the Australian health system's resilience, preparedness, and responsiveness to changing environmental conditions and extreme weather events. The implications of the HEAL research program for health policy and practice are still unclear at this stage.

National Preventive Health Strategy 2021 - 2030	**Department of Health**	The strategy highlights climate change and extreme weather events as important determinants of health and emphasises the need for preparedness at all levels. It calls for a comprehensive prevention monitoring and surveillance system, which should include information about wider, systemic factors that underpin health and wellbeing, including climate change. Commits to the development of a national environmental health strategy by 2030.
2020–25 National Health Reform Agreement (NHRA)	**Department of Health**	A national health reform programme that aims to improve health outcomes across all Australian jurisdictions. The reform does not have a direct focus on healthcare sustainability, but aims to: help deliver safe, high-quality care; prioritise prevention; drive best-practice and performance using data and research; and improve efficiency and ensure financial sustainability of healthcare.

Queensland

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Health Sector Emission Reduction Strategy 2020-2030	**Queensland Health**	Queensland Health has committed to a minimum of 30% emission reduction by 2030 below 2005 levels. This is in line with the state-wide target of net zero emissions by 2050. This target has been embedded in Queensland Health's climate risk strategy. The target aims to "foster a climate ready and resilient public health system which delivers safe and quality health services for all Queenslanders".
Healthcare emissions reporting and monitoring	**Queensland Health**	A baseline greenhouse emissions assessment was conducted for Queensland Health in 2018. A second Whole of Government agency emissions analysis is underway in 2022.
Queensland Health Emission Reduction Fund	**Queensland Health**	Queensland Health has established a 10-year $30 million rolling Emission Reduction Fund for energy conservation measures in existing health infrastructure.
Office of Hospital Sustainability	**Queensland Health**	Queensland Health established the Office of Hospital Sustainability in 2021 to assist Hospital and Health Services in building a low-carbon, resilient, and environmentally sustainable health sector.
Human Health and Wellbeing Climate Change Adaptation Plan	**Queensland Government**	Outlines 10 priority adaptation measures that provide a roadmap to support the health and wellbeing system in a changing climate. Aims to enable health sector stakeholders to work collaboratively, harness opportunities to protect the health and wellbeing of present and future generations and realise economic and social co-benefits through climate change adaptation and mitigation action. It has the overarching goal of building climate resilience in the health sector to ensure service quality and continuity, and to protect the health of the community from climate change impacts.
Climate Risk Strategy 2021-2026	**Queensland Health**	Requires each hospital and health service in the state to implement Climate Risk Action Plans and seeks to build resilience and capacity within the broader community to manage physical and mental health impacts caused by climate risks, and foster an ongoing, high-quality public health system that is resilient and adaptive to climate threats. As part of preparing Climate Risk Action Plans, health vulnerability assessments will be undertaken on the scale of regional Hospital and Health Services.
Climate Change Adaptation Planning Guidelines	**Queensland Health**	Guidance developed by Queensland Health, with the aim of supporting all parts of the health system to assess climate risks and create plans to manage those risks. The guidance aims to build the capacity of health stakeholders to understand and plan for how climate change might impact the sustainability of operations, human resources and infrastructure. It supports health stakeholders to identify climate change- related risks and incorporate them into existing risk management approaches.

Climate change adaptation guidance Almanac	**Queensland Health**	Almanac developed by Queensland Health, which provides a compendium of information to support the development of a Climate Change Risk Management Plan for hospitals and health services. Provides an overview of health risks and responses to address specific climate risks. To be used alongside the department's planning guidelines and templates.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**Queensland Government**	Queensland has adopted a state-wide target of net zero emissions by 2050. To achieve this, it has adopted an intermediary target of 30% emissions reduction below 2005 levels by 2030, as well as a 50% renewable energy target by 2030.
Disaster and Emergency Incident Plan	**Queensland Health**	Outlines the roles of responsibilities of Queensland Health arrangements in response to a disaster or emergency incident under the Queensland State Disaster Management Plan.
Aboriginal and Torres Strait Islander Environmental Health Plan	**Queensland Health**	Provides the overarching policy direction to guide the Health Department of Queensland in the long-term effort towards closing the health gap, with a focus on environmental health.
Aboriginal and Torres Strait Islander Cultural Capability Framework	**Queensland Health**	Framework for the period 2010 - 2033 that considers the specific needs of ATSI peoples in disaster management planning and aims to improve resilience and health outcomes of ATSI peoples across Queensland.
Heatwave Management Sub-Plan	**Queensland Health**	State plan to reduce the health impact of heatwaves on Queensland communities. It outlines arrangements for preparedness, response and recovery for heatwaves.

New South Wales

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
COP26 Health Programme	**NSW Health Ministry**	In joining the programme, NSW Health has committed to: • a climate change and health vulnerability and adaptation assessment by 2025; • a sustainable low carbon health system, with a commitment to halve emissions by 2030 and net zero emissions by 2050; and • a baseline carbon footprint (including supply chains) and a decarbonisation roadmap by 2025.
Healthcare emissions reporting and monitoring	**NSW Health**	A baseline carbon footprint exercise for NSW Health is planned for 2022. This would lay the foundation for a more regular monitoring process for healthcare sustainability.
Healthcare climate risk assessment	**NSW Health**	All NSW health districts are tasked to conduct a climate risk assessment in 2022, and report findings to NSW Health. NSW Health is guiding work to establish standardised metrics for measuring climate risks in healthcare, based on the 'Climate Risk Ready NSW Guide'. This has the overarching objective to ensure "access to timely, high quality, patient-centred health care".

Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**NSW Government**	The NSW government has committed to reduce emissions by 50 per cent on 2005 levels by 2030 and reach net zero emissions by 2050. This is supported by a net zero plan and climate change policy framework. The NSW government has expressed interest to incorporate this target down to a healthcare sector level.
Climate Change Policy Framework	**NSW Government**	State plan to achieve the long-term objectives of net-zero emissions by 2050 and resilience against a changing climate. Sets out a state policy direction to "Reduce climate change impacts on health and wellbeing" and supporting communities that are more vulnerable to the health impacts of climate change.
Regional adaptation plans	**NSW Government**	State program of regional climate vulnerability assessments and adaptation planning. Regional adaptation plans include a focus on health to varying degrees.
Climate Risk Ready NSW Guide	**NSW Government**	Practical guidance for the NSW Government sector to assess and manage climate change risks. Establishes a standardised risk assessment and management process and various tools. Currently being trialled by NSW health districts.
Internal Audit and Risk Management Policy	**NSW Treasury**	Policy that outlines how NSW government agencies are required to consider climate risks in their planning, operations and management of assets. Used alongside the NSW Asset Management Policy for the Public Sector. Both policies apply to 4 NSW health agencies.

Australian Capital Territory

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Health sector net zero emissions target	**ACT Government**	The ACT government has committed to achieve net zero emissions for the public health sector by 2040, while maintaining safety and quality of care.
Health sector emission reduction roadmap	**ACT Government**	ACT has established a roadmap to a zero emissions ACT Government health sector by 2040. The pathway provides governance and leadership guidance and will be reviewed every five years.
ACT Health Baseline Assessment of Emissions	**ACT Health Directorate**	The net zero emissions roadmap of the ACT Health directorate will be informed by an assessment of all current and planned public health facilities. This will allow for the establishment of a baseline and tracking of progress, which are crucial to ensure efficacy and continued safety and quality of care.
ACT Climate Change Adaptation Strategy	**ACT Government**	Outlines climate adaptation actions, including for the Community Health and Wellbeing Sector, such as implementing the Active Travel Strategy, reviewing workplace health and safety guidelines to ensure climate impacts on workers are addressed, and identifying heat refuges to provide relief during heat waves. The policy includes provisions for reviewing health and safety guidelines in the context of climate change, to ensure climate impacts on workers are addressed.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**ACT Government**	State-wide target to achieve net zero emissions by 2040. Has been translated down to the level of the (public) healthcare sector.
ACT Climate Change Strategy 2019-2025	**ACT Government**	Outlines strategies that focus on adaptation and mitigation, in order to secure a “a liveable and healthy future for our community”. The strategy includes monitoring of climate-related health impacts and costs and reducing strain on the health care system.
ACT Wellbeing Framework	**ACT Government**	A framework that identifies 12 factors that impact on the quality of life and wellbeing of Canberrans. The Environment and Climate is identified as one of these factors, for which a host of indicators are provided to measure community wellbeing.

Victoria

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Health sector emission reduction roadmap	**VIC Government**	The Victorian health department does not yet have a stand-alone net zero roadmap for the health sector. However, the state-wide net zero target includes several health sector targets: a target for hospitals and other public services to be 100% powered by renewables by 2025, a target for an entirely electrified car fleet by 2032, a regional Health Solar program of $13.5 million for the installation of solar panels in public health services, and a $40 million programme to improve energy efficiency in public hospitals.
Healthcare emissions reporting and monitoring	**VIC Health**	The Victorian Health service reports certain (but not all) types of emissions. Emissions reporting was improved from FY 2015/16 onwards for Scope 1 and 2. No emission assessment has taken place for supply chains. Victorian health services are required to monitor their emissions if they want to fulfil environmental sustainability requirements. An Environmental Data Management System provides a standardised platform for managing environmental and utility data. The Department of Health also provides policy and funding guidelines and templates for health services.
Environmental Sustainability Strategy 2018–2023	**Victorian Health and Human Services Building Authority**	Outlines the state department's commitment to improve the environmental performance of health system infrastructure and increase its resilience in the face of climate change. The strategy is supported by a strategic implementation plan and progress reporting mechanisms. The strategy builds on the 'carbon management principles' developed by the Victorian Environment Protection Authority (EPA). The strategy has direct implications on the healthcare sector's procurement, environmental planning and monitoring, energy, transport, waste and water.
Regional Health Solar program	**Victorian Health Building Authority**	A $13.5 million state program will install solar panels in public health services buildings across regional and rural Victoria. The goal is to install around 8.8 megawatt-peak of solar photovoltaic (PV) arrays across 79 Victorian health facilities.
Ambulance Victoria Climate Strategy	**Ambulance Victoria**	Ambulance Victoria has committed to a 39% reduction in its operational emissions by 2025, 60% by 2030, and net-zero emissions by 2045. They have also committed to source 100% of energy from renewable sources by 2025 and are implementing an adaptation plan to ensure the agency is climate-resilient. An example of a Victorian government health agency which has "translated" the state's sustainable healthcare policies into its governance and operations. Recognises social and environmental responsibility is directly linked to patient care.
Health and Human Services Climate Change Adaptation Action Plan 2022–2026	**VIC Health**	Health adaptation plan, focused on improving the system-wide capacity of the health sector to prepare for and respond to climate change. Plan with the overarching goal to ensure the health and human services system is resilient to climate change and ecologically sustainable, while reducing health vulnerabilities.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**VIC Government**	The state of Victoria has committed to a target of net zero emissions by 2050, with interim targets of 28-32% by 2025 and 45-50% by 2030. The net zero target is enshrined in Victoria's Climate Change Act (2017), while the roadmap to achieve this commitment is described in the "Whole of Victorian Government emissions reduction pledge".
Victoria's Climate Change Strategy	**VIC Government**	A policy roadmap to net-zero emissions and a climate resilient Victoria by 2050, with the goal to "improve community health and wellbeing due to less pollution".

Victorian Public Health and Wellbeing Plan 2019-2023	**VIC Health**	This plan prioritises action to tackle climate change and its impact on health through 1) assessing the health risks of climate change and the health co-benefits of reducing emissions, and 2) accelerating the implementation of healthy food/drink supply policies in communities and key public settings (including health services) and implementing initiatives and approaches to support healthier lifestyles.
Social procurement framework	**VIC Government**	Government framework which establishes requirements that apply to Victorian Government departments and agencies, including health, when procuring goods, services and construction. This includes guidance on achieving positive environmental outcomes. An estimated 2/3rds of the carbon footprint of Victoria's healthcare sector is related to the procurement of goods and services.

Tasmania

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Climate Health Roundtable	**Department of Health**	A 2019 roundtable by the Tasmanian government to identify additional policies and programs to build community resilience to population health risks in a changing climate. Recommendations from the roundtable include measures to develop a sustainable and climate-resilient health sector, including through the development of guidelines. It is unclear to what extent the recommendations of the 2019 roundtable have been implemented in 2022.
Climate and health risk assessment	**Department of Premier and Cabinet**	The Tasmanian Department of Premier and Cabinet has announced it has funded a risk assessment exercise across the state's healthcare sector, which would be a first step to identify and address healthcare risks and ensure safety and quality of care. It is unclear when findings will be made public.
Energy audits of health agencies	**Department of Premier and Cabinet**	The Tasmanian government has indicated it aims to improve the energy efficiency of health agencies (and other Tasmanian Government owned and leased buildings) through ongoing energy audits, cost effective capital upgrades and a behaviour change program.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**Department of Premier and Cabinet**	State-wide legally binding target of net zero emission by 2050, with a goal of reaching net-zero emissions by 2030. This has not yet been translated down to the healthcare sector.
Climate Change Action Plan	**Department of Premier and Cabinet**	Tasmania's latest climate change and action plan (Climate Action 21) concluded in 2021, and a new plan is currently in progress that will draw on themes and actions from Climate Action 21. Priority actions in the previous plan included the delivery of policies and programs to build community resilience to population health risks in a changing climate.
Healthy Tasmania Five-Year Strategic Plan 2022-2026	**Department of Health**	This plan includes a focus area on climate change and health, acknowledging the health impacts of climate change and the co-benefits of climate action on health and wellbeing. Strategies include supporting local food production and actions that improve water and air quality.
Our Healthcare Future	**Department of Health**	Program to reform Tasmania's healthcare system in the long-term. Limited focus on sustainable healthcare, but will likely have indirect effects on sustainability, resilience, and quality of care.

South Australia

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Health sector sustainability roadmap	**SA Government**	South Australia's Climate Action Plan 2021 - 2025 commits the state to develop a sustainability policy for healthcare. This is not yet developed, but is being considered by a Climate Change Focus Group in the SA Health Department.
Climate Change Action Plan 2021 – 2025	**SA Government**	State-wide adaptation plan, which includes a focus on enhancing climate change adaptation in emergency management and health services. The plan commits the SA Health department to conduct a vulnerability assessment of its assets and programs and enhance climate change adaptation in SA health services.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**SA Government**	South Australia has a state-wide goal of reducing greenhouse gas emissions by more than 50% by 2030 and achieving net zero emissions by 2050. This has not yet been translated down to the level of the healthcare sector.
Regional Adaptation Plans	**SA Government**	Various regional adaptation plans have prioritised health. SA Health supports local councils with public health planning, including consideration of climate change risk as a key public health issue. However, South Australia currently has no state-wide health adaptation plan.
Health and Wellbeing Strategy 2020–2025	**SA Health**	Recognises that climate change poses risks for the health system and acknowledges the need to reduce the carbon footprint of the health sector as well as respond to the health impacts of climate change.
State Public Health Plan 2019–2024	**SA Health**	Identifies protecting against public and environmental health risks and responding to climate change as a key priority.
Extreme Heat Strategy	**SA Health**	Outlines strategies to reduce the harmful effects of extreme heat on the health of the community by ensuring a planned, managed, and effective response to a heatwave, providing a coordinated SA Health communication plan, and promoting community resilience and adaptation to extreme heat conditions.

Western Australia

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Climate Health Inquiry	**Department of Health**	A 10-year plan to help adapt WA's health system to climate change and better protect the health of the community, and to support health services to reduce emissions and waste without compromising the quality of patient care. The Report also makes 10 recommendations to plan and respond to the health impacts of climate change, one being the establishment of a Sustainable Development Unit, which is underway.
Health Sustainable Development Unit	**Department of Health**	A Sustainable Development Unit (SDU) has been established in the Department of Health to promote sustainable development, reduce carbon emissions and energy costs, and improve health outcomes within the WA health system.
Climate health strategies	**WA Government**	The WA government has committed to implement "climate health strategies" and undertake reforms in areas that include policy and procurement to mitigate the health system's environmental footprint, as well as plan and implement adaptations to reduce health risks of climate change for WA communities. These are part of the state-wide 'WA Climate Change Policy', which aims to safeguard the health of WA communities.
Baseline Assessment of Health Sector Emissions	**Department of Health**	A baseline assessment for Scope 1 and 2 emissions in the healthcare sector is underway in 2022.
Climate and health Community of Practice	**Department of Health**	Participant members work across government and non-government organisations at the interface of climate and health. Regular meetings held every few months are focused on networking, collaboration, relationship building and thought leadership.
Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**WA Government**	The WA government has committed to achieve net zero emissions by 2050. This has not yet been translated down to the level of the healthcare sector.
WA Climate Change Policy	**WA Government**	Sets out the State Government's plan for a climate-resilient community and a prosperous low-carbon future. One of its key goals is to safeguard the health and resilience of WA's communities. It aims to accomplish this by implementing "Climate health strategies".
Climate Risk Framework	**WA Government**	The WA government is planning to develop a new climate risk framework to manage climate impacts for its assets and operations, minimising risks of service disruption and costs. It is unclear at this point what stage of development to framework is currently in, and whether or not it will include health.
Community Disaster Resilience Strategy	**WA State Emergency Management Committee**	The WA Community Disaster Resilience Strategy is being developed in 20222. The purpose of the strategy is to increase the capacity of communities to cope with and recover from the possible impacts of disaster risks and includes climate change and health risks.
State Hazard Plan Heatwave	**State Emergency Management Committee**	This plan describes arrangements for the management of heatwaves in WA, outlining risk reduction strategies, preparedness for, response to and initiation of recovery arrangements following the impact of a heatwave.

Northern Territory

Policies directly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
Climate and health advisory committee	**Department of Health**	The NT Health Department has appointed a climate change and health advisory committee. The committee will advise the department of health on the climate risks the NT health sector is facing.

Policies indirectly supporting sustainable healthcare		
Policy or Program	**Institution**	**Relevance to Sustainable Healthcare**
State-wide net zero emissions target	**NT Government**	The NT government has an aspirational target of reaching net zero emissions by 2050. This has not yet been translated down to the level of the healthcare sector.
NT Climate Change Response: Towards 2050	**NT Government**	Policy framework for NT to manage climate change risks to the territory. One of the key priorities of this plan is to support Territorians to respond and adapt to the impacts of climate change by identifying and prioritising risks to human health. It also commits to develop climate change risk adaptation and response frameworks.
Climate Change Health Advisory Group	**NT Department of Health**	Group of experts advising the department of health, providing oversight on human health impacts of climate change and appropriate responses.
Regional climate risk assessments	**NT Department of Climate Change and Energy Efficiency**	Some local NT government climate risk assessments also include health risks and measures (e.g., East Arnhem, Wagait).

Institutional Analysis: Tables

Table 4: Sustainable healthcare practices in Australia

Leadership

Institution	Activity
South Metropolitan Health Service	**Environmental sustainability framework** The South Metropolitan Health Service (SMHS) in Western Australia has established a comprehensive sustainability framework for all 10 GGHH action areas. Under the area of leadership, it includes the establishment of a Medical Lead for Climate Health and Environmental Sustainability, as well as clear accountability and finance provisions. (more info)
South Eastern Sydney Local Health District	**Developing an Environmental Sustainability Plan** A SESLHD Environmental Sustainability Plan 2019-21 was created. This plan included four areas; a sustainable organisation, people and places, green healthcare, high value sustainable models of care, with ten 'hotspots' to guide work. The plan was prepared to elevate sustainability work already underway and to align with key strategic initiatives. (more info)
Mater Health Services	**Voluntary environmental sustainability pledge** A voluntary environmental sustainability pledge was created to engage staff in environmentally sustainable behaviours related to energy, water, waste and transport. The pledge reached the target of 2,500 staff and is included in orientation for new employees. (more info)
Sunshine Coast Hospital and Health Service	**Environmental management strategy** Sunshine Coast Hospital and Health Service has an environmental sustainability strategy based on all 10 GGHH action areas, with a goal of being Australia's "*cleanest greenest Hospital and Health Service by 2030*". (more info)
Central and Eastern Sydney PHN	**Developing a climate change and health statement** The Central and Eastern Sydney Primary Health Network has developed an organisation-wide statement on climate and health, laying out priority actions for the network to decarbonise its operations and strengthen resilience. (more info)

Energy

Institution	Activity
Department of Health, Victoria	**Regional Health Solar Program** A $13.5 million initiative funded by the Victorian Government to install solar panels in regional and rural public health services across Victoria. The program has adopted an innovative 'cluster' sourcing approach to enable bulk procurement opportunities and deliver lower purchase costs. (more info)
Kooweerup Regional Health Service	**Renewables and resilience in the Kooweerup Regional Health Service** The Kooweerup Regional Health Service is implementing a sustainability strategy centred around energy. This includes the installation of solar panels, the application of reflective paint to buildings to reduce heat load in summer, staff awareness campaigns and partnerships with local agencies. (more info)
Mater Health Services	**Parking Lot Lighting** Fluorescent tubes were changed which negated the need to change light fittings and resulted in energy reduction and a two year return on investment. (more info)
UnitingCare Community and Blue Care	**Community Energy Efficiency Program** An external energy management firm was contracted to implement energy efficiency upgrades, including general electrical, heating, ventilation and air conditioning, management controls and water systems. Workshops were also delivered to staff to raise awareness on energy efficiency in the home and workplace. (more info)
Southern Cross Care	**Reducing energy costs and emissions through efficiency measures** Southern Cross Care, located across NSW & the ACT, implemented a set of electricity saving measures after performing an energy audit. This brought down electricity costs AUD$21,400 per annum and reduced emissions. (more info)

Chemicals

Institution	Activity
Western Health	**Reducing emissions from anaesthetic gases** Western Health has replaced the use of the anaesthetic agents from desflurane and nitrous oxide to sevoflurane and propofol, where clinically possible. This change has led to significant financial savings and a reduction in greenhouse gases, while delivering similar clinical effects. (more info)
Australian Nursing & Midwifery Federation	**Auditing chemicals used in medical practice** The Victorian branch of the Australian Nursing & Midwifery Federation has initiated an audit to identify chemicals on premises and screen them for health and environmental impacts. At the same time, safe alternative replacements are being explored. (more info)
Maldon Hospital	**Reducing chemical cleaning products**

	The Maldon hospital has significantly reduced its use of harsh chemical cleaners, and switched to the use of steam sterilisers instead. (more info)
Monash Health	**Cleaning without chemicals** Monash Health has trialled a cleaning method that was effective in reducing patient risk of acquiring multiple drug resistant organisms from hospital environments but was also more environmentally friendly and time-efficient. (more info)

Waste

Institution	Activity
Western Health	**PVC Recovery in Hospitals Program** A sustainability program first piloted at Western Health in 2009, to allow for the recycling of used PVC medical products into useful new products. This pioneering program has now been implemented in over 90 hospitals across Australia and New Zealand. (more info)
Royal Melbourne Hospital	**Reducing Waste from Operating Theatres** With much of the equipment used in operating theatres being disposable, the Royal Melbourne Hospital has successfully implemented a waste reduction program, improving recycling and shifting from clinical waste disposal to regular waste disposal, where safe to do so. (more info)
Uniting Care Queensland	**Minimising plastic straw use** The Wesley Hospital identified an opportunity to reduce straws and switch to paper alternatives. Under the new process, patients are only provided straws on request. This program has reduced waste to landfill and helped highlight other opportunities for avoiding waste. (more info)
Northern Health	**Diverting waste to specialised recycling** Northern Health has developed recycling practices for various specialised waste streams, including sharp medical tools, PVC, organics, batteries, fluorescent tubes, E-waste, wooden pallets, metal and polystyrene. (more info)
Mater Private Hospital	**Waste management Planning in a New Build** During construction of the new Mater Private Hospital, waste management was one of the goals of the project. This included minimising waste disposal costs, optimising responsible and compliant waste management, seeking waste avoidance opportunities and maximising recycling rates. (more info)

Water

Institution	Activity
Epworth Healthcare	**Reusing dialysis wastewater for local gardens and toilets** Water used for dialysis is being recycled for use in gardens and toilet flushing across the facilities of Epworth Healthcare. This simple intervention saved one million litres of water in just four months. (more info)

WA Country Health Service	**Incorporating water saving measures in building development** The WA Country Health Service is considering a series of water saving measures in the redevelopment efforts of several of its hospitals.
West Wimmera Health Service	**Recycling water in the healthcare facility** The West Wimmera Health Service is currently planning to install new water recycling systems on its facilities to help reduce hospital water consumption.
Australian Nursing & Midwifery Federation	**Onsite water tanks** The Victorian branch of the Australian Nursing & Midwifery Federation has installed onsite water tanks on most of its sites, to supply rainwater for toilet flushing and fire reserves. (more info)

Transportation

Institution	Activity
Alice Springs Hospital	**Promoting active transport to and from the hospital** The Alice Springs Hospital has expanded its bicycle parking, and staff are encouraged to travel actively to meetings or go for a ride during their lunch break using the fleet of Health House bicycles. At the same time, several charging stations for electric vehicles have also been installed in the hospital car park. (more info)
Uniting Care Queensland	**Phasing out petrol and diesel vehicles** UnitingCare has been transforming its passenger fleet to smaller and more eco-friendly vehicles, with the goal of transitioning to a 100% hybrid and electric fleet. (more info)
Mater Health Services	**Review of fuel use and carbon emissions** The majority of Mater's fleet vehicles have been swapped to lower emissions/fuel intensive vehicles. There was also a change to vehicle eligibility criteria for senior staff. This resulted in a reduction in vehicles, financial savings and larger proportion of fleet in the lower emission and more fuel efficient category. (more info)
Mater Health Services	**Developing a Transport Access Guide** With the aim to reduce scope 3 emissions (staff travel to/from work), Mater Health released a Transport Access Guide to encourage active transport by staff. (more info)
Ambulance Victoria	**Transitioning to zero emission vehicles** Ambulance Victoria has procured several hybrid vehicles, and is planning to transition its entire fleet to zero emission vehicles (ZEV). (more info)

Food

Institution	Activity
Mater Health Services	**Room service model** Mater Health Services was the first private hospital in Australia to implement the room service model. This change meant that patients can receive their meal orders within 45 minutes and are prepared fresh. The room service model resulted in an increase in patient satisfaction, decrease in plate waste, reduction in food costs, improvement in protein and energy intake and provided opportunity to offer seasonal produce. (more info)
Cairns and Hinterland Health Service	**Reuse of unopened oral nutrition supplements** Cairns and Hinterland Health Service have developed an internal protocol to collect, sanitise and re-serve oral nutrition supplements that had returned from patients' trays unopened.
Melbourne Health	**Redistribution of excess meals to the community** Excess hospital meals produced by the central production kitchen are collected by OzHarvest (food rescue organisation) and delivered to Northpoint Centre (provides emergency food relief to the community). This has resulted in a reduction of food sent to landfill and associated greenhouse gas emissions, as well as economic savings in landfill costs. (more info)
Queanbeyan Hospital and Health Service	**Redistribution of packaged foods and recycling organic food waste** Queanbeyan hospital partnered with GoTerra to collect organic food waste and send it to a commercial facility to produce soil conditioners. They also partnered with OzHarvest to redistribute packaged food items to the community. Both initiatives resulted in a reduction of food and plastic waste in landfill, reduction in CO2 emissions and production of livestock feed. (more info)
Princess Alexandra Hospital	**Kitchen garden** A food growing garden was established for patients to participate in and consume vegetables and herbs. (more info)

Pharmaceuticals

Institution	Activity
Western Health	**Developing a local sustainability action plan to limit pharmaceutical waste** After an initial audit identifying high levels of pharmaceutical waste going to landfill, a five year action plan was created. Brainstorming sessions were held to identify 21 action items to include in a Local Sustainability Plan. A green champion was appointed to coordinate the rollout of the actions. (more info)
Royal Melbourne Hospital	**Introducing Pharmasmart bins** The Royal Melbourne Hospital has introduced Pharmasmart bins across all its facilities to ensure pharmaceutical waste is safely disposed of and managed.

Australian Nursing & Midwifery Federation	**Introducing more sustainable waste disposal protocols** ANMF Victoria has worked with the Victorian Therapeutics Advisory Group (VicTAG) to develop a framework and several tools to support the development of appropriate hospital protocols for pharmaceutical waste disposal. (more info)

Buildings and infrastructure

Institution	Activity
ACT Health	**5-star health buildings in the ACT** The ACT Health Directorate, the Canberra Health Services, and the Calvary Public Hospital are electrifying all their health assets, to facilitate the uptake of renewable energy. The ACT Government has also committed to a 5-star rating for 'Critical Services Buildings'. (more info)
NT Health	**Preparing health infrastructure for EVs** Health services in Central Australia and the Barkly regions are redesigning their ambulatory care buildings, incorporating charging stations to accommodate a fleet of electric patient transport vehicles, including renal patient transport. (more info)
WA Country Health Service	**Building back better in the regions** The WA Country Health Service is actively engaging with contractors, including through workshops, to redevelop major regional facilities to be more sustainable while continuing to deliver high-quality care. (more info)
Epworth Healthcare	**A sustainable building upgrade** Epworth healthcare has expanded its clinical services with a new building, which was constructed with a focus on renewable energy and sustainable building practices. (more info)
Nepean Blue Mountains Local Health District	**Developing sustainable design standards for healthcare buildings** NBMLHD is working closely with NSW Health Infrastructure to agree on sustainable developments as part of a new Nepean Campus Stage 2 tower. Together, they have developed a sustainability minimum design standards brief. (more info)

Procurement

Institution	Activity
Ambulance Victoria	**Social and environmental procurement** Ambulance Victoria has developed a Social Procurement Framework to improve the social and environmental value of its purchasing decisions, with various indicators included in its procurement contracts. (more info)
Royal Melbourne Hospital	**Promoting sustainable business practices through procurement** The Royal Melbourne Hospital has a social procurement strategy which includes several environmental goals, and ensures procurement is in line with its 'climate change policy objectives'. (more info)
Peter MacCallum Cancer Centre	**Aligning providers with carbon neutrality goals**

	The Peter MacCallum Cancer Centre has set itself the goal to become carbon neutral across all of its services. To achieve this, it is conducting regular reviews of its energy and waste management practices and choosing providers who align with its carbon neutrality goal. (more info)
South Metropolitan Health Service	**Involving staff in sustainable procurement** After adopting a comprehensive Sustainability Framework, including on procurement, the SMHS now includes information about sustainable procurement and the service's environmental sustainability commitment in the induction information provided to all new staff. (more info)

Reducing Emissions

Institution	Activity
Ambulance Victoria	**Targeting 100% Renewable Energy by 2025** Plan to source 100% of energy requirements from renewable sources by 2025 for ambulance services across Victoria, as well as net-zero emissions by 2045 for all Scope 1 and Scope 2 emissions. (more info)
Mater Health Services	**Reducing emissions throughout the whole health system** The Mater Health group of hospitals and health centres has set the ambitious goal of reducing their emissions by 80% by 2030. To achieve this, it is implementing an ISO 50001 energy management system, retiring its coal-fired boilers, installing onsite solar, and trialling electric vehicles. It has developed 25 key performance indicators to track progress. (more info)
Hunter New England Local Health District	**Becoming carbon and waste neutral by 2030** The Hunter New England Local Health District has made a commitment to be carbon and waste neutral by 2030 (excluding clinical waste). It has set up an initiative to invest in renewables, rethink waste management, adopt sustainable water practices, transition to 'green' forms of transport, and support staff to be sustainability champions. (more info)
Northland District Health	**Keeping track of emissions reductions** The Northland District Health Board has set a goal to reach net zero emissions by 2050, and halve emissions by 2030. By the end of the 2021 financial year, the organisations' emissions were down by 21 percent compared with their 2016 baseline, thanks to the implementation of many initiatives. (more info)
South Metropolitan Health Service	**Monitoring the carbon footprint of healthcare** As part of its commitment to reduce its environmental impact, SMHS is currently completing a carbon impact assessment for all of its sites. This will allow it to set an emissions baseline and reduction target in the near future. (more info)

Health Workforce

Institution	Activity
Australian Nursing &	**Enabling sustainability among nurses and midwives** The Victorian Branch of the Australian Nursing & Midwifery Federation, representing over 83,000 nurses and midwives in Victoria, provides environmental education seminars to its members, and supports them to take practical sustainability ideas back to their workplaces. (more info)

Midwifery Federation	
South Western Sydney Local Health District	**Involving healthcare staff with sustainability action** The South Western Sydney Local Health District established a sustainability group in 2014. The group holds regular consultations and surveys of the institution's 12,000 staff members, in order to understand the workforce's attitude towards sustainability and co-create a sustainability plan. (more info)
Ambulance Victoria	**Climate & Health Literacy Course** Ambulance Victoria has developed a climate and health literacy course, which can be taken by all staff. (more info)
Northern Health	**Assessing awareness of environmental sustainability** As part of its sustainability planning, Northern Health regularly assesses the awareness of and sentiment towards environmental sustainability of its staff, and shares regular updates of its ongoing sustainability activities. (more info)
Monash Health	**Eco Champions** Monash Health has an Eco Champions Committee that meets regularly to explore, discuss, prioritise and implement sustainability efforts across the organisation. In 2019/2020, ten new Green Teams were formed and the Eco Champions group grew to over 110 representatives. (more info)
Australian Medical Students' Association	**Training medical students in green healthcare** AMSA has set up an initiative called 'Code Green', supporting medical students to learn about sustainability in a healthcare setting, and help them develop sustainability initiatives. (more info)

Sustainable models of care

Institution	Activity
Ambulance Victoria	**Assessing the "triple bottom line" of care** Ambulance Victoria regularly reviews its model of care through a 'triple bottom line analysis', which assesses the environmental, social, and financial costs of its actions. (more info)
WA Health	**Conducting a Sustainable Health Review** WA Health is establishing a comprehensive reform of the WA health system over the next decade through the process of a sustainable health review. The review has identified 8 strategies and 30 recommendations to drive a cultural shift in healthcare, from a predominantly reactive, acute, hospital-based system to one with a strong focus on prevention, equity, sustainability, and access to services. (more info)
Wiser Healthcare - Carbon Neutral	**Developing the evidence base for safely decarbonising healthcare** Wiser Healthcare is a research collaboration seeking to reduce overdiagnosis and overtreatment in Australia and around the world. The Wiser Healthcare Carbon Neutral initiative seeks to build the evidence base for reducing emissions by avoiding or reducing unnecessary or low value care. (more info)

Resilience

Institution	Activity
Ambulance Victoria	**Climate Adaptation Action Plan (CAAP)** Extensive health adaptation plan, including • a review of climate change's likely impact on insurance (1.8) • a review of overall impacts of climate change to regions (2.4) • Identifying climate change risks within health supply chains (2.9) • Review of capacity and capability of First and Co-Responders in light of climate change impacts, such as skills, capability, specialist areas (2.12) • The implementation of health and wellbeing climate prevention strategies, e.g. to heat, hydration, exposure (4.4) (more info)
Kooweerup Regional Health service	**Preparedness of health services for extreme events** The district nursing team of the Kooweerup Regional Health Service has implemented a comprehensive Client Risk Assessment initiative and a Severe Weather Register, in order to guide and support staff and patients in case of extreme weather events such as extreme heat, bush-fire alerts, and flood warnings. (more info)
Nepean Blue Mountains Local Health District	**Developing Climate Resilient Healthcare** The Nepean Blue Mountains Local Health District is developing plans to review, understand and adapt to the immediate and long-term impacts of climate change, while continuing to deliver quality care. It has set up a working group and is utilising a 'Prioritisation Matrix Tool' to determine priority actions. (more info)
Uniting Care Queensland	**Reducing the health risks from extreme heat** Uniting Care is implementing two pilot projects, in partnership with the Queensland Government, to prevent or reduce the impact of extreme heat on vulnerable older people, through 'green' infrastructure and community outreach. (more info)
ACT Health Directorate	**Planning for climate-resilient health infrastructure** The ACTHD has developed the Canberra Hospital Master Plan, which is a staged approach to improving aged assets as well as upgrading them to be more climate resilient. (more info)

Literature review: Tables

Table 5: Review-level studies ordered by GGHH categories (n = 17)

Leadership

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Systematic reviews (n = 2)		
Drew (2021) 10 / 13 44 studies 15 May 2020	Summarize the state of life cycle assessment (LCA) practice in surgical and anesthetic care	• Operating suites have an annual climate impact of 3.2 – 5.2 million kg CO2 • Anesthetic gases; single-use equipment; and heating, ventilation, and air conditioning system operation were the main emissions hot spots • Extant studies address a miniscule fraction of the numerous services, procedures, and products available today
Li (2021) 5 / 11 374 articles 2020	Detect the status quo and future trends of healthcare facility resilience (HFR) research systematically from 2000 to 2020 using thematic and scientometric analyses	• **Leadership:** the detected seven co-citation clusters were grouped into four knowledge domains: **climate change impact**, strengthening resilience in response to war and epidemic, resilience assessment of healthcare facility, and the applications of information system • *Climate change impact:* With the frequent threat of global climate change, the term "resilience is increasingly discussed in healthcare facilities' operation areas. A series of resilience measures to climate change adaptation are studied in recent years, including enhanced energy supply management, establishing early warning systems to collect climate and morbidity information, ensuring environmental sustainability of healthcare facilities • Monitoring the risks of public health and the loopholes of the healthcare systems are essential for the healthcare facilities' disaster prevention. • The operational healthcare facility and its emergency management heavily depend on external lifeline services, internal equipment systems, healthcare organizations, and social units. • Tightly linking the recovery and learning experience to preparedness is crucial although often neglected once the function is recovered.
Narrative reviews (n = 1)		

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Qin (2022) 11 / 12 220 studies April 2021	Review literature (including LMIC) and generate evidence-based, policy-oriented recommendations for integrating climate change into national surgical planning in the Western-Pacific region	• **Infrastructure / energy:** addressing the main sources of GHG emissions - equipment and consumables, inhaled anaesthetic agents and energy use – can reduce the carbon footprint of operating rooms by 80 - 95% e.g., maximise equipment lifespan, limit single-use devices, energy efficient building design • **Waste:** reduce volatile gases (desflurane – disproportionate use contributes 80% to GHG emissions in HIC), low gas flow • **Transportation:** telemedicine • **Leadership:** Educating surgical, obstetric and anaesthesia care providers on sustainable practices; advocacy by these groups; Making sustainability a surgical system performance indicator; Conducting LCA of surgical procedures in diverse settings across the region; Reviewing institutional and national policies and regulations to facilitate sustainability; Linking meteorological and surgical data to monitor the impact of climate change on surgical disease burden and outcomes; Mobilising climate change adaptation and disaster risk reduction funds for surgical system strengthening • **Purchasing:** Performing long-term financial and environmental cost-effectiveness analysis to guide decision-making; Environmentally preferable purchasing • **Building:** sustainable design

Waste

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Systematic reviews (n = 4)		
Pradere (2022) 8 / 11 38 studies 09 Dec 2020	Perform a systematic review of the available actions that could limit CO2 emission in the operating room (OR) and their potential benefits upon the environment, whilst preserving quality of care	• **Waste:** Reducing waste production (evidence of reduction in solid waste by 12%, 59% - 75% less medical bag waste, 19% increase in recycling, 50% decreased annual waste) improving segregation, reuse • **Energy:** Reduce heating, ventilation and air conditioning; use clean energy • **Leadership:** Surveys of attitudes and beliefs (overall high willingness); Measurement of emissions (e.g., single use laryngoscope 16 – 18 x CO2 than re-useable with steel handle); Further multidisciplinary consensus is needed to provide quality endpoints to use in this setting
Martin (2021) 6 / 11 129 studies 31 Apr 2021	Provide an effective baseline of data that will consider the drivers, opportunities and recommendations for the implementation of sustainable practice in general dental practice	• **Waste:** Reuse equipment and devices e.g., dental burs; recycle; waste separation e.g., separating • **Transportation:** dentistry contributes more to travel emissions than other professions sue to repeated visits over time. Reducing oral disease e.g., through preventive fluoride treatment can ultimately reduce travel; public education is also required to consider greener modes of travel; bulk purchases • **Energy:** Renewable energy, energy-efficient appliances (LED lights, sensor lights; turn off standby • **Water:** low flow devices, dry rather than wet vacuum pumps; maintaining hardware • **Leadership:** Education is key to an increase of professional awareness; The use of best practice guidelines through the adoption of technology, effective logistical management systems and environmental regulations are key to a more sustainable practice; Professional engagement with policy making at all levels, from a domestic in-practice level to regional, national or international is essential for the formulation and promotion of best-practice guidelines.
Taghilou (2021) 6 / 11 96 studies 24 Oct 2020	Evaluate the toxic emissions from medical waste incineration and the inorganic components in ambient air and ash	• Emissions levels depend on many factors like the composition of the feeding, waste type, incinerator type. For example, emissions of Medical Waste Incinerators (MWIs) rise sharply with a decrease in temperature, increase in oxygen levels and chlorine content in waste, and the absence or weak function of air pollution control systems • Reducing medical waste at the source and recycling the medical PVC plastics to reduce emissions in the waste combustion process is recommended. • Using high-efficiency pollution control systems in medical incinerators to protect public health is vital. Phasing out ‘old fashioned’ medical incinerators and stronger enforcement of regulations were identified as important strategies

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Andeobu (2022) 3 / 11 142 studies 2021	Identify the problems/challenges relating to the management of medical waste from COVID-19 and recommend safe and sustainable short- and long-term solutions for managing medical waste from COVID-19 to significantly reduce transmission and environmental impacts	• **Waste:** The following medical waste management needs have been identified: (a) improve consistency in medical waste definitions in various jurisdictions; (b) develop national medical waste management procedures, guidelines, and regulations; (c) synchronise and streamline established technologies for the treatment of medical waste at the national level; (d) create a harmonized system for the supervision and monitoring of healthcare sector; and (e) improvement and innovation in the healthcare sector in response to future pandemics • **Leadership:** Re-evaluation of the existing policies and regulations should be undertaken to appraise respective responses to COVID-19 waste management to better respond to similar future pandemics and clarify the actions that need to be taken; Ongoing assessment of current medical waste systems is recommended to identify the capacities and gaps in respective states and territories and increase the usage of recommended treatment technologies towards maximum capacity; Public awareness and continuous training of medical staff and municipal employees on the positive impact of the appropriate management of hazardous or infectious medical waste should be enhanced.
Narrative reviews (n = 3)		
Wu (2021) 11 / 12 78 articles n/s	To review strategies to reduce medical waste from the operating room (OR)	• **Waste**: recycling (20-25% of OR waste can be recycled), reusing and repurposing; waste segregation; minimising unnecessary devices and packaging; Choosing anaesthetic gases based on environmental footprints (avoiding N2O and desflurane), low flow anaesthesia; use regional or total intravenous anaesthesia; donating medical equipment • **Leadership:** formation of an OR committee or a hospital green team; choosing different surgical venues e.g. outpatient / clinic location reducing overnight stays • **Energy:** power-down idle ORs (ORs are unoccupied 40% of the time); LED lights (49% less energy) • **Water:** alcohol-based hand rub (can save 2.7 million litres in handwashing); motion sensors
Ma (2022) 8 / 12 n articles n/s search date n/s	Suggest changes that can be made in hand surgery for a more sustainable practice	• **Waste:** “Reduce, Reuse, Recycle, Research, Rethink and Culture” framework; cutting down oversupply of materials; adopting protocols to perform cases in ambulatory settings; use regional or total intravenous anaesthesia; reuse / repurpose drapes, gowns and other materials; multiple surgeries in one room; recycling; donating medical equipment (using WHO guidelines); charts showing carbon footprint of materials • **Energy:** Temperature regulation; power-down when not in use; replacing lighting • **Leadership:** Quantify carbon footprint; life-cycle assessments • **Purchasing:** Work with vendors that produce sustainable materials • **Transportation:** Telemedicine; consider the need for conference travel vs ‘virtual’ meetings

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Agrawal (2021) 6 / 12 n articles n/s search date n/s	To review economic, environmental and social sustainability of single use (disposable) endoscopes	Key points in evaluating the sustainability of endoscopes: • recyclability is restricted to small metal portions of single-use endoscopes – 'recycling programs' burn all other parts; • eliminating all possible endoscopy-associated infections may not be feasible or necessary; cost estimates of reprocessing and infections should involve examining assumptions • re-useable endoscope overseas manufacturing/assembly/transport may offset benefits of recycling; poor and disadvantaged communities are therefore disproportionately burdened and do not reap benefits

Food

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Systematic reviews (n = 3)		
Alberdi (2021) 8 / 11 26 studies Dec 2019	Identify the nature and extent of the evidence found in the literature on the processes related to food procurement within healthcare systems and analyse them from the perspective of sustainability dimensions	• Multilevel governance, a sustainable food supply system, and healthy and sustainable food services were highlighted as main action areas for a sustainable food procurement strategy (SFPS). • Health organizations must overcome obstacles related to the balance between supply and demand, capacity for the participation of small farmers and the investment commitment, lack of skills, and the long-term vision of managers. • SFPS will allow the development of local and sustainable food supply and food services within the health services as well as the integral care of health through sustainable diets
Carino (2020) 9 / 13 80 studies 28 Nov, 2018	Identify and synthesize environmental / economic impacts of foodservice; environmental food service sustainability strategies; perspectives of patients, staff, and stakeholders	• **Food / Waste:** The environmental impact most widely explored was food waste, with many studies reporting on food waste quantities, and associated economic losses; Strategies focused on reducing food waste by increasing patients' intake (for example different preparation) • **Leadership:** Perspectives identified a shared vision for sustainable foodservices, although there are many practical barriers to achieving this (e.g., procurement / contract challenges, • **Purchasing:** Local food procurement (57% - 77% awareness of local food); sustainable meat procurement (10 – 20% reduction in meat procurement)

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Stephens (2021) 5 / 11 17 studies 31 May, 2021	Understand the alignment between high-level sustainability reports and guidance that influence food procurement and foodservice practice in Australian healthcare and aged care sectors, and the opportunities for research and training for these workforces	• **Purchasing:** Implementation of healthy and sustainable food procurement and food services were limited by staff knowledge and self-efficacy, and unsupportive management. Further intervention and monitoring of healthy and sustainable food procurement and foodservice practices is needed. • **Waste:** reduction of food waste, establishment of community garden, use of reusable crockery, cutlery and containers • **Leadership:** establishment of sustainability committee, accountability e.g., environmental performance data; There is an urgent need to resolve the existing gap between recommendations to adopt environmentally sustainable practices and staff training across these sectors.

Pharmaceuticals

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Narrative reviews (n = 2)		
Smale (2021) 11 / 12 June 2020	To scope how stakeholders can prevent the waste of potentially viable medication.	• **Manufacturers:** extending medication shelf-life; sustainable storage conditions; adjusting package sizes (EpiPens are potent up to 50 months after expiration date; up to $1.8 billion of anticancer medication was wasted in 2016 in the United States due to dose not matching vial size) • **Distributors:** optimise stock management; reduce minimal shelf life (e.g., Netherlands, 4500 packages of generic medication are disposed by warehouses; can be reduced by 39% by altering shelf-life criterium from 12 to 9 months) • **Prescribers:** rational prescribing practices (quantities and durations – over 3 months leads to unnecessary medication waste) • **Pharmacists:** stock management, efficient preparation / dispensing; redispense unused medication • **Patients:** conscious medication-ordering; participation in waste-minimising interventions • **Health authorities:** Creating awareness and enforcing waste-minimising measures

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Wilkinson (2021) 6 / 12 n articles n/s search date n/s	A review of low carbon footprint alternatives to salbutamol metered dose inhalers (MDI) in the UK	• **Waste:** Reduce overuse of salbutamol; provide environmental data to patients; collaborating with patients to improve asthma conditions and reduce carbon footprint e.g., by using a dry powder inhaler (DPI) instead of a metered dose inhaler (MDI); avoid disposing medications with unused doses; consider recycling • **Pharmaceuticals:** HFC propellants have much higher carbon footprint than other inhalers like dry-powder inhaler (DPI) and soft mist inhalers (SMI). Brands of MDI with HFC-227ea have 3x carbon footprint than brands that use HFC-134a. DPI and SMI carbon footprint is much lower at 200-920 gm/inhaler • **Chemicals:** Novel propellants are also expected to reduce carbon footprint by approximately the year 2025: e.g., the HFA152A inhaler would have a 10-fold lower carbon footprint than current HFC 134a MDI

n/s – not stated

Energy

Author (Year) Quality score N studies Search date	Review Aim	Key findings / conclusions
Narrative reviews (n = 1)		
Fathy (2021) 6 / 12 n articles n/s search date n/s	To review the existing recommendations for mitigating healthcare's contribution to climate-change in outpatient settings	• **Energy:** Calibrate, improve, or replace energy-inefficient building systems and appliances with greener alternatives; optimise thermostat function - set office thermostats to 74F (23 C) in the summer and 68F (20 C) in the winter - and minimise operation; automate lights and use LED / compact florescent; turn off water heating when not in use; reduce standby energy use; purchase renewable energy; install solar panels • **Purchasing:** Use 100% recycled paper; Purchase products with less packaging that are free of harmful components, such as latex, polyvinyl chloride, and di-ethylhexyl phthalate. • **Water:** Replace washroom toilets and taps with alternatives that use less water; replace disposable Styrofoam cups with biodegradable or recyclable cups • **Waste:** Clearly indicate which materials are considered medical waste according to the Occupational Safety and Hazard Administration's bloodborne pathogens standard; • **Chemicals:** Replace toxic cleaning products with nontoxic alternatives.

n/s – not stated

Table 6: Primary studies ordered by GGHH categories (n=21)

Leadership (12 studies)

Author (Year) N participants Study type	Aim	Key findings / conclusions
Gordon (2021) Life-cycle analysis of biopsy	Apply life cycle assessment to quantify greenhouse gases (GHGs) associated with processing a gastrointestinal biopsy in order to identify emissions hotspots and guide mitigation strategies	• **Leadership:** Scenario 1 (1 specimen jar) generated 0.29 kg of CO2 equivalent; Scenario 2 (3 jars) generated 0.79 kg • Emissions from biopsy processing in the US are equivalent to yearly GHG emissions from 1,200 passenger cars. • Opportunities to reduce pathology laboratory emissions include efficient use of biopsy jars, thoughtful prescribing of biopsy procedures, and green purchasing practices for equipment and supplies • Health care delivery produces significant environmental emissions that adversely affect human health; processes affecting these emissions must be detailed to devise mitigation strategies
Husain (2021) 10 stakeholders representing an NHS trust serving > 2 million patients Cross-sectional	Evaluate the extent to which organisational factors facilitate or inhibit the implementation of the National Health Service (NHS) carbon reduction strategy within acute hospital settings	• Organisational factors, particularly Board leadership and internal implementation pathways, have a significant bearing on whether carbon reduction measures (CRM) are implemented or not. • How NHS organisations can, or should, introduce renewable energy remains in question with many currently constrained by long--term energy contracts before alternative arrangements can be considered. • CRM which was perceived to possess greater co--benefits were more likely to be implemented.
Mann (2022) Sustainability review of a dermatology department	Identify opportunities to reduce paper usage and introduce recyclable products within the dermatology department	• **Leadership / Waste:** A quality improvement project (QIP) involving the reintroduction of recycling bins to the minor operation procedure room identified that an estimated 16% of non-sharps surgical wastes could be recycled. • Another QIP found multiple identical copies of academic journals deposited in the departmental library due to staff subscribing to the same professional bodies • Environmentally conscious publishers are shifting towards online-only issues, which will reduce the carbon footprint.

Author (Year) N participants Study type	Aim	Key findings / conclusions
McAlister (2021) Life cycle analysis of pathology testing in two 400-bed public hospitals	Develop a life cycle assessment model of six commonly used pathology tests within a hospital setting: Full blood examination (FBE); Coagulation profile (APPT or INR); Urea plus electrolytes (U+E); C-reactive protein (C-Rp); Arterial blood gas (ABG); and Urinalysis	• Impact of a single blood test given in a hospital range from 74 g CO2e through to 274 g CO2e, whilst for a urinalysis in a hospital the impact is greater at 538 g CO2e. • The major source of impacts was the collection tubes and jars, and the electricity use of the analysers • Globally, tens of billions of pathology tests are performed annually, with each individual test having a low environmental impact however, not all are necessary. • Reducing unnecessary testing will reduce environmental and economic impacts and potential adverse health outcomes. • Increasing laboratory utilisation (efficiency) can lead to better environmental (and financial) outcomes.
Omer (2022) Methodology and application of sustainability audit	Propose a methodology for analysing and addressing consumption related sustainability issues in organisations and demonstrate application of the proposed methodology in the context of a large healthcare organisation	• The proposed methodology for conducting a pro-environmental organisational change project involves five key elements: detailed analysis of context; outlining a theoretical framework; establishing project boundaries; acknowledging connectivity of practices; and choosing data collection methods • The methodology allows researchers and managers to understand workplace consumption issues from several perspectives and identify the best angle from which to approach potential resolutions. • The methodology was tested in an NHS hospital trust employing 5000 people and serving a community of 600k. Opportunities identified included changes to **electricity use**, reducing use of everyday consumables and **waste** (especially clinical waste)
Prasad (2022) 49- bed acute care unit (14,427 hospitalisation days) and a 12-bed ICU (2, 536 hospitalisation days)	Quantify solid waste and greenhouse gas emissions (GHGs) per bed-day in a regular inpatient (low intensity) and intensive care unit (high intensity)	• An acute care unit generates 5.5 kg of solid **waste** and 45 kg -CO2-e per hospitalization day while an ICU generates 7.1 kg of solid **waste** and 138 kg -CO2-e per bed day. • Most emissions originate from purchase of consumable goods, building energy consumption, purchase of capital equipment, food services, and staff travel. • Understanding the source of emissions in a specific care pathway can help to put limited financial and human resources to effective use in reducing those emissions. • With more cities and individuals pushing for carbon-free economies, more action needs to be taken by the healthcare sector to strategically reduce the overconsumption of resources and minimize the public health effects of health services.

Author (Year) N participants Study type	Aim	Key findings / conclusions
Rammelkamp (2021) 23-bed OR suite Waste audit	Determine the exact weights and composition of waste generated in the operating room (OR) setting, broken down by operation, to provide guidance as to which procedures should be the focus of interventions at reducing waste	• Two 5-day OR audits at the Minneapolis Veterans Affairs (VA) Health Service found that 231.3 kg of total **waste** was generated per day, of which 84.5%, 8.83%, 2.79%, and 3.88% were general, recyclable, biohazard, and blue wrap waste, respectively. • By studying the amounts and types of waste that different hospitals produce, a systems-approach could be applied to waste reduction in the OR and effect policy change that would promote environmental sustainability in the hospital setting. • It is against VA policy to use repurposed surgical equipment and donate unused, expired, or excess equipment to third-world health services. Changing these policies could provide a huge opportunity for improvement in environmental sustainability within the healthcare system in the United States.
Rizan (2021) NHS regional hospital Life cycle assessment	Quantify the environmental impact of personal protective equipment (PPE) distributed for use by the health and social care system to control the spread of SARS-CoV-2 in England, and model strategies for mitigating the environmental impact	• The carbon footprint of PPE distributed during the study period totalled 106,478 tonnes CO2e, with greatest contributions from gloves, aprons, face shields and Type IIR surgical masks. • Scenario modelling indicated UK manufacture would have reduced the carbon footprint by 12%, eliminating gloves by 45%, reusing gowns and gloves by 10% and maximal recycling by 35% (the maximal recycling projection is unrealistic due to the lack of adequate infrastructure for waste segregation). • A combination of strategies may have reduced the carbon footprint by 75% compared with the base scenario, and saved an estimated 183 DALYS, 0.34 species.year and US $7.4m (GBP £5.4m) • The environmental impact of PPE is large and could be reduced through reduced use of gloves by using hand washing alone, domestic manufacture, rationalising glove use, using reusables where possible and optimising **waste** management.
Rizan (2022) NHS regional hospital CO2 footprint analysis	Estimate the carbon footprint and financial cost of decontaminating (steam sterilization) and packaging reusable surgical instruments, indicating how that burden might be reduced, enabling surgeons to drive action to- wards net-zero-carbon surgery	• The carbon footprint of decontaminating and packaging instruments was lowest when instruments were part of sets (66–77 g CO2e per instrument), with a two- to three-fold increase when instruments were wrapped individually (189 g CO2e per instrument). • High-temperature incineration of waste increased the carbon footprint of single-use packaging by 33–55%, whereas recycling reduced this by 6–10% • Carbon and financial savings can be made by integrating individually wrapped instruments into sets rather than streamlining them, efficient machine loading, and using low-carbon energy sources alongside recycling.

Author (Year) N participants Study type	Aim	Key findings / conclusions
Stamps (2020) Regional hospital in NY State, US	Show how the chief nursing officer (CNO) council of one health care system partnered with the organization's sustainability department to integrate sustainability efforts into daily operations across the system	• Nurse leader support is essential to operationalize and deploy sustainability measures and engage nursing staff in the workplace • Specific initiatives included education, **waste** reduction and diversion, donation of useable medical supplies and equipment to third world countries and single use device reprocessing • Recycling of > 2,000,000 pounds of waste saved over $250,000 annually; additional savings for **energy** efficiency were $1.5m, renewable electricity 120k and single-use device reprocessing 700k
Tennison (2021) NHS Carbon footprint assessment	Present results for the most recent carbon footprint assessments for the NHS, covering emissions from 1990 to 2019, alongside a detailed description of the hybrid accounting model taken	• In 2019, the NHS's emissions totalled 25 megatonnes of CO2e, which was a reduction of 26% from 1990 and a decrease of 64% in the emissions generated per inpatient finished admission episode • 62% of the 2019 footprint came from the **supply chain (purchasing)**, 24% from the direct delivery of care, 10% from **staff commuting (transport)** and patient and visitor **travel** and 4% from private health and care services commissioned by the NHS • The decarbonisation of the **energy** system contributed significantly to the reduction from 1990 to 2019 • Per-capita results for the NHS in England (plus social care and public health) of 540 kg CO2e per capita compared with similar national studies of health-care sectors place it in proximity to results for Japan (566 kg CO2e per capita in 2015) but less than those for Austria (799 kg CO2 per capita in 2014, CO2 only), Canada (899 kg CO2e per capita in 2015), **Australia (1,495 kg CO2e per capita in 2015)**, and the USA (1889 kg CO2e per capita in 2013).
Vergunst (2020) 333 patients Secondary data analysis of an RCT	Evaluate the feasibility of applying the triple bottom line (TBL) of sustainability to the evaluation of a healthcare intervention – calculating the financial cost in Pound Sterling, the environmental costs in CO2 equivalents and the social sustainability associated with the intervention	• The financial costs of care per patient were high – approximately £40,000 per patient, per year, due to a high level of disability and need • The mean environmental impact was 2415 kg CO2e for community care and 8374kg CO2e for hospital admission. • In terms of social outcomes, most patients were unemployed, had low levels of overall functioning and diminished health-related quality of life, despite the high economic and environmental costs. • TBL assessment can be retrospectively calculated for a healthcare intervention to provide a more complete assessment of the true costs of an intervention and represents a promising opportunity to increase healthcare sustainability.

Transportation (4 studies)

Author (Year) N participants Study type	Aim	Key findings / conclusions
Bowden (2021) D2S staff Longitudinal	Review the environmental impact of Designed to Smile (D2S) by estimating the carbon footprint of the programme and identify carbon hotspots for future targeted action	• **Transportation, purchasing:** The annual carbon footprint of D2S was estimated at 388 tonnes of CO2e (tCO2e) with 31% attributed to staff travel, 23% to business travel and 46% to procurement. • **Leadership:** 968,638 plastic items were distributed by D2S during 2016/17; estimated carbon emissions from the processing, manufacture and distribution of these plastics was 86 tCO2e – using recycled plastic would reduce this to 18 tCO2e • First steps in local action must be part of a broader societal level change that includes considering personal commuting behaviour and promoting an organisational culture that supports active travel options.
Chen (2020) Modelling based on 109,228 hospital and census blocks (each with average 23.7 households and 65.5 people)	Investigate the vulnerability of people's health to the impact of climate change on healthcare accessibility in the San Francisco Bay Area	**Transportation:** • In the baseline scenario, hospitals were accessible to 35.9% of the general population, whereas in the PWL (140) scenario 35.1% had access to hospitals. Healthcare reform increased the accessibility of hospitals to low-income households, and these populations had equal access in the PWL (140) scenario • Our findings call for focusing considerable attention on planning and policy making based on this geographical and spatial analysis to deliver accessible health services for low-income households **Leadership:** • The application of a healthcare facility assessment can support the development and enhancement of health services and address climate change risks. • It is critical to incorporate climate change adaptation and accurate health resource allocation into the planning process.

Author (Year) N participants Study type	**Aim**	**Key findings / conclusions**
Wang (2021) 298 adult elective spine surgery patients Retrospective cross-sectional analysis	Analyse the climate impact of an anaesthesiologist-led telehealth preoperative evaluation centre model that implemented a telehealth screening process and latest guidelines to reduce unnecessary testing for patients undergoing elective spine surgery	• Based on life cycle analysis (**leadership)** GHG emissions were reduced by 8.09 kg CO2e (9.6%) per patient, from 84.52kg CO2e pre-intervention to 76.43kg CO2e post-intervention (p = 0.019), with the largest reduction (14.71kg CO2e) stemming from fewer in-person clinic evaluations. • If only necessary testing had been performed, an additional reduction of 18.07kg CO2e per patient would have been possible • Extrapolated to one year of elective spinal surgeries, 8754kg CO2e emissions were saved.
Whetten (2019) 2,020 neuro-emergent telemedicine consultations across 1 academic center and 12 rural hospital sites Cross-sectional	Calculate the avoided GHG emissions for 2,020 teleconsultations completed in a 26-month time period across New Mexico and estimate potential GHG reduction if the program were to be expanded nationwide	• The use of a neuro-emergent telemedicine consultation program resulted in avoiding travel distances of 477,932 miles and resulted in a GHG emissions avoidance of 618.77 metric tons of CO2e in aviation emissions. • If this program has been operational nationwide, it is estimated to have resulted in GHG emission avoidance of 213,279 metric tons of CO2e. • While telemedicine used an estimated 32kg of CO2e for the 2,020 consultations, this is minor compared to the GHG emissions produced by patient transfers. • While GHG reduction was not the main intention of this telemedicine program, it was a significant by-product that further supports the implementation of telemedicine services.

Waste (3 studies)

Author (Year) N participants Study type	Aim	Key findings / conclusions
Ghersin (2020) Waste audit in a 14-bed ICU	Explore how wasteful practices have become engrained in the healthcare industry culture and the ethical imperative to address it and detail efforts to create a 'greener' future in the paediatric intensive care unit (PICU) of Massachusetts General Hospital for Children, Boston.	• A total of 76 kg of unused medical waste was collected over a three-week period. • The vast majority of items collected were unopened • The overall reduction of items stocked inside patient rooms may have the largest impact on the amount of unused medical waste produced • Healthcare professionals must find a balance between being prepared and limiting practices that have negative consequences on the environment, and to save resources where possible.
Grimmond (2021) 40 NHS hospital trusts Before-after trial	Compare global warming potential (GWP) of hospitals converting from single--use sharps containers (SSC) to reusable sharps containers (RSC)	• **Waste / Purchasing:** The 40 trusts converting to RSC reduced their combined annual GWP by 3267.4 tonnes CO2 e (−83.9%); eliminated incineration of 900.8 tonnes of plastic; eliminated disposal/recycling of 132.5 tonnes of cardboard; and reduced container exchanges by 61.1%. • Adoption of reusable over SSC can reduce GHG emissions permanently with minimal staff behavioural change. • RSC lifespans can be substantially reduced and achieve marked GWP reductions over SSC.
Vacharathit (2022) General Surgery Residents (n not stated) Healthcare sustainability program	Implement a physician-driven program to engage surgical staff and trainees to target waste reduction in the 214 system-wide Cleveland Clinic operating rooms	• **Leadership:** The authors successfully implemented a novel resident-focused fellowship program in healthcare sustainability, involving the submission of proposals to 'Green the Operating Room' and the selection of a healthcare sustainability fellow to execute their proposal. • Fellowship projects included water waste reduction (20% reduction in water waste); regulated medical waste reduction / pre-incision plastics recycling (1 million pounds of plastic diverted from landfill) and electrical energy use reduction ($53k and 717 tons of CO2 saved annually) • Likely barriers to the adoption of this proof-of-concept program include resource restrictions of individual health services – however, an investment of $3000-$5000 USD per fellow annually is likely to save more than 20 times this per annum in the long term and the program is therefore considered to be self-sustainable.

Energy (1 study)

Author (Year) N participants Study type	Aim	Key findings / conclusions
Alshqaqeeq (2020) Review of radiology criteria (10 categories; 162 subcategories; 810 variants)	Examine the use of the American College of Radiology (ACR) Appropriateness Criteria as guidance for similar, "usually appropriate" imaging modality choices (that is, ratings of 7, 8, and 9) and identify which is the lower energy use modality alternative	• There were 48% of patient conditions where there are similar imaging modalities with a "usually appropriate" rating; cardiac was the area with most potential • Using low-energy alternatives could save $2.5 – 25 million USD annually

Food (1 study)

Author (Year) N participants Study type	Aim	Key findings / conclusions
Thiel (2021) Large New York City hospital kitchen Waste audit	Analyse waste generation over one day in the kitchen of an academic medical center, including characterising the waste for diversion potential and quantifying GHG emissions associated with its disposal	• The hospital kitchen generates over 442,067 kg (487 US tons) of **waste** and emits approximately 294,466 kg of CO2e annually from waste disposal • 85% of its **waste** (415 US tons per year) is sent to landfill; through increased recycling and moderate composting this could be reduced to 55% and thereby reduce its GHG emissions by 64% • The authors noted operational and regulatory barriers to implementing waste diversion strategies including logistics, space constraints and resources required

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Appendix 1: Review Protocol

Review title
A rapid review of the effectiveness of sustainable health care interventions to minimise patient safety and quality risks.

Anticipated start and completion date
29/4/22 - 27/5/22

Stage of review at time of this submission to Open Science Framework
Review parameters are being refined in close collaboration with the review client. Searching, selection, quality appraisal and data extraction are commencing in May 2022.

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Funding sources/sponsors
This research is funded by Australian Commission on Safety and Quality in Health Care

Conflicts of interest
There are no known conflicts of interest.

Review question
Primary: What is the effectiveness of sustainable health care interventions for addressing patient safety and quality risks?

Secondary: What are the main patient safety and quality care risks facing health services with regards to sustainable health care?

Key Definitions

- **Health Services:** Any health service organisations providing health care (including all care types such as those in acute, primary and community care) and the Australian population they serve with particular attention to the needs of the primary care and rural sector

- **Patient quality care:** Doing the right thing for the right patient, at the right time, in the right way to achieve the best possible result.

- **Patient safety:** The prevention and reduction of risks, errors and adverse effects to patients during provision of health care

- **Risk:** Risks associated with not taking action to prepare for the adverse effects of climate change on health which can be addressed by delivering ‘sustainable healthcare’ (as defined below). These include extreme weather events and associated mental health impacts, air pollution, direct impact on healthcare

infrastructure (RACP focus) - Health service organisations need to be prepared to manage increasingly extreme and frequent weather events and reduce the burden of disease individuals and communities experience associated with climatic events

- **Sustainable health care:** Actions taken by health services to address:
    - The hazards that climatic change and environmental destabilisation pose to the delivery of future health services and the population's health; and
    - The effect that health service organisations pose to the climate and environment through emissions, waste production and supply chains when delivering care or when utilising low value models of care

Examples of such actions include, but are not limited to:

Monitoring / evaluation / strategy
Conducting a carbon footprint analysis
Routine collection and monitoring of sustainability indicators
Strategic sustainability plans to build resilient and adaptable health services to the effects of changes in weather and disease patterns

Activities with the primary purpose of more sustainable healthcare
Changing to more sustainable manufacturing and procurement systems / processes, for example in pharmaceuticals, medical devices
Facility design, management and / or maintenance, for example use of solar energy, recycling of water
Pursuing more sustainable transport for consumers or staff, for example minimising unnecessary travel, electric vehicles
Improving waste management

Activities with other primary purposes that have sustainability benefits
Reducing low value or unnecessary tests, procedures, or interventions
Addressing poorly implemented or delivered public health and preventative health
Addressing poor quality use and management of medicines or devices

Searches
We will search the following databases:

- Medline via Ovid and Global Health via Ovid
- Scopus

Draft search strategy
The search terms are combinations of keywords (and associated synonyms) across five categories:

- Healthcare system
- Climate change
- Interventions
- Reviews (to identify global review-level literature on healthcare system responses)
- Australia, United Kingdom, United States (to identify primary studies on healthcare system responses from these countries)

Medline via Ovid and Global Health via Ovid strategy

1	("health care" or healthcare or "health* system*" or "health* service*" or "health* sector*" or "health* facilit*" or "health* network*" or "health* center*" or "health* centre*" or "health* unit*" or "health* department*" or "health* delivery" or "health* infrastructure*" or "health* operations" or hospital* or clinic* or "general practice" or "specialist health*" or "allied health*" or "primary health*" or "primary care" or "secondary care" or "secondary health*" or "tertiary health*" or "tertiary care" or "community health*" or medicine or medical or prescription* or prescrib* or "health* personnel" or "health* professional*" or clinician* or doctor* or nurs* or physician* or "general practi*" or GP or surgeon* or surgery or psychiatr* or obstetric* or gynaecolog* or ophthalmolog* or anaesthe* or anesthe* or "emergency department*" or "emergency care" or "emergency health*" or ED or "intensive care" or ICU or intensivist*).mp.
2	((climat* or "global warming" or sustainab* or emission* or carbon or "net zero" or "greenhouse gas*" or GHG) adj10 (intervention* or program* or strateg* or experiment* or campaign* or trial or initiative* or policy or policies or action* or respon* or adapt* or mitigat* or advoca* or recommendation* or resolution or "position* statement*")).mp.
3	(review* or overview or synopsis or "literature review" or "concept synthesis" or "conceptual framework synthesis model" or "conceptual review" or "critical interpretive synthesis" or "critical literature review" or "evidence synthesis" or "integrative review" or "integrative literature review" or "interpretive synthesis" or "knowledge synthesis" or "meta-aggregation" or "meta aggregation" or "meta-analys*" or "meta analys*" or "meta-ethnography" or "meta ethnography" or "meta-interpretation" or "meta interpretation" or "meta-interpretive" or "meta interpretive" or "meta-narrative" or "meta narrative" or "meta-review" or "meta review" or "meta-narrative" or "meta narrative" or "meta study" or "meta-synthesis" or "meta synthesis" or "mixed-methods review" or "mixed methods review" or "mixed-methods synthesis" or "mixed methods synthesis" or "mixed-methods systematic review" or "mixed methods systematic review" or "mixed studies review" or "mixed-studies review" or "narrative review" or "narrative synthesis" or "rapid review" or "realist review" or "realist synthesis" or "research synthesis" or "review of qualitative studies" or "scoping review" or "systematic literature review" or "systematic review" or "systematic synthesis" or "thematic review" or "thematic synthesis" or "qualitative meta-synthesis" or "qualitative meta synthesis" or "qualitative review" or "qualitative synthesis" or "horizon scan").mp.
4	(Australia* OR "New South Wales" OR Victoria OR Tasmania OR Queensland OR "Northern Territory" OR "South Australia" OR "Western Australia" OR "Australian Capital Territory" OR NSW OR ACT OR SA OR WA OR QLD OR NT).mp.
5	1 AND 2 AND 3
6	1 AND 2 AND 4
7	5 OR 6
8	Limit 7 to (english language) and yr="2021-Current"
9	("United States" OR "United States of America" OR USA OR America OR American OR England OR Wales OR Scotland OR Ireland OR UK OR "United Kingdom" OR Britain OR British OR English OR "New Zealand" OR NZ OR Aotearoa).mp.
10	(NHS OR "National Health Service").mp.
11	9 OR 10
12	1 AND 2 AND 11
13	Limit 12 to (english language) and yr="2016-Current"
14	8 OR 13
	Yield May 4 2022 = 2441

Scopus strategy

1	TITLE-ABS-KEY("health care" or healthcare or "health* system*" or "health* service*" or "health* sector*" or "health* facilit*" or "health* network*" or "health* center*" or "health* centre*" or "health* unit*" or "health* department*" or "health* delivery" or "health* infrastructure*" or "health* operations" or hospital* or clinic* or "general practice" or "specialist health*" or "allied health*" or "primary health*" or "primary care" or "secondary care" or "secondary health*" or "tertiary health*" or "tertiary care" or "community health*" or medicine or medical or prescription* or prescrib* or "health* personnel" or "health* professional*" or clinician* or doctor* or nurs* or physician* or "general practi*" or GP or surgeon* or surgery or psychiatr* or obstetric* or gynaecolog* or ophthalmolog* or anaesthe* or anesthe* or "emergency department*" or "emergency care" or "emergency health*" or ED or "intensive care" or ICU or intensivist*)
2	TITLE-ABS-KEY((climat* or "global warming" or sustainab* or emission* or carbon or "net zero" or "greenhouse gas*" or GHG) w/10 (intervention* or program* or strateg* or experiment* or campaign* or trial or initiative* or policy or policies or action* or respon* or adapt* or mitigat* or advoca* or recommendation* or resolution or "position* statement*"))
3	TITLE-ABS-KEY(review* or overview or synopsis or "literature review" or "concept synthesis" or "conceptual framework synthesis model" or "conceptual review" or "critical interpretive synthesis" or "critical literature review" or "evidence synthesis" or "integrative review" or "integrative literature review" or "interpretive synthesis" or "knowledge synthesis" or "meta-aggregation" or "meta aggregation" or "meta-analys*" or "meta analys*" or "meta-ethnography" or "meta ethnography" or "meta-interpretation" or "meta interpretation" or "meta-interpretive" or "meta interpretive" or "meta-narrative" or "meta narrative" or "meta-review" or "meta review" or "meta-narrative" or "meta narrative" or "meta study" or "meta-synthesis" or "meta synthesis" or "mixed-methods review" or "mixed methods review" or "mixed-methods synthesis" or "mixed methods synthesis" or "mixed-methods systematic review" or "mixed methods systematic review" or "mixed studies review" or "mixed-studies review" or "narrative review" or "narrative synthesis" or "rapid review" or "realist review" or "realist synthesis" or "research synthesis" or "review of qualitative studies" or "scoping review" or "systematic literature review" or "systematic review" or "systematic synthesis" or "thematic review" or "thematic synthesis" or "qualitative meta-synthesis" or "qualitative meta synthesis" or "qualitative review" or "qualitative synthesis" or "horizon scan")
4	TITLE-ABS-KEY(Australia* OR "New South Wales" OR Victoria OR Tasmania OR Queensland OR "Northern Territory" OR "South Australia" OR "Western Australia" OR "Australian Capital Territory" OR NSW OR ACT OR SA OR WA OR QLD OR NT)
5	1 AND 2 AND 3
6	1 AND 2 AND 4
7	5 OR 6
8	Limit 7 to (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021)
9	TITLE-ABS-KEY("United States" OR “United States of America” OR USA OR America OR American OR England OR Wales OR Scotland OR Ireland OR UK OR "United Kingdom" OR Britain OR British OR English OR “New Zealand” OR NZ OR Aotearoa)
10	TITLE-ABS-KEY(NHS OR “National Health Service”)
11	9 OR 10
12	1 AND 2 AND 11
13	Limit 10 to (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016)
14	8 OR 13
	Yield May 4 2022 = 4293

Eligibility criteria

	Include	Exclude
Study Type	Systematic, narrative and scoping reviews Primary studies (defined as leader author / majority authorship team / location of intervention) from • Australia • United Kingdom • United States of America	Book chapters, theses, commentaries, editorials, review protocols
Population / Setting	Networks or groups of: Healthcare professionals, health services (at all levels e.g. individual practice, pre-hospital care, inpatient settings), specialist colleges / disciplinary groups, policymakers *Healthcare systems* refers to healthcare infrastructure, personnel and operations in all states and territories, including hospitals, general practice, specialist and allied health services, medical colleges, primary health and local hospital networks, Aboriginal community-controlled health organisations and medicines and prescriptions.	
Study Design	Any	
Study Setting	Reviews based on healthcare settings in any country Primary studies based in Australia / UK / USA	Stand-alone recommendations or policy guidelines from countries other than Australia
Intervention	Actions / responses taken by or based in healthcare systems as defined above to mitigate and adapt to climate change and / or improve sustainable healthcare	
Outcome	No restrictions	
Publication status	No restrictions	
Time period	Reviews and Australian primary studies published since the RACP report Other primary studies published from 2019 onwards	
Language	English only	Other languages

Main outcome(s)
The review is designed to identify sustainable healthcare interventions, including their rationale and the risks being addressed by these interventions.

Data extraction (selection and coding)
Search results will be exported into Covidence (Cochrane technology platform). Duplicates will be removed from the total number of identified records. For each title/abstract, two reviewers will independently screen for eligibility, applying a priori inclusion and exclusion criteria (see below). Following title/abstract screening, two reviewers will independently apply the inclusion and exclusion criteria to remaining full-text records. Any conflicts for any step will be resolved by a third reviewer. Data extraction will focus on the following data items: authors; publication date; study aim and rationale (especially with regards to risks being addressed); research design; study period; study location, study population; data sources; and main findings. Reviewers will cross-check a selection of studies (e.g. 10%) to ensure extraction accuracy. Indicative meta-headings for intervention categories will be based upon those of the Green and Healthy Hospitals Network[6], with some variations to capture studies not fitting their 10 categories:

- LEADERSHIP: Prioritise environmental health
- CHEMICALS: Substitute harmful chemicals with safer alternatives
- WASTE: Reduce, treat and safely dispose of healthcare waste
- ENERGY: Implement energy efficiency and clean, renewable energy generation
- WATER: Reduce hospital water consumption and supply potable water
- TRANSPORTATION: Improve transportation strategies for patients and staff
- FOOD: Purchase and serve sustainably grown, healthy food
- PHARMACEUTICALS: Safely manage and dispose of pharmaceuticals
- BUILDINGS: Support green and healthy hospital design and construction
- PURCHASING: Buy safer and more sustainable products and materials

Risk of bias (quality) assessment
Risk of bias, or quality assessment, will be assessed for each *review-level* study using an appropriate quality appraisal tool for systematic and non-systematic reviews. There is insufficient resource for quality appraisal of primary studies, but a broad ranking of study design may be employed.

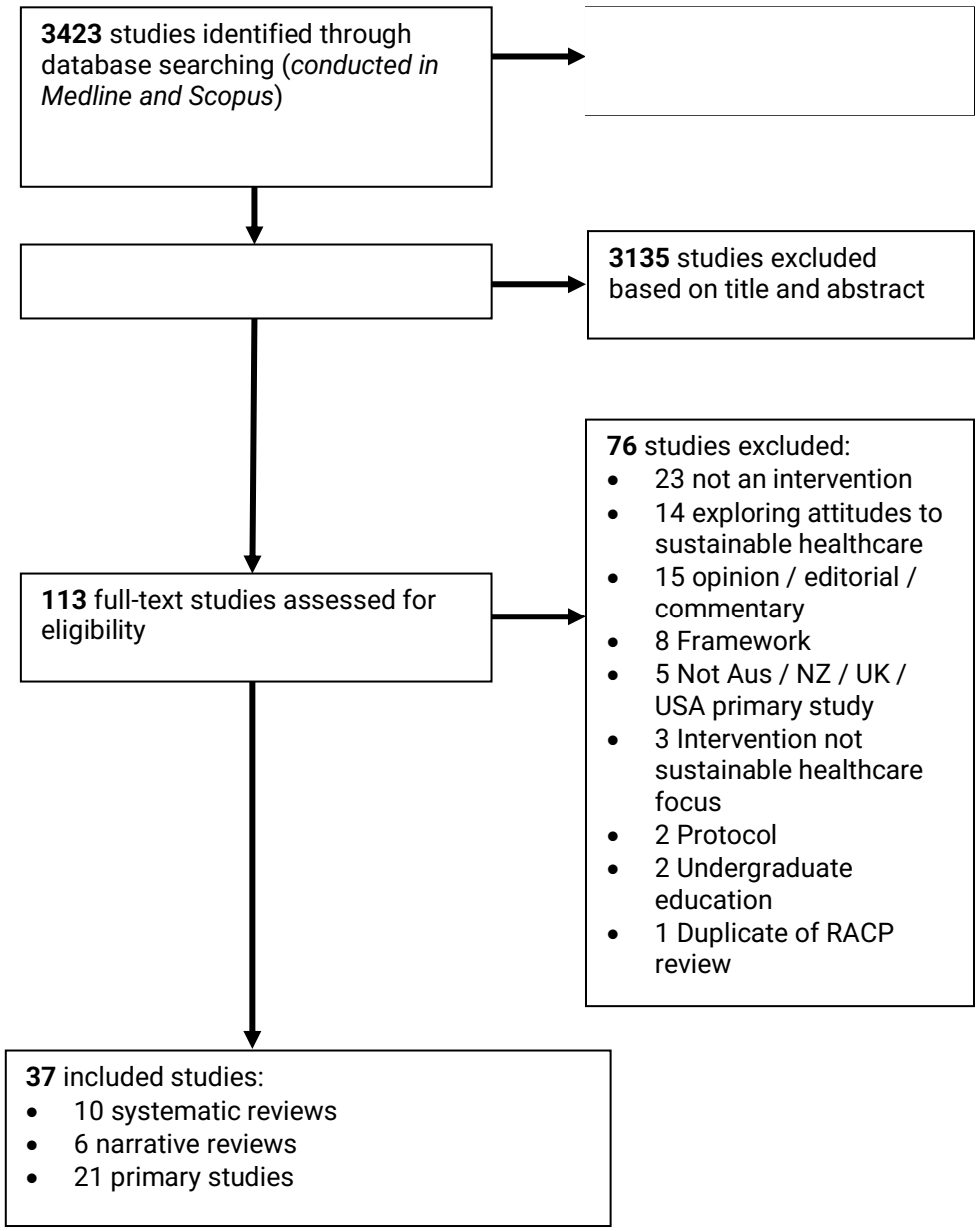
Strategy for data synthesis
The extracted data will be thematically analysed and narratively synthesised.

Analysis of subgroups or subsets
Analysis of subgroups might be undertaken but this cannot be predicted in advance.

[6] https://www.greenhospitals.net/sustainability-goals/ Accessed May 4, 2022

Appendix 2: Results of study selection and quality appraisal

Study selection summary (PRISMA)



Systematic review quality appraisal results

Criterion (AMSTAR 2) PY = Partial Yes; N/A = Not applicable; N M/A = no meta-analysis conducted	Alberdi (2021)	Andeobu (2022)	Carino (2020)	Drew (2021)	Li (2021)	Martin (2021)	Pradere (2022)	Stephens (2021)	Taghilou (2021)
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	Y	N	Y	Y	N	N	Y	N	N
3. Did the review authors explain their selection of the study designs for inclusion in the review?	Y	N	Y	N	N	Y	Y	Y	Y
4. Did the review authors use a comprehensive literature search strategy?	PY	PY	PY	PY	PY	PY	PY	N	PY
5. Did the review authors perform study selection in duplicate?	Y	N	Y	Y	N	Y	Y	N	Y
6. Did the review authors perform data extraction in duplicate?	Y	N	Y	N	N	Y	N	N	N
7. Did the review authors provide a list of excluded studies and justify the exclusion?	N	N	N	N	N	N	N	N	N
8. Did the review authors describe the included studies in adequate detail?	PY	N	PY	PY	PY	N	PY	PY	PY
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A
10. Did the review authors report on sources of funding for the studies included in the review?	N	N	N	Y	N	N	N	Y	N
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A
13. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?	N/A	N/A	N	Y	N/A	N/A	N/A	N/A	N/A
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results?	N	N	N	Y	Y	N	Y	N	N
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A	N M/A
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Y	Y	Y	Y	Y	Y	Y	Y	Y
TOTAL yes / applicable items	**8/11**	**3/11**	**9/13**	**10/13**	**5/11**	**6/11**	**8/11**	**5/11**	**6/11**

Narrative review quality appraisal results

Criterion (SANRA)	Agrawal (2021)	Fathy (2021)	Ma (2022)	Qin (2022)	Smale (2021)	Wilkinson (2021)	Wu (2021)
1. Justification of the article's important for the readership	2	2	1	2	2	1	2
2. Statement of concrete aims or formulation of questions	0	1	2	2	2	0	2
3. Description of the literature search	0	0	1	2	2	0	2
4. Referencing	2	2	2	2	2	2	2
5. Scientific reasoning	1	0	1	1	1	1	1
6. Appropriate presentation of data	1	1	1	2	2	2	2
TOTAL / 12	**6**	**6**	**8**	**11**	**11**	**6**	**11**

Appendix 3: Summary of the Global Green and Healthy Hospitals Agenda

Agenda area	Definition (from GGHH Agenda)	Examples
Leadership	Demonstrate leadership support for green and healthy hospitals in order to: create long-term organizational culture change; realize widespread hospital worker and community engagement; and foster public policy that promotes environmental health	• Hospital taskforce • Research • Community engagement • Advocacy for environmental health policy • Strategic / policy leadership – e.g. statements of intent, policy imperatives • Vulnerability assessments – resilience • Carbon accounting / auditing – mitigation • Life Cycle Analysis
Energy	Reduce fossil fuel energy use as a means to improve and protect public health; foster energy efficiency as well as alternative, renewable energy use with the long-term goal of 100% of energy needs to be supplied by on-site or community renewable energy sources.	• Reduce consumption in existing buildings • Energy audits, awareness and retrofitting • Purchase clean renewable energy
Chemicals	Improve the health and safety of patients, staff, communities and the environment by using safer chemicals, materials, products and processes, going beyond the requirements of environmental compliance"	• Chemicals and materials policy • Replace mercury-based thermometers • Seek alternatives to chemicals of concern e.g. PVC, BPA, glutaraldehyde
Waste	Protect public health by reducing the volume and toxicity of waste produced by the health sector, while implementing the most environmentally sound waste management and disposal options.	• Environmentally preferable purchasing • Waste management committee • Waste reduction program • Waste Segregation, recycling • Recycling anaesthetic gases
Water	Implement a series of conservation, recycling and treatment measures to reduce hospital water consumption and wastewater pollution. Establish the relationship between potable water availability and healthcare resilience to withstand physical, natural, economic and social disruption. Promote public environmental health by providing potable water for the community.	• Aspire to 'net zero water use' • Install efficient taps, toilets • Switch from film to digital imaging • Harvest rainwater

Agenda area	Definition (from GGHH Agenda)	Examples
Transportation	Develop transportation and service delivery strategies that reduce hospitals' climate footprint and their contribution to local pollution.	• Provide care in accessible locations including primary and home care • Use telemedicine and email alternatives to face-to-face contact • Encourage walking, car pooling • Invest in hybrid, electric or biofuel hospital vehicles
Food	Reduce hospitals' environmental footprint while fostering healthy eating habits in patients and staff. Support access to locally and sustainably sourced food in the community.	• Buy local and organic food • Eliminate fast food e.g. sugary drinks • Encourage vendors to supply sustainable food • Minimise and beneficially reuse food waste
Pharmaceuticals	Reduce pharmaceuticals pollution by reducing over-prescription practices, minimizing inappropriate pharmaceutical waste disposal, promoting manufacturer take-back, and ending the dumping of pharmaceuticals as part of disaster relief.	• Minimise prescription amount, don't provide sample medications • Educate about safe disposal of expired medicines • Work with pharmaceutical companies to develop more efficient medication delivery systems • Ensure that pharmaceutical waste is treated and disposed of using WHO guidelines
Buildings	Reduce health care's environmental footprint, and make hospitals healthier places to work and visit, by incorporating green building principles and practices into design and construction of health facilities.	• Aspire to carbon-neutral building operation • Minimise building and other hard surface footprint • Use passive design and protect natural habitat • Use local and safe building materials
Purchasing	Source sustainably produced supply chain materials from socially and environmentally responsible vendors.	• Review procurement practices and use local vendors • Co-ordinate between hospitals to optimise purchasing power • Use purchasing power to favour environmentally responsible, ethical suppliers

Appendix 4: Policy & Institutional Analysis: Study Design & Methods

Study design & methods

Both the policy and institutional analysis used a standard qualitative methodology, including a survey, community mapping, literature review, semi-structured interviews and thematic data analysis, commonly used in health and policy research.

Literature review and semi-structured interviews

This comprises a critical scoping review, using a semi-systematic, snowball technique to identify policy materials (i.e. government policy, official reports, public submissions, stakeholder commentaries, board and corporate reports, etc.), as well as relevant scholarly works.

The literature review for international sources identified 687 policies and programs related to sustainable healthcare. Six semi-structured interviews with international experts were used to select a sample of 12 exemplary international healthcare sustainability policies and programs that would have most relevance for the development of a potential sustainable healthcare module in Australia. Care was taken to retain the confidence of each informant, including anonymizing their views and being sensitive to any risks to their position from participation. This helps to reduce messenger bias, encourages open discussion, and improves the quality of data collected.

The literature review for Australian government policies and programs related to sustainable healthcare reviewed policies at the level of commonwealth, state, and territory governments. Around 156 Australian policy documents were identified and analysed for their relevance on sustainable healthcare. Information was validated through requests for information, which were sent to the health departments of 8 state and territory governments. Six state and territory governments provided written feedback on their sustainable healthcare policies.

Mapping of institutional practice

An analysis of climate–health institutional practices was performed using the Pacific regional network of Global Green and Healthy Hospitals (GGHH), which comprises 108 Australian health services, representing 439 hospitals and 1687 health service providers, or approximately 33% of Australian hospitals.

A survey was conducted on the GGHH Pacific network to identify institutional practices on sustainable healthcare. The 10 GGHH goal areas of sustainability were used as categories: Leadership - Chemicals - Waste - Energy - Water - Transportation - Food - Pharmaceuticals - Buildings & Infrastructure - Procurement. Additional categories consisted of: emission reductions and measurements - health workforce - sustainable models of care - healthcare resilience.

In addition, the survey posed a set of qualitative questions to health services, gauging their experience of the implications of their sustainability efforts on the safety and quality of care, as well as the extent with which their institution would monitor, or otherwise measure the effectiveness, of their sustainability efforts.

Limitations

The literature review for international sources revealed a large body of sustainable healthcare practices, the systematic analysis of which went beyond the scope of this review.

Semi-structured interviews relied on a relatively small sample size, and were flexible in nature, possibly influencing the selection of the 12 exemplary international policies.

The literature review for national sources was exhaustive (i.e. all relevant policies were identified) but is likely incomplete due to a lack of publicly available documentation on government's sustainable healthcare policies and programs.

The institutional analysis mapped sustainability practices using a voluntary network of health services, representing approximately 33% of Australian hospitals. Given the voluntary membership and thematic focus of the GGHH network, this might not necessarily be representative of the entire Australian healthcare sector, and should not be interpreted as such. Nonetheless, it provides a snapshot of sustainable practices in the segment of the healthcare sector that could be identified as 'first movers on sustainability', and provides an overview of best practice.

Appendix 5: Membership of GGHH network

Member	Category (hospital - facility - system - organization)	No. of Hospitals	No. of Health Centers
WESTERN AUSTRALIA			
Child and Adolescent Health Service (CAHS)	Health Systems	1	3
Department of Health WA	Health System	0	0
East Metropolitan Health Service	Health Systems	3	2
North Metropolitan Health Service	Health Systems	4	6
King Edward Memorial Hospital	Hospitals	/	/
Dental Health Services WA	Health service	0	180
Sir Charles Gairdner Osborne Park Health Care Group	Health Systems	/	/
Pathwest Laboratory Medicine WA	Health Organization	0	0
Perth Clinic	Hospital	1	0
Rural Clinical School of Western Australia	Health Organization	0	0
South Metropolitan Health Service (SMHS)	Health Systems	4	1
WA Country Health Service (WACHS)	Health Systems	70	237
Western Australia Country Health Service (WACHS), SW coastal	Health Systems	/	/
Broome Health Campus	Health Care Facilities	/	/
SOUTH AUSTRALIA			
Australian Nursing & Midwifery Federation (SA Branch)	Health Organization	0	0
Burnside War Memorial Hospital	Hospitals	1	0
Women's and Children's Hospital	Hospitals	1	0
NEW SOUTH WALES			
Family Planning New South Wales	Health Systems	0	9
Gosford Private Hospital	Hospitals	1	0
Hunter New England Local Health District	Health Systems	27	54

Singleton District Health Service	Hospitals	/	/
Nepean Blue Mountains Local Health District	Health Systems	5	0
New South Wales Nurses and Midwives' Association	Health Organization	0	0
Northern Sydney Local health district	Health Systems	6	14
Royal North Shore Hospital (RNSH)	Hospitals	/	/
Prince of Wales Private Hospital	Hospitals	1	0
Queanbeyan District Hospital	Hospitals	1	0
South Western Sydney Local Health District	Health Systems	6	13
St. John of God Burwood Hospital	Hospitals	/	/
St Vincent's Lismore	Hospitals	1	0
Sydney Children's Hospitals Network	Health Systems	2	4
Sydney Local Health District	Health Systems	5	4
Sydney North Health Network	Healthcare facility	0	1
South Eastern Sydney Local Health District (SESLHD)	Health Systems	9	0
Southern Neurology	Healthcare facility	0	1
Sydney Surgical Centre	Hospitals	1	0
Uniting War Memorial Hospital (UWMH)	Hospitals	1	0
Western Sydney Local Health District (WSLHD)	Health Systems	4	7
QLD			
Beaudesert Hospital	Hospitals	1	0
Cairns and Hinterland Hospital and Health Service	Health System	9	20
Children's Health Queensland Hospital and Health Services	Health Systems	1	15
Darling Downs Hospital and Health Service	Health Systems	17	6
Department of Health, Queensland	Health Systems	0	0
Far North Queensland Sustainability in Health	Health Organization	0	0
Gold Coast hospital and health service	Health Systems	3	18
Herston Private Hospital	Hospital	1	0

Mater	Health Systems	18	30
Metro North Hospital and Health Service	Health Systems	6	0
Caboolture Hospital	Hospitals	/	/
Kilcoy Hospital	Hospitals	/	/
Queen Elizabeth II Jubilee Hospital	Hospitals	1	0
Queensland Nurses and Midwives' Union	Health Organization	0	0
Queensland Eye Hospital	Hospitals	1	0
Princess Alexandra Hospital	Hospitals	1	0
Sunshine Coast Hospital and Health Service	Health Systems	4	1
Uniting Care Queensland	Health Systems	4	460
Kingaroy Hospital	Hospitals	1	0
TAS			
Public Health Services- Tasmanian Government Department of Health	Health Systems	0	0
Tasmanian Health Service - South (THS-S)	Health Systems	2	14
NATIONAL			
Australian Healthcare and Hospitals Association	Health Organization	0	0
Australian Medical Association	Health Organization	0	0
Australian Medical Students' Association (AMSA)	Health Organization	0	0
Australian College of Nursing (ACN)	Health Organization	0	0
Children's Healthcare Australasia	Health Organization	0	0
Cura Day Hospitals Group	Health System	26	0
Healthy Futures	Health Organization	0	0
Institute of Healthcare Engineering	Health Organization	0	0
Mercy Health	Health Systems	2	52
Optometry Australia	Health Organisation	0	0
Southern Cross Care (NSW & ACT)	Health Systems	0	70
St. John of God Health Care	Health Care facilities	24	0

St. Vincent's Health Australia Limited	Health Systems	16	24
Tresillian	Health service	0	23
Women's Healthcare Australasia	Health Organization	0	0
VICTORIA			
Ambulance Victoria	Health Organization	0	260
Australian Nursing and Midwifery Federation (Victoria Branch)	Health Organization	0	0
Cabrini Health	Health Care Facilities	2	6
coHealth	Health System	0	30
Victorian Department of Health	Health Systems	122	0
Austin Health	Health Systems	/	/
Bairnsdale Regional Health Service (BRHS)	Health Systems	/	/
Bendigo Health	Health Care Facilities	/	/
Dental Health Services Victoria	Health Systems	/	/
Goulbum Valley Health	Health Systems	/	/
Central Highlands Rural Health	Health Systems	/	/
Kilmore District Health	Hospital	/	/
Kooweerup Regional Health Service	Health Systems	/	/
Maldon Hospital	Hospitals	/	/
Melbourne Health	Health Systems	/	/
Northeast Health Wangaratta	Hospitals	/	/
Northern Health	Health Systems	/	/
Peninsula Health	Health Care Facilities	/	/
The Royal Womens Hospital (RWH)	Hospitals	/	/
South West Healthcare	Health Systems	/	/
Swan Hill District Health	Hospitals	/	/
Tallangatta Health Service	Health Care Facilities	/	/
West Wimmera Health Service	Health systems	/	/

Western Health	Health Systems	/	/
Epworth HealthCare	Health Systems	11	0
IPC Health	Health Systems	0	6
Manningham Day Procedure Centres (MDPC)	Health Care Facilities	1	0
North East Sustainability and Health Group	Health Organization	0	0
North Western Melbourne Primary Health Network	Health Organization	0	0
Peter MacCallum Cancer Centre	Hospital	1	4
Victorian Allied Health Professionals Association	Health Organization	0	0
Northern Territory			
Central Australia Health Service (CAHS)	Health System	2	29
Top end Health Service	Health System	4	56
Purple House	Health System	0	18
ACT			
ACT Government health system	Health System	4	9
TOTAL:		**440**	**1687**

AUSTRALIAN COMMISSION
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